THE INTERACTION BETWEEN REFLECTIVE PROCESSING AND LANGUAGE AMONG BILINGUAL SPEAKERS

Poh Wei Lin

Department of Psychology

University of Nottingham Malaysia Campus

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University of Nottingham Malaysia Campus

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ABSTRACT

Internal or Reflective attention can refer to our thoughts/reflections in order to make sense of our external world through our senses and perception. Reflective attention also includes the act of refreshing which is the act of thinking back and shifting internal attention towards previously activated mental representations. Previous research (M.R. Johnson et al., 2013) has shown that refreshing mirrors a striking similarity to that of inhibition of return (IOR) effect which inhibits visual attention to return to a previously cued location (Posner & Cohen, 1984; Posner, Rafal, Choate, & Vaughan, 1985). This IOR-like mechanism helps facilitate our thoughts (similarly to perception) by encouraging internal attention to move towards new information and avoid constant fixation on a single thought (M. R. Johnson et al., 2013) which was coined as reflective IOR (rIOR). The objective of the thesis investigates variables such as time duration and language during the production of rIOR mechanism.

A total of seven experiments were conducted. The first set of experiments (Experiments 1 to 3) aimed to examine the time course of refreshing while the second set and (Experiments 4 to 7) examined the effect of language on reflective attention. In each experiment, participants were shown two stimuli, either in the form of pictures or English/Malay words. They were instructed to refresh by keeping one item (i.e., mental representation) active while ignoring the other. Results showed an attentional shift or bias towards the unrefreshed mental representation, more so in the experiments which used word stimuli rather than picture stimuli. The novelty of the current thesis is that early language processing (i.e., English and Malay words) in bilingual speakers was taken into account while investigating the reflective attention. This pattern was consistent whether the words were presented in English or Malay which are consistent with M. R. Johnson and colleagues' finding that IOR mechanism shifts internal attention to new information However, if

participants were presented with English stimuli, refreshed the English word but were then probed in the equivalent Malay word, a stronger priming effect emerged instead. The behavioural pattern implicated that asymmetrical cost during language switching could be reduced as a result of refreshing.

The data also showed that while refreshing may cause a temporary inaccessibility to recently activated items, refreshed words were more memorable in a later recognition task. This suggested the role of refreshing plays an important role encoding and storing mental representations in later long term retrieval. Mental representations that were ignored or were not given attention tended to fade away more quickly. The novelty of the thesis is that language processing was explored as a component to this mechanism by manipulating languages of the refreshed words presented. Participants were more likely to make false alarms when they were presented with an English equivalent word in the recognition task, when the original word had in fact been presented (i.e., previously refreshed) in Malay. Language models such as the Revised Hierarchical Model (RHM) (Kroll and Stewart, 1990, 1994) were applied in examining refreshing in stronger or weaker languages that gave rise to poor memory performance. According to the RHM's logic, words activated in non-dominant language would subsequently activate words in the dominant language in order to access the meaning of the word. In this language processing route, it is possible that refreshing a word in the weaker language would subsequently activate the similar word in the stronger language which is reflected as a false memory incident.

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Declaration

I declare that this thesis is my own work carried out under the normal terms of supervision.

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ABBREVIATIONS

ACC	Anterior Cingulate Cortex
ACS	Attentional Control Setting
ANOVA	Analysis of Variance
AOA	Age of Acquisition
BIA/BIA+	Bilingual Interactive Activation/Bilingual Interactive Activation Plus
C	Consonant
CTOA	Cue-Target Onset Asynchronies
CS	Conceptual Store
fMRI	Functioning-Magnetic Resonance Imaging
ETeMS	English for Teaching of Mathematics and Science
IA	Interactive Activation
IC	Inhibitory Control
IOR	Inhibition of Return
L1	First Language
L2	Second Language
LFV	Left Visual Field
LIFG	Left Inferior Parietal Gyrus
M	Mean
MBMMBI	Merabatkan Bahasa Malaysia dan Merperkukuhkan Penguasaan Bahasa Inggeris (In English*: To Uphold Bahasa Malaysia and to Strengthen the English Language*)
MEM	Multiple-Entry, Modular model of cognition
MSE	Mean Square Error
PFC	Prefrontal Cortex
RHM	Revised Hierachical Model
rIOR	Reflective Inhibition of Return
RT	Response Times
RVF	Right Visual Field
SD	Standard Deviation
SE	Standard Error
SEM	Standard Error of Mean
SES	Socioeconimic Status
SOA	Cue-Target Stimulus Asynchrony
TOT	Tip-of-the-Tongue
V	Vowel
WEAVER++	Word-form Encoding by Activation and VERification

CHAPTER 1

General Introduction: Inhibition effect within Reflective Attention

1.1 Overview on Attention

William James was one of the first researchers to define “attention” and claimed it refers to “taking possession by the mind of one out of several simultaneously possible objects or other familiar terms such as train of thoughts or mental events” (James, 1890). Modern research has continued to work and expand upon this broad definition of attention; it is considered a core cognitive process. Bartlett (1958) famously described thinking as a high level skill that exhibits a ballistic property of “point of no return”. In other words, once a thought is committed in a particular direction, it cannot be altered. Posner (1980) also agreed with Bartlett’s claims, and his theory of orienting attention (either towards sensory input or semantic structures) operates on similar principles. I presented a brief overview on the differences between external (perceptual) and internal (reflective) attention. I also reviewed evidence of Inhibition of Return (hereafter known as IOR) and how it shares similar concepts to Bartlett’s metaphor that our thought (or internal attention) is governed by a ballistic “point of no return” property.

Attention is a widely used concept in cognitive literature. Chun, Golomb and Turk-Browne (2011) stated that it should be considered as a “characteristic and property of multiple perceptual and cognitive control mechanism” (see also: Lavie, Hirst, de Fockert, & Viding, 2004; Pashler & Sutherland, 1998; Yantis, 1998). The first property of attention is that it has a limited capacity by nature. The explanation for this claim is because the information available to us is more than we can process at any given moment. In order to efficiently process information, focus was kept on the important ones that were most relevant to on-going goals and behaviours (Pashler, Johnston, & Ruthruff. 2001). Another property is *selection* by means of selecting or biasing competition of available information provided from multiple sensory modalities in favour of ongoing events. Higher level processes of thinking, such as decision making, could involve choosing between two decisions before acting upon. The third characteristic is *modulation*, this part of the process focuses on selected information and attention influences processing in the absence of overt competition. The authors (Chun et al., 2011) defined *modulation* as focusing on current events and results in an immediate effect of attention processing. Lastly, *vigilance* is described as the ability to keep attention over extended periods. Perceptual and cognitive activities ebb and flow and do not always function at its peak. Because of this reason, it is important for modulation of attention to be sustained over long period of time.

Chun and colleagues (2011) provide a taxonomy of attention as a comprehensive framework for understanding cognitive functions involved in attention. The proposed model suggests attention can be examined based on type of information selected, thus broadly dividing between internal and external attention. In other words, there is a difference between selecting information from sensory input (external attention) and information represented in the minds, maintained in the current working memory or recalled from long-term memory (internal attention). Internal attention selects, modulates and maintains generated information in our mind such as task rules, long-term memory and working memory; this has been referred to as central or reflective attention (Johnson, 1983; Miller & Cohen, 2011). By contrast, Chun et al. (2011) noted that external attention (perceptual attention) selects and modulates sensory and perceptual information from dimensions such as space, time or modality for things that were experience in the environment. External processes are directed at external sensory information that can be organized by features or into objects.

As outlined above, the mechanisms of orienting attention help guide behaviour by selecting relevant information from the external world for further processing as well as scanning inner representations within our working memory. Another aim of the current thesis was to explore what happens to information gathered and how such information is processed as mental representations or categorizations in our minds? M. R. Johnson[1] and M. K. Johnson (2009) suggest our memory is categorized based on informational content. First, memory is categorized based on its content whether it be episodic or semantic memory (Tulving, 1983); or the types of processes engaged such as familiarity or recollection (Atkinson & Juola, 1974; Jacoby & Dallas, 1981; Mandler, 1980; Tulving, 1985); or types of encoding whether they are shallow or deep encoding; or types of process whether they are perceptual or reflective processing (M. K. Johnson & Hirst, 1991) and lastly by regions of the brain involved (Poldrack & Packard, 2003; Poldrack & Rodriguez, 2004). I introduced the concepts of perceptual and reflective attention and compare how these two mechanisms manage and process information. I focused on one particular component known as *refreshing,* which is a process to reflective attention and is the central theme to this thesis; how it functions, and factors which modulate reflective attention will be discussed later on within this chapter.

1.2 Perceptual and reflective attention

In attentional studies (for a review see Chun & M. K. Johnson, 2011), one of the main themes investigates the question of whether attention to the external environment (perceptual attention) was directed the same way as the internal working memory (reflective attention). Selective attention is important in prioritising the information processing that is most related to our motivations or expectations by enhancing certain information that we received through

[1] M. R. Johnson and M. K. Johnson are involved in refreshing or reflective attention studies, thus their initials (M. R. or M. K.) are indicated throughout the thesis to avoid confusion. However, if the initials were not indicated, then the name "Johnson" would refer to another experimenter.

our sensory modalities (Lepsien & Nobre, 2006). Chun & M. K. Johnson (2011) describe both internal and external aspects of attention as the ability to orient attention to process mental representations within working memory and perceptual input from the external environment, respectively. For example, does perceptual attention function the same way as reflective attention in term of selecting information? Logically, it is impossible for perceiving and reflecting to share exactly the same neural substrates and produce the identical mental consequences; if so, this would result into difficulty in distinguishing between perception and imagination (M. K. Johnson, 2006; Chun & M. K. Johnson, 2011). However, these processes engage in or activate overlapping representational and processing brain regions such as frontal and parietal regions that control the direction of focus (Yi, Turk-Browne, Chun, & M. K. Johnson, 2008) (see **section 2.1** for further neuroimaging technique details). Moreover, an interaction between these processes is crucial as a way to accumulate and regulate information between perceiving and reflecting.

A number of studies have shown similarities and differences between both perceptual and reflective attention. To cite a one, Johnson and colleagues (Johnson, McDuff, Rugg, & Norman, 2009) directly compared the selective mechanism in both these concepts and showed similar effects on sensory representations. In the experiment, participants were either cued in advance to attend to one picture stimuli (in this case either a face or a scene) presented perceptually or cued after the stimuli was removed and they were instructed to refresh by visualising one of the stimuli. Results from these conditions indicated similar enhancement and suppression effects in comparison to the passive viewing condition. These results suggest the activity that modulates both perceptual and reflective attention shares similar neural representations as well as serving related functions (Chun & M. K. Johnson, 2011). Other studies using functioning-magnetic resonance imaging (fMRI) that further this line of research have found that the process of refreshing shows activity in posterior areas involved in perception (Curtis & D'Esposito, 2003; Ranganth, Cohen, & Brozinsky, 2005; Harrison & Tong, 2009; Johnson et al., 2009).

On the contrary, there are also studies suggesting otherwise and that mechanisms of these concepts are separable. A number of studies have investigated this distinction by directly comparing perceptual and reflective attention: stimulus-oriented versus stimulus independent attending (Burgess, Dumontheil, & Gilbert, 2007), selective attention versus memorial selection (Nee & Jonides, 2009), attentional orienting in perceptual domain versus the working memory (Lepsien & Nobre, 2006) and attentional modulation of sensory information and information in working memory (Awh, Vogel, & Oh, 2006).

Roth, M. K. Johnson, Raye, and Constable (2009) directly compared the activity in brain regions when information were into focus of attention, either perceptually (update) or reflectively (refresh). In the update block, participants had to read a stream of words while keeping the cued word active in the working memory. In the refresh block, participants also saw a stream of words and were cued to think back the just-previous words, but not continually think of the refreshed word. The data in fMRI scan showed that when word stimuli were presented, regions for perceptual attention (reading) showed activity in the right frontal cortex and bilateral posterior visual cortex. Active regions for reflective attention (refreshing) were found in the left cortex, left temporal cortex, and bilateral inferior frontal cortex. These areas are in the frontal regions associated with modulating representations that are no longer present perceptually (see also M. R. Johnson, Raye, D'Esposito, M. K. Johnson, 2007). Updating showed greater activity in the posterior visual processing regions because new information were attended and processed (Roth et al, 2009). The neuro-imaging data suggested that the neuronal activity for both reflective and perceptual attention share similar and separable pathways (also see Chun & M. K. Johnson, 2011 for full review). Within the complex and intricate interaction of these cognitive processes, the scope of the thesis is focused more specifically to *refreshing*, which is a component process of reflective attention and the core of this thesis is investigating how refreshing influences the thought processes.

1.2.1 Component processes and refreshing

Refreshing is an act of reflective attention that keeps the mental representation in the mind briefly active (Cowan, 1999; Oberauer, 2002) and bridges the gaps of ongoing cognition such as connecting one thought to the other (M. K. Johnson, Reeder, Raye, & Mitchell, 2002). This simple cognitive process will be investigated throughout the thesis. *Refreshing* is described as thinking of or "foregrounding" a recently active memory representation. This action facilitates processing of the refreshed item in the moment, but also has long-term consequences; a single act of refreshing is sufficient to improve long-term memory compared to perceiving the same item again (M. K. Johnson, et al., 2002; Raye, M. K. Johnson, Mitchell, Reeder, & Greene, 2002).

Refreshing is one component process that belongs to a general theoretical model known as the Multiple-Entry Model (MEM) framework (M. K. Johnson, 1992; M. K. Johnson & Hirst, 1993; M. K. Johnson & Reeder, 1997; M. R. Johnson & M. K. Johnson, 2009). The aim of this model is to describe a set of basic cognitive processes that, when combined, form more complex cognitive operations. Although a full analysis of the MEM framework is beyond the scope of my discussion, a brief description of the overall architecture of the framework will be presented. Later, I focused more on how refreshing operates and its behavioural (M. K. Johnson et al., 2002; Higgins & M. K. Johnson, 2009) and neural correlates (Raye et al., 2002, 2005; M. K. Johnson, Mitchell, Greene, & M. R. Johnson, 2007).

The MEM framework is a component-process approach whereby each cognitive process creates a memory record of its own processing. There is no distinction between the component that stores these memory records and the other that solely processes information. The model suggests two separate forms of processing: perceptual and reflective. Perceptual processing is considered more lower level, primarily because it involves bottom-up processing by extracting sensory information about the objects and events in our perceptual world with relatively little top-down input (goal oriented behaviour). We do this process so often that we are not consciously aware of it. This perceptual process includes two levels of processing. Low-level processing (P-1) include functions such as *locating*, *resolving*, *tracking* or *extracting* basic information. Like its name, it focuses on processing lower-level sets of sensory elements of stimuli. The higher-level processing is known as the P-2 cognitive processes, which include *placing*, *identifying*, *examining* or *structuring* and focuses on broader semantic aspects. P-2 cognitive processes are considered to reflect higher level processes as they involve gradual increase of awareness and control compared to P-1. Directing perceptual attention to external stimulus enables us to learn about our external world.

The second cognitive process which is the main theme of this thesis is reflective processing/reflective attention. Reflective processing is categorized as a higher level of information processing compared to perceptual processing (i.e., P-1 and P-2). The reason for this is reflective processing relies on perceptual processing for raw material, but then elaborates further on information obtained from perception. Furthermore, reflective processing also sustains and maintains representation within our minds, thus allowing for processing of information when an object is no longer present in our perceptual environment. Similar to organization within perceptual processing, reflective processing is divided into two levels, R-1 and R-2. The first level (R-1) includes *noting* relation between thoughts, *shifting* attention, and *refreshing* (which prolongs activation of just-activated representations). After R-1 processing, information enters a more controlled cognitive process within the second level (R-2) that mirrors the essences of processes in R-1. The R-2 processes are *discovering* relations between representations, *initiating* sequences of process, *rehearsing* information (a purposeful recycling of information, often for the purpose of recalling it soon) and *retrieving* (reviving no-longer-active representations though the strategic self-generation of cues). Although all of these processes between both levels are conceptually similar, more cognitive control is exerted during R-2 processes. The refresh process is therefore one of the simpler reflective (i.e., self-generated) processes contained within the MEM framework.

The current thesis investigated one of the many R-1 reflective sub-processes. As mentioned, our daily cognition derives from a mix of perceptual and reflective attention: we engage in perceptual attention as we look and perceive things such as colours and shapes that stimulate our sensation, while we engage in reflective attention (e.g., *refreshing* or *rehearsing*) when the stimuli are no longer present. Refreshing a previously activated percept is a way to foreground this information relative to competing ones (M. R. Johnson & M. K. Johnson, 2009). This sub-process is a building-block that plays a role in more complex constructs within working memory and executive function. Neuro-imaging studies using fMRI methods (Raye et al., 2002, 2007; M. K. Johnson, et al., 2005) have shown that refreshing serves as a basic maintenance process by prolonging an activated representation while also improving the subsequent retrieval performances. A single refresh has been shown to improve long-term memory in relation to perceiving the item again (M. K. Johnson et al., 2002; Raye et al., 2002; see also Ranganath et al., 2005). In this case, refreshing can benefit long-term memory besides serving as a simple process serving larger and more complex cognitive processes. This refreshing benefit (i.e., enhanced long-term memory) is another element of the thesis which I investigated the consequences of languages on refreshed representation. In sum, the act of refreshing is thought to be like moving the spotlight of reflective attention of active memory representation within our working memory, similar to spotlight of perceptual attention moving from one visual object to another in an eye-tracking task (M. R. Johnson, 2011).

I would like to point out the core assumptions in E-Z Reader Model that provided a theoretical framework for thinking about the eye-movement behaviour, cognition and allocation of attention have similarities to the research question that was explored in the thesis. The E-Z Reader Model is one of the many cognitive-control models that propose a tight link between the eyes and mind while reading. There are two core assumptions described in this model. The first is that attention is allocated in serial manner and to only focus on one word at a time. The second core assumption is parallel process that encoding of the attended word are signals for both saccadic programming in eye movement and shifts of covert attention (Reichle, Pollastek & Rayner, 2006). The significance of this assumption is an early stage of lexical processing known as familiarity check – cognition control of eye movements through text while reading.

The first assumption in the model posits that attention is allocated serially to process one word at a time. The visual processing that is needed for lexical processing is insufficient to also support word identification. Attention is allocated on the word being processed during word identification. This assumption is based on large evidence that attention is needed to bind visual objects together so they can be encoded as a single and unified representation (Pollatsek & Digman, 1977; Treisman & Gelade, 1980; Treisman & Souther, 1986; Wheeler & Treisman, 2002; Wolfe, 1994; Wolfe & Bennett, 1996). Pollastek and Rayner (1999) suggested an advantage of allocating attention serially to process the representations is that it provides a simple mechanism for encoding the order of words that are being read.

The familiarity check in the model is an early stage of lexical processing that gives readers' the overall feeling of familiarity (Yonelinas, 2002; see also Reichle & Perfetti, 2003) and a preliminary stage of word-form processing (e.g., orthographic processing; Reichle, Tokowicz, Liu, & Perfetti, 2011; Reingold & Rayner, 2006). The importance of the familiarity check is that it initiates the lexical process of the word and initiates saccadic programming of eye movements so that the eyes leave (or attention) a word to the next after its meaning has been processed (Liu & Reichle, 2010; Liu, Reichle, & Gao, 2013; Reichle & Laurent, 2006; Reichle, Rayner, & Pollastek, 2012). The inhibition of return (IOR) effect can also be generalized in saccadic eye movements such that readers' are reluctant to move their eyes back to words they have just read (Rayner, Juhasz, Ashby, & Clifton, 2003). The authors (Rayner et al., 2003) suggested the reason for this may not necessarily mean that readers' consciously keep track of all of the places they had fixated on but it is due to neurophysiological system for eye movement control (Yang & McConkie, 2001). Although the neurophysiological approach is beyond the scope of my investigation, I investigated the IOR effect that mediates the reflective attention allocated on mental representations in the working memory which is the theme of this thesis and will be discussed throughout.

In defining the E-Z Reader Model, Reichle, Pollastek and Rayner (2006) adopted estimate duration of 50ms that is needed to transmit visual information from the eye to the brain (see experiments using physiological methods to support this assumption: Clark, Fan, Hillard, 1995; Foxe & Simpson, 2002, Mouchetant-Rostaing, Giard, Bentin, Aguera, & Pernier, 2000; Van Rullen & Thorpe, 2001). This assumption also meant that visual information extracted from a viewing location will be processed by the cognitive system until new information from the next viewing location becomes available. The result of this assumption is that the “eye-to-mind” lag is essentially invisible except in cases that involve large saccades (Reichle, Pollastek & Rayner, 2006). The process of how information is processed and transmitted from the visual field (early or pre-attentive stage) to the brain is beyond the scope of this thesis. The research questions that I am interested in seeking are mental representations in the mind and the duration attention that has been allocated on these representations (see Chapters 3 and 5). Overall, the assumptions in E-Z Reader Model provide a conceptually simple account for how cognitive processes that mediate attention and lexical processing. These assumptions are useful in lending insights to processing mental representations pertaining to higher levels of language processing. The behavioural outcomes of these mechanisms are investigated in this thesis. In the next section, I provide a review on a selection of behavioural experiments that tests this specific component process, which this thesis will employ in later experimental chapters.

1.2.2 Experimental designs on refreshing and its implications

In a typical refresh paradigm, participants are presented with one or more stimuli, followed by a short delay and then a refresh cue instructing the participant to direct reflective attention towards one of the just-presented stimuli while ignoring the other. Refreshing is considered to operate similarly across modalities. For example, in terms of word processing, refreshing may involve thinking and/or speaking of the item aloud whereas in picture/image processing, it may involve visualizing the item. An example of a refresh task is given in the figure below (see **Figure 1.1**).

Word, Person, or Place	Delay	New Item (*Read*) Same Item (*Repeat*) or • (*Refresh*)		<		>		>		Blank
1,550 msec	450	1,550	450	1,400	600	1,400	600	1,400	600	2,000

Figure 1. 1. Typical refresh task experimental design. The sequence of events in a trial which consist of three conditions such as read, repeat and refresh using a set of examples of stimuli (i.e., words, people and places). The numbers indicated the duration (in milliseconds) of each event-trial. The arrows “<” or “>” cued participants which stimuli to read or refresh. Adapted from M. K. Johnson et al. (2005).

A related study by M. K. Johnson, Reeder, Raye and Mitchell (2002), tested this refresh process using word stimuli. English words were displayed onscreen and participants were instructed to say aloud as the words appeared while response times were recorded using voice key SR-Box. The experiment compared across three conditions: (1) a baseline condition: single-presentation of words, (2) a repeat condition: a word appeared twice onscreen subsequently one after the other, (3) the refresh condition: a cue appeared after a word was presented, thus participants had to think about the word presented earlier before making a response. A slower response was observed in the refresh condition compared to the repeat condition. This result is in line with Tulving and Schacter’s (1990) finding on repetition-priming facilitation occurs in perceptual identification due to prior exposure.

Miliken and colleagues (Miliken, Tipper, Houghton, & Lupianez, 2000) argued that repeating an action over time increases efficiency in learning a new skill. Repetition-priming effect is typically obtained when participants respond faster and/or provide more accurate responses when a prime and target stimuli are similar (related) in relation to when a prime and target are different (unrelated) (Forster & Davis, 1984). This repetition-priming effect has been replicated in controlled laboratory settings using word identification tasks that also tap into highly practiced skills (Jacoby & Dallas, 1981; Scarborough, Cortese, & Scarborough, 1977).

Secondly, responses to the refresh condition was slower than repeat condition, therefore suggesting a dissociation between R-1 subsystem processes (i.e., *refreshing*) and P-2 subsystem processes (i.e., *identifying* stimulus) in the MEM framework. I would like to note that research questions these refresh studies focused on English words as the mental representations. As a result, the novelty of the thesis extended this line of research to investigate word representations in different languages would have effect on the bilingual speakers' reflective attention. However, the in-depth discussion of my research questions and literature review relating to bilingualism are in Chapter 2. The following review focused on the refresh process and I drew connections with the inhibition of return mechanism which is one of the research questions examined in this thesis.

Disruptions to the refresh process can have wider consequences for cognition. M. K. Johnson and colleagues (2002) further suggest the reflective process allows for binding simple cognitions or features of complex experience by prolonging the duration of activated features. Therefore, *refreshing* extends the representation within our working memory longer, which helps it to be better encoded into our long term memory. The results also show that there was better long-term memory performance in the refreshed items. Previous research has also investigated the refresh deficit by comparing reflective processes between older and younger adults and found older adults were slower compared to the younger group during the refresh condition (M. K. Johnson, Hashtroundi, & Lindsay, 1993; Mitchell, M. K. Johnson, Raye, Mather, & D'Esposito, 2000). The explanation for this observation was that inhibitory process among older adults could have been impaired, thus suppressing irrelevant information became inefficient. If irrelevant information remains activated within working memory, then reflective processing, which operates during ongoing cognition to increase activation of information that is relevant to the current behavioural goal, would be interfered, (M. K. Johnson, 1992). Although the central questions of this thesis will not delve further into age-related deficit findings, the example here is to show the factor of age can have consequences on the refresh process that will also impact other cognitive processes.

There are studies that focus on identifying areas of neural activities during refreshing (see meta-analysis M. K. Johnson et al., 2005). Other studies have indicated perceptual and reflective attention share similar neural representation. Neuro-imaging studies are also beyond the scope of this thesis, but a brief review is provided here to show perceptual and reflective representations in working memory engage in similar brain regions. In a fMRI study, Raye and colleagues (2002) instructed participants to either read words silently as they appeared onscreen or when they were cued. The experiment consisted of three conditions, and trials were randomly intermixed (see **Figure 1.1**). On each trial, participants saw a word that was followed by the same word (repeat condition), new word (read condition), or a dot cueing participants' just presented word (refresh condition). The results showed refreshing was associated with activity in the left dorsolateral prefrontal cortex (PFC), temporal and parietal cortex. Refreshing shares similar neural characteristics with perceptual attention. In testing perceptual attention, participants were presented with another stimulus again (repeat condition) to look at instead of a cue that would direct attention to a just presented item.

Previous studies found partially overlapping activity in the neural frontoparietal network for both refreshing and perceptual attention. In addition, these two networks also modulate activity in visual cortical areas relevant to the target item (M. R. Johnson et al., 2007; M. R. Johnson & M. K. Johnson, 2009; Lepsien & Nobre, 2007; Roth, M. K. Johnson, Raye, & Constable, 2009).

1.2.3 Retro-cueing

As mentioned earlier, *refreshing* is a type of reflective attention. Refresh studies typically use a retro-cue to cue participants to orient attention to a spatial location in working memory after an array of perceptual stimuli are presented (Griffin & Nobre, 2003). The retro-cue paradigm is very similar to cueing paradigms used by Posner (1980) to study perceptual attention, with the main difference being that cue and other stimuli are reversed in time (i.e., in traditional perceptual attention studies, the cue comes before the other stimuli, but in retro-cue paradigms, the other stimuli come before the attention cue). Other studies have used similar retro-cue paradigms that also probe attention within working memory, although they name this act other than *refreshing*. In this thesis, I will use the term *refreshing* and will be relevant to the research questions.

Is orienting attention within the working memory directed in a similar way to perceptual attention which is guided on a voluntarily basis? To test this hypothesis Griffin and Nobre (2003) adapted a traditional cueing paradigm used to investigate visual spatial orienting (Posner, 1980) with a partial-report paradigm (Averbach & Coriell, 1961; Sperling, 1960) and use probes to specific aspects of iconic memory traces of briefly presented items in visual arrays. Three types of cues were used in this experimental task. The first type of cue was the pre-cue which is a spatial cue presented onscreen, followed by a set of four coloured "X"s arranged around central fixation. The pre-cue facilitated participants in predicting the location of a later target probe. Previous results indicated that informative cues, location of pre-cue is similar to the target probe, improves behavioural performance (reaction times and accuracy) compared to uninformative cues or neutral cues (Jonides 1981; Posner, 1980). The second type of cue was a retro-cue which appeared after a set of stimuli was presented thus indicating the location of relevant stimulus. Therefore, the retro-cue enhances performance based on internal representation of the stimulus set within working memory. The third type of cue was a neutral cue which did not provide any information regarding to the location of target probes, which was used as a baseline for comparisons. Griffin and Nobre (2003) highlight the behavioural results for both pre-cue and retro-cue shows similar enhancement patterns in terms of accuracy and reaction time, they suggest that retro-cues could possibly play a role in enhancing parts of the internalized representation of stimulus array that was previously available. Cueing effects found in retro-cues were comparable to those produced by pre-cues. These findings replicated other well-known effects of orienting spatial attention to upcoming visual arrays (Posner, 1980; Jonides, 1981; Muller & Findlay, 1987; Muller & Rabbit, 1989). In sum, pre-cues and retro-cues provide similar benefits to reaction times (RTs) and accuracy in their paradigm, which reflects one similarity between reflective and perceptual attention.

Lepsien, Griffin, Delvin and Nobre (2005) used a retro-cuing task and found results suggesting memory performance was enhanced if items were cued at valid locations compared to neutral locations (also in Griffin & Nobre, 2003). Awh and colleagues (Awh & Jonides, 2001; Awh, Jonides, & Reuter-Lorenz, 1998; Awh et al., 1999) proposed the advantage of this enhanced memory performance is due to spatial attention serving as a basis for rehearsal of information. Lepsien and colleagues (2005) extended this notion that spatial orienting would enhance the quality of working memory representation within the focus of related location, facilitate retrieval of information from that location and/or inhibit irrelevant distractors. This form of orienting in working memory has a comparable effect on mental representation and it highlights information in working memory by selectively enhancing activity associated with maintenance of relevant information. All of this suggests spatial orienting serves as an important mechanism that will improve memory retrieval. In addition, these findings suggest valid (informative) retro-cues lead to improved quality of internalized representation within the working memory or improved access to it.

1.3 Inhibition of return (IOR)

1.3.1 Early discovery and characteristics

Inhibition of return (IOR) is described as shift of attention or bias towards a new peripheral location or new source of stimulation while there was delayed response to already processed peripheral location (Klein, 2000). Klein (1988) reasoned the significant bias of orienting away from recently processed locations is in order to facilitate visual foraging behaviour or visual search. In a way, this behaviour of constant searching at new locations is a vital skill that organisms should possess. This voluntary control over orienting reflexes was deemed as an important evolutionary development. According to Klein (2000), efficient foraging for objects such as food, places or playmates involves both voluntary control over orienting and the use of information from previous orienting experiences which stored in memory. If a location with an abundance of food source is discovered, then the location should be remembered as a place to return to. On the contrary, locations that have been stripped bare of resources should be avoided in the future. IOR is vital in that if an event is not task relevant, then attention has had time to disengage from it. This inhibition after-effect can be measured in terms of a delayed response towards stimuli that were subsequently cued at the original location.

Posner and Cohen (1984) first described the IOR effect as an attentional phenomenon that is thought to help orient our attention to novel stimuli in the environment. An example of the traditional IOR experimental design is illustrated in **Figure 1.2** below. At the beginning of the trial, a pre-cue task is presented where the cue (S1), which is non-informative, appears between 0 to several hundred milliseconds before the target cue (S2) is presented. The basic finding is that if cue (S1) appeared 200ms or less (shorter intervals) before target cue (S2), faster responses to the cued target in the same location compared to the uncued target is observed. There is a facilitation effect of reflexive attention orienting towards the cue. However, if the S1 cue appeared 300ms or more before target (longer intervals), inhibition to cued target (slower response times) in the same location was observed. The authors characterized this mechanism as slowed perceptual processing to a target stimulus whose location was previously cued approximately 300ms earlier. Both these results demonstrate a crossover point where facilitation changes to inhibition somewhere between 200-300ms after the onset of S1 cue. It is strongly implied that attention moves toward then away from the target location. The slowed response to previously cued target locations is attributed to orienting towards and subsequently removal of attention at the examined location. This effect discourages attention from re-orienting back to the originally attended location but moves our attention towards new locations or novel stimuli, promoting efficient visual search.

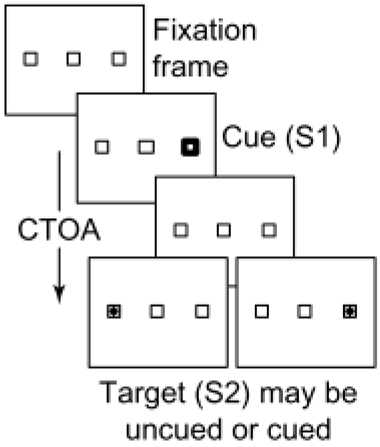

Figure 1. 2. Typical IOR experimental design. The sequence of events composed by a fixation display and first stimulus (cue S1): brightening of one of two peripheral boxes. A short interval (cue-target onset asynchronies, CTOA) is presented before target S2 is presented either at previously cued location (right peripheral box) or uncued location (left peripheral box). Participants were instructed to make a speeded response as they detect target presented. Adapted from Klein (2000).

1.3.2 Time course of IOR and how task difficulty affects its emergence

Time course is a critical part of IOR, where the pattern is typically facilitation at earlier time points but inhibition at later time points. However, the exact times at which facilitation shifts to inhibition can be changed by various demands and other features of the task. This is a concurrent theme of this thesis, as several experiments will explore the time course of IOR like effects. The onset of IOR depends on the attentional demands related to performing a task, for example whether it is to determine target identity or discriminate between targets.

Folk, Remington and Johnston (1992) introduced attentional control setting (ACS) to explain why onset of IOR varies with task difficulty. An early assumption is that in order to perform a task well, the observer first sets internally a level of attention that will be allocated to a target related to the task. A simple detection task requires low intensity of attention whereas a more difficult discrimination demands higher intensity of attention. The higher its intensity, the more attentional setting will be applied to the peripheral cue thus it will become more attended. LaBerge (1973) found that when more intense attention is applied to the cue, the longer attention will dwell on it. Besides task difficulty, factors such as the presence of distractors during an experimental block can affect the onset of IOR (Lupianez & Miliken, 1999). If a block of trials was not accompanied by distractors, ACS would apply more attention to the cue. As a result, a longer dwell time and stronger attentional engagement at target, thus a later onset of IOR is observed instead. On the contrary, if distractors are present, the ACS needs to locate a target instead of the distractor, resulting in a weaker attentional capture; hence an early IOR emerges. Together these results indicate the appearance of IOR can be manipulated, either by accelerating or delaying it, or by shifting attention away from the cue.

The robustness of IOR effect can differ depending on type of tasks used and the temporal parameters. Lupianez, Milan, Tornay, Madrid, and Tudela (1997) found later onset of IOR in a colour discrimination task rather than a detecting task. In their detection experiment, they found a significant IOR effect appeared after a 400ms interval between cue and target, and persisted to be present after 1,300ms. Conversely, in a discrimination experiment, the effect was reported to be shorter as it appeared later and disappeared sooner. In a traditional attentional cuing experiment, if the cue-target stimulus asynchrony (SOA) is less than 300ms, responses to cued locations are faster compared to uncued locations. But if SOAs were longer than 300ms, the opposite pattern is observed instead, whereby the uncued location yields faster responses compared to the cued locations, indicating the IOR effect. In short, the onset of IOR depends on the difficulty of task. The next section will focus on how IOR can be affected by spatial cues in experiments that use letters or words.

1.3.3 IOR, spatial cues and letter/word perception

There are ample studies investigating the spatial distribution of IOR in the visual field (e.g., Bennet & Pratt, 2001) or how IOR tags are attached to objects in a scene with moving elements (Abrams & Dobkin, 1994; Gibson & Egeth, 1994; Tipper, Driver, & Weaver, 1991; Tipper, Weaver, Jerreat, & Burak, 1994). These areas are not directly related to the current thesis, but I have included previous studies that are relevant to experiments used in the experimental chapters. Some studies have looked into the influence of spatial attention in letter and word perception by combining a masked priming paradigm with an exogenous cueing procedure (see review Finkbeiner & Forster, 2008). In a related study by Marzouki, Grainger, and Theeuwes (2007), targets were presented centrally which were then preceded by masked letter primes that were either the same or a different letter, or to the left or right of central fixation. Results showed that repetition priming was obtained in the presence of valid spatial cues and this priming was significantly stronger at the right visual field (RVF) compared to left visual field (LVF). The explanation for this was that there is a general bias toward the RVF for linguistic stimuli in languages that are read from left-to-right; therefore engagement of attention is faster to stimuli that appeared in the RVF. In a later experiment, Marzouki, Grainger, & Theeuwes (2008) extended this study by introducing a delay between the offset of spatial cue and onset of prime stimulus in order to generate an IOR effect. This manipulation allowed them to investigate the engagement and disengagement mechanisms associated with attentional capture. They found IOR effects for primed items in the RVF such that repetition priming was stronger following an invalid cue compared to a valid cue. The opposite pattern was observed in the LVF, as the priming effect was stronger during valid cues. Visual fields (i.e., LVF and RVF) strongly influenced whether IOR was observed or not. In addition, the presence of IOR is an indication of a speeded disengagement and engagement of attention is in RVF compared to LVF. Essentially, the authors explained this asymmetrical IOR effect is specific to how linguistic stimuli (e.g., letters and words) are processed, resulting in a bias generated by participants' reading or writing habits from left-to-right. This bias appears to favour new information that appears in the RVF, which is unsurprising considering the RVF is known to be more dominant in processing language compared to the LVF (right hemisphere). This is in line with other standard RVF advantages found for visual word recognition studies (Kinsbourne, 1970; McCann, Folk, & Johnson, 1992; Mondor & Bryden, 1992; Nicholls & Wood, 1998; Ortells, Tudela, Noguera, & Abad, 1998).

1.3.4 IOR effects within reflective attention

IOR is a well-established effect in perceptual attention research as a mechanism to forage for new information in the visual environment. A related study by M. R. Johnson, et al. (2013) showed that reflective attention mirrors this IOR effect, which suggests that refreshing facilitates reflective attention by directing it to previously encountered information. In this experiment, items that were held actively in the working memory for a brief moment and then refreshed by directing internal attention towards them were later inhibited if the items were presented again. Participants first saw two items and were cued to refresh one item, then had to identify either the refreshed item, unrefreshed item, or a novel item. Results indicated that participants were significantly slower to respond to refreshed items relative to unrefreshed ones. This effect persisted even when different stimuli were employed, including pictures and words. By contrast, in control experiments where participants were simply shown pictures or word stimuli again (similar to the repeat condition), the inhibition effect was absent, thus affirming that the inhibitory effect was induced due to the process of refreshing. The slowing of responses to previously refreshed stimuli indicate a brief inhibition towards the just activated representation but facilitation towards unrefreshed or ignored representation resembles that of perceptual IOR effect.

The basic assumption by M. R. Johnson et al. (2013) is that there is a need for attention to be disengaged from one internal thought to move forward to the next. The authors implied that the purpose of this reflective IOR-like effect (hereafter known as rIOR) is a bias towards new mental representations, as in perceptual attention, this mechanism encourages attention to move towards new representations instead of fixating on already processed information. As a result, rIOR serves as a mechanism in foraging for new thoughts in a more efficient way, and is possible how creativity can be sparked through this constant and active search for novelty. This notion parallels William James's (1890) description on the flow of thoughts or the stream of consciousness: that our thoughts are constantly moving forward. At this point in time, the literature on rIOR is relatively small and there is still a need to understand how this mechanism works and warrants further investigation.

1.4 Central questions to thesis

The main focus of this thesis involved the mechanisms within working memory, what happens when attention is focused on a particular item/concept and how that would then affect subsequent processing of the same item/concept. More specifically, I examined if longer duration is spent on attending to a mental representation, then would this trigger priming or inhibition effect on subsequent target information, which previous refresh studies have yet to address. Word items from two sets of language were also used in examining the reflective attention and the robustness of rIOR mechanism among bilingual speakers. The previous refreshing studies provided in the literature review focused on English words and did not address the difference between monolingual and bilingual speakers as a possible issue in affecting the processes in reflective attention. This is an interesting area that I will investigate. Hence in Chapter 2, I provided a review of research on bilingual speakers and how they respond in word recognition and production tasks. Research questions pertaining to bilingualism are elaborated in the following paragraph. Chapter 3 explored the refresh duration influences engagement and disengagement of attention. The aim of Chapter 3 was to investigate the time course of refreshing (turning one's internal attention towards) a thought in working memory and the potential for an IOR effect to take shape. In other words, I manipulated the interval between a refresh item and target probe in order to examine the impact on the robustness of rIOR effect. I hypothesised that shorter refresh intervals would result in a facilitation effect as a mental representation of an item is activated, hence attention is primed to that representation. However, at longer intervals, I predicted that attention towards the refreshed item would be suppressed, indicating a stronger inhibition effect would take place instead. The interpretation for this prediction is internal attention should be attracted to move toward another item encoded into the working memory (unrefreshed), but not toward the already refreshed items, so faster response would be observed for unrefreshed items.

Previous refresh studies have used pictures and English word stimuli, primarily tested among American students who were predominantly monolingual English speakers. For example, M.R. Johnson and colleagues (2013) found a rIOR effect with word stimuli. Therefore, I wanted to test whether this effect will persist across languages (in this case, English and Malay) among bilingual/multilingual speakers, and observe the outcome of language switching on reflective attention. Would participants' language background/proficiency modulate the refreshing mechanism when switching between languages (i.e., facilitate or reverse)? I am the first to address this aspect as well as combining these two cognitive processes, refresh component and language processing. I also examined the IOR mechanism in the interaction between these components.

In order to untangle the complexities within this research question, Chapter 4 first addressed whether rIOR is a not a language specific event. Experiments in Chapter 4 employed word stimuli from English and Malay corpora in the refresh experiment designs, thus adding another layer to the research question. By expanding languages of word stimuli, I investigated reflective attention allocated in single-language or mixed-language contexts. Secondly, I tested whether there is a benefit of refreshing on long-term memory in which refreshed words should be remembered better. Meuter and Allport (1999) were among the first to suggest inhibitory mechanism in bilingual language control which suggests bilinguals would take longer time to name an object in their native language directly following naming in their second language (see Bobb & Wodniecka, 2013 for review). The evidence from these studies implicated that naming in native and second language would produce slower and faster response time. Chapter 5 further examines the time course of rIOR with the interaction of language and refreshing which also concludes the scope of research area in this thesis. The mechanism of bilingual speakers is also central to the thesis, thus Chapter 2 consisted of the literature review and in-depth research questions for experimental Chapters 4 and 5.

CHAPTER 2
General Introduction:
Influence of word recognition and production in Bilingual speakers

2.1 Overview on Bilinguals

Bilingualism and multilingualism have gained strong research interest. Early research by Bloomfield (1933) claimed that in order to be viewed as "bilingual", individuals must be fully fluent in each of their languages. Grosjean (1989) provided a more pragmatic view and claimed that bilinguals should be able to function in a specific language depending on their current needs. Bialystok (2001) defines bilingual speakers as those who know two (or more) languages to a certain degree of proficiency. According to Harris & McGhee Nelson (1992), bilingualism is present in most parts of the world and bilinguals are not an exclusive group. Grosjean (1997) also mention that a balanced bilingual, characterized by native like proficiency in both languages is quite rare, because a bilingual usually has a dominant language that is stronger than the other.

Even though bilingual speakers report to have a language as the dominant one, their proficiency in that language is not as strong as the proficiency of a monolingual speaker who only spoke that one language. These bilinguals reported even if they tried to avoid using their first language (L1), they are unable to speak in their second language (L2) like that of a native speaker of that language (Grosjean, 1997). This implies that bilinguals may find it difficult to be fluent in one single language compared to monolinguals who only one language at all times. In recent years, The American Council of Teaching Foreign Languages (ACTFL) defines proficiency as functional language ability because it is practical in real-world situations. Bilingual speakers' second language proficiency is described as a continuum that ranges from highly articulate speaker to a speaker with little or no functional ability (ACTFL, 2012)

Age is another factor that is often taken into account in defining bilingualism. Kovelman, Baker, and Petitto (2008) suggested the criterion that distinguishes between early bilinguals and late bilinguals is the age (lower or higher than the age of 3-4) of first exposure to the second language (L2). This time point is argued to be vital as it is the beginning of when the bilingual child receives intensive and continued exposure to a second language, resulting them to exhibit monolingual like linguistic processing in L2 (e.g., Johnson & Newport, 1989; Bialystok & Hakuta, 1999). Other studies have also supported this claim that late bilingual children who are exposed to L2 after the age of four do not always exhibit native-like activity when processing their L2 (Weber-Fox & Neville, 1999; Perani et al., 2003; Jasinka & Petitto, 2013). Paradis (2010) noted that there is a distinction between simultaneous and sequential bilinguals (L2) learners. Simultaneous bilinguals are children who are immersed in an environment where they are exposed to both languages before the age of three years, often from birth. Sequential bilinguals are children who have already acquired their L1 before they begin learning L2, mainly at school entry. The most common factor researches used to divide between simultaneous and sequential bilinguals is the age of acquisition of the L2 (Genesee, Paradis, & Crago, 2004). According to Genesee et al. (2004), young children from these categories tend to be more proficient in one of their languages for which the dominant language has received the greatest exposure. Kohnert (2004) expanded on this notion and suggested that the dominant language can change over time as sequential children can end up with being more proficient in L2 if exposure to L2 increases substantially.

Now that the term “bilingual” has been outlined in this context, what follows is an overview on the general disadvantages and advantages on being bilingual and recent studies

(Paap, Johnson, & Sawi, 2015) addressing the issue on the bilingual advantage phenomenon is biased. The discussion will focus on models (both monolingual and bilingual models) on word recognition and production, as these mechanisms are employed in the experimental paradigm. In addition, these models will be used in the interpretation of results.

2.1.1 General disadvantages

Bilinguals have been found to be slower in naming whether the stimuli are words or pictures compared to monolinguals. Studies have shown that bilinguals demonstrated more "tip-of-the-tongue" retrieval problems compared to monolinguals (Gollan & Acenas, 2004; Gollan & Silverberg, 2001; Gollan, Bonanni, & Montoya, 2005; Gollan, Ferreira, Cera & Flett, 2014; Pyers et al., 2009). Tip-of-the-tongue (hereafter known as TOT) states are described as temporary word-finding problems, characterized by a brief inability to retrieve an intended word despite a strong feeling of knowing the word (Gollan & Acenas, 2004). On average, monolinguals are estimate to experience TOT on a weekly basis in natural settings and 10% to 20% in laboratory settings in the attempt to retrieve low frequency words (R. Brown & McNeill, 1966; for review papers see A. S. Brown, 1991; Schwartz, 1999). The explanation for this result was first explained based on the dual-language activation hypothesis that when bilinguals produce a word in one language the information about that word in another language is also activated. As a result, bilinguals who have a larger number of stored lexical nodes would experience increased competition for selection that would impede word retrieval. (Colomé, 2001; Ecke, 2004; Gollan et al. 2014; Kroll, Bobb, Misra & Guo, 2008)

Gollan and Acenas (2004) associated bilinguals' retrieval problems with cognate status of the target words. Cognates are two words across different languages that share similar orthographic representation and meaning (e.g., "bed" means the same thing in both English and Dutch). If two words share similar orthography but refer to different meanings these are known as homographs (e.g., “room” in English means “cream” in Dutch). However, fewer retrieval problems were observed if target words were noncognate words. Noncogante words are translation equivalents that share similar meaning but dissimilar orthography across both languages (e.g., “pepino” in European Portugese means “cucumber” in English) (Pureza, Soares, & Comesaña, 2015). Gollan and colleagues (2005) explained that the double processing load of both languages would cause general difficulties in producing words. The authors (Gollan & Acenas, 2004) explained that the shared connections of cognate words make their phonological information more activated and available compared to noncognate words because the former are used more frequently and have high levels of priming effect. This is also in line with frequency-lag hypothesis (Gollan, Slattery, Goldenberg, Van Assche, Duyck, & Rayner, 2011; or previously known as weaker link hypothesis by Gollan & Acenas, 2004), that because bilinguals used less words of each language (especially noncognate words), thus resulting to the words to have weaker links between the levels of bilinguals’ speech production system (Gollan & Acenas, 2004; Gollan et al., 2011; Kroll et al., 2008).

Other research also showed evidence pertaining to this phenomenon that bilinguals experience this more than monolinguals. Also, TOTs’ occurrence increases with age and older adults experience these states more (Burke, MacKay, Worthley, & Wade, 1991; Miozzo & Caramazza, 1997; Burke & Shafto, 2004; Gollan, Montoya, & Bonnani, 2005; Gollan et al., 2014; Theocharopoulou, Cocks, Pring, & Dipper, 2015). Brown (1991) found that low frequency words (e.g., “goblet”) elicit more TOT states than high frequency words (e.g., cup). Gollan and colleagues (2008) showed that TOT states for low frequency words were more prominent in bilinguals than in monolinguals. Besides TOT states, bilinguals show disadvantages in other experimental measures. Some studies have found that bilinguals tend to be slower in picture naming tasks (Gollan, Montoya, Fennema-Notestine & Morris, 2005; Kaushanskaya & Marian, 2007; Roberts, Garcia, Desrochers, & Hernandez, 2002), generated fewer words in verbal fluency tasks (Gollan, Montoya & Werner, 2002; Rosselli et al., 2000; Portocarrero, Burright, & Donovick, 2007), demonstrated poorer word identification through noise (Rogers, Lister, Febo, Besing & Abrams, 2006), and experienced more interference in lexical decision tasks (Ransdell & Fischler, 1987). Altogether, these results indicated that the problem lies within the need to resolve interference from other languages. These results are also evidence that adult bilinguals' vocabulary/lexical access can be limited or effortful.

The reason for these deficits is unclear and many authors have provided several views on this issue. Michael and Gollan (2005) suggested that because bilinguals use each of their languages to a lesser extent compared to monolinguals, weaker links among the relevant connections have been formed. As a result, rapid and fluent speech production is then obscured. This is in line with connectionist models indicating underlying pathways connecting networks between words and concepts distributed across two languages. Due to the fact that bilingual speakers have less practice in making associations among these two networks, they become less fluent over time compared to monolingual speakers who focus on the associations for one language (Dijkstra, 2005). This view is based on models of bilingual speech production that will be discussed later.

Another explanation for this is conflict is based on the assumption that the competition from corresponding items in the non-target language reduces lexical access. According to Green (1998), this competition requires a mechanism for controlling attention to the target language by inhibiting any possible interference such as an irrelevant word from another language. This conflict is generally resolved by executive function processes that are also responsible for processes such as control, attention and switching. The executive system consists of three primary functions including inhibiting irrelevant information, updating information in working memory and shifting mental task or multitasking (also known as cognitive flexibility or task switching) (Miyake, Friedman, Emerson & Howerter, 2000). This set of general processes is important in regulating our thoughts and behaviours to accomplish certain goals. If these processes are involved in daily speech production, then constant application of the executive control would increase the overall efficiency and availability over time. However, constantly activating the "inhibitory" control would contribute to cognitive deficits such as task fluency and picture naming. Enhanced executive control may be a burden for rapid lexical access and vocabulary access it may serve as an advantage in other areas or functions.

2.1.2 General advantages

Despite the linguistic disadvantages that bilinguals have to deal with, they do show enhanced performance in conflict resolution and executive function in non-linguistic tasks (Bialystok, 2009). As discussed in earlier, if language production involves constant application of executive control in order to focus on the target language, then an enhanced executive control system would increase the robustness of other functions. This cognitive advantage is observed in bilingual children's ability to ignore irrelevant information compared to monolingual children in a meta-linguistic task that require controlled attention and inhibition but not grammar knowledge (Bialystok, 1988). For example, in a grammar judgment task, both groups (i.e., bilingual and monolingual) children were successful in detecting grammatical errors in sentences (e.g., "Apples growed on trees"). However, bilingual children were more successful in indicating anomalous sentences (e.g., "Apples grow on noses") to be grammatically correct compared to monolingual children (Bialystok, 1986; Cromdal, 1999). In this task, bilingual children outperform monolingual children, as this task demands effortful attention to ignore irrelevant or misleading information.

Bilinguals have been found to perform well in tasks that require selective attention and are more effective in identifying and resolving conflict in nonverbal tasks as well (Bialystok & Majumder, 1998). The ability to solve conflicts that contain misleading information is an aspect of executive control and is found to develop earlier in bilingual children compared to monolingual children (Bialystok, 2001; Carlson & Meltzoff, 2008; Kovacs, 2009). In a dimensional card sorting experiment (Zelazo, Frye & Rapus, 1996) children were required to sort a set of bivalent stimuli according to one feature (e.g., colour) and immediately re-sort based on a new feature (e.g., shape). On average, children at the age of 4 to 5 continue to re-sort the stimuli based on the previous rule despite knowing the new rule. The cause of this error was not due to misunderstanding of the second rule but inability to attend to the new feature while ignoring the previous feature. This ability to switch criteria during the sorting task while attending to the new rule while ignoring the previous one is an important feature to the executive control. Bialystok and colleagues highlight that bilingual children mastered this ability at an earlier age compared to monolingual children (Bialystok 1999; Bialystok and Martin, 2004).

Bialystok, Craik, Klein and Viswanathan (2004) also showed early evidence to support the idea that bilinguals have improved performance in inhibiting irrelevant information during a standard Simon task. In the experiment, coloured stimuli were presented at either the left or right side of the computer screen and each colour was associated with one side of the screen. For example, participants had to press the left key on the keyboard if a blue square appeared and the right key if a red square appeared. Congruent trials consisted of correct response for that colour is on the same side as the stimulus while incongruent trials had the correct response on the opposite side of the stimulus. When comparing the Simon effect between bilinguals and monolinguals, bilinguals responded to congruent and incongruent trials faster and also showed a smaller Simon effect. This smaller Simon effect indicated bilinguals were less affected by the irrelevant information while performing the task (Bialystok et al., 2004). According to Lu and Proctor (1995), bilinguals have enhanced executive processing and show an advantage on the Simon task, as they are able to easily resolve this conflict.

Although there is compelling evidence that demonstrates an overall bilingual advantage, recent studies suggest that this advantage may not always be easily observed, only under very strict experimental conditions that these advantages appear (Paap et al., 2015). Paap and colleagues (2015) suggest that confounds such as socioeconomic status (SES), immigrant status and culture differences play a major role and can be partly responsible for the significant bilingual advantage. For example, recent studies (Anton et al., 2014; Duñabeitia, et al., 2014) did not replicate the bilingual advantages in inhibitory control and monitory as obtained by Engel de Abreu, Cruz-Santos, Tourinho, Martin and Bialystok (2012). In the former studies, the experimenters used Basque-Spanish bilinguals that included children the same age acquired both languages early, were highly proficient and were carefully matched on SES. The participants used in the latter study (Engel de Abreu et al., 2012) were not at all proficient in their L2. However, results from the Basque-Spanish bilingual studies did not show any bilingual advantage. For this reason, this comparison is noteworthy, thus it is possible that there are other factors other than bilingualism causing the bilingual advantage (Paap et al., 2015).

2.2 Overview on word recognition – How do we recognize words?

Word recognition occurs in two stages. The first is to find a connection between the written or spoken word to its orthographical (spelling) or phonological features stored in our memory. In the second stage, a connection between syntax and morphology must be established before the meaning of the word is retrieved (De Groot, 2011). Early research focuses on understanding how bilinguals process words based on monolingual word recognition models like the Interactive Activation (IA) connectionist framework (McClelland & Rumelhart, 1981), which was later extended into the Bilingual Interactive Activation Plus (BIA+) model proposed by Dijkstra and Van Heuven (2002). The word identification system of these models incorporates orthographic, phonological, and semantic representations. Orthographic network of nodes is comprised of various representational units including features, letters, words, and language membership. The model suggests that written words are recognized via a series of steps. For example, if a participant reads the word "WORK", the curved and straight lines would activate letter representation in memory, such as W, O, and K. Subsequently, these letters would also activate other "neighbour" words such as CORK, FORK, WORN, and WORK. Through a gradual process of activation and elimination via competitive inhibition, neighbourhood words are excluded as potential targets until "WORK" remains as the only target activated. During reading and word recognition processes, the target word becomes active, as well as other words within lexical access that share similar aspects with the target word. For example, words are recognized faster if the reader experience the words on a more regular basis (e.g., table) compared to a word that was less frequently encounter (e.g., superfluous) (Forster & Chambers, 1973), and if mapping of spelling to sound is unambiguous (e.g., Jared, McRae, & Seidenberg, 1990).

2.2.1 Models on Bilingual word recognition

Bilingual word recognition models were adapted from monolingual models in order to understand bilingual word processing. For bilingual readers, previous studies suggest that there is activation of a word in their L2, could also activate the lexical representations in their L1. For example, if a Dutch-English bilinguals read the target words in their L2 (English), this will briefly activate orthographic and phonological codes associated with lexical candidates in their first or dominant language (Dutch) (e.g., Dijkstra, van Jaarsveld, & ten Brinke, 1998; van Heuven, Dijkstra, & Grainger, 1998; Dijkstra, Grainger, & van Heuven, 1999). In addition, a similar effect was found even if language roles were reversed when reading the target word in the dominant language. The phonological and orthographic features of the second language would be inadvertently activated (e.g., Jared & Kroll, 2001; Jared & Szucs, 2002; van Hell & Dijkstra, 2002). This effect was present even if languages do not share similar alphabetic or orthographic codes (e.g., Gollan, Forster, & Frost, 1997).

Studies have explored cross-language similarities of words to test whether factors that affect word recognition would be present across languages. To test this, cognates and homographs were used. Languages such as English and Dutch that share similar alphabet and orthographic representation will have words that resemble one another. By manipulating cross-language properties, empirical experiments can determine if the process of word recognition is selective with respect to language. In a related study by Dijkstra and colleagues (1998), Dutch-English bilinguals were asked to identify if a string of letters was a real word. If the task was presented in their second language (English), there was significant facilitation for cognates relative to the controls but there was no activation for homographs. However, if the experiment included real words from the non-target native language (Dutch), a clear inhibition effect on homographs was present relative to unambiguous controls. And when participants were instructed to identify real words for both languages, homographs produced a significant facilitation relative to the controls. Furthermore, Lemhoefer, Dijkstra and Michel (2004) reported a triple cognate effect among Dutch-English-German trilingual speakers. In a lexical decision task in their third language (German), the authors found faster response times for Dutch-German cognates. This suggests that native language and another foreign non-target language can influence target word language comprehension. In sum, these results suggest that the initial stage of bilingual lexicon access is non-selective with respect to language. In the next section, I will focus on specific models on how bilinguals' languages can impact word recognition.

2.2.1.1 RHM, BIA and BIA+ models on word recognition

The Revised Hierarchical Model (RHM; Kroll & Stewart, 1994) was proposed to account for the asymmetries in translation performance by late bilinguals who acquired their second language (L2) after early childhood and they are still more proficient in their first language (L1) compared to their second language (L2). This model describes forward translation. In this case, moving from L1 to L2 needs longer translations latencies compared to backward translation (L2 to L1) as a reflection of asymmetrical strength that links words and concepts in each bilingual's languages. RHM (see **Figure 2.1**) posits two levels of representation during word processing: lexical (word) and conceptual (Luna & Peracchio, 1999). According to Caruana & Abdilla (2005), the lexical level is consists of separate language compartments whereas the conceptual level is a single compartment in which words share a common representation or meaning. The word to concept route differs for both L1 and L2 and word representations in L1 have direct access to meaning. However, L2 is more complex which requires a mediation via L1 translation equivalent until the bilingual acquires sufficient skill in L2 before being able to access meaning directly. Based on this notion, backward translation (L2 to L1) can be accomplished via lexical mediation by retrieving the translated word in L1 and without semantic access. On the contrary, forward translation (L1 to L2) would be semantically mediated as the link between L1 and meaning is stronger. Previous research supports the idea that the asymmetrical results occur because forward translation show stronger engagements to semantics relative to back translation (see review Kroll & Stewart, 1994; Sholl, Sankaranarayanan, & Kroll, 1995). To illustrate this point, Sholl and colleagues (1995) show that only translation from L1 to L2, instead of translation from L2 to L1, had a significant priming effect. They explain that the asymmetrical priming effect demonstrated greater reliance on semantics for L1 to L2 translation. However, Brysbaert and Duyck (2009) suggest the RHM should be replaced by a connectionist model such as Bilingual Interactive Activation (BIA/BIA+) model as these models accurately account for evidence that suggests non-selective access in bilingual word recognition (see review Kroll, Van Hell, Tokowicz, & Green, 2010).

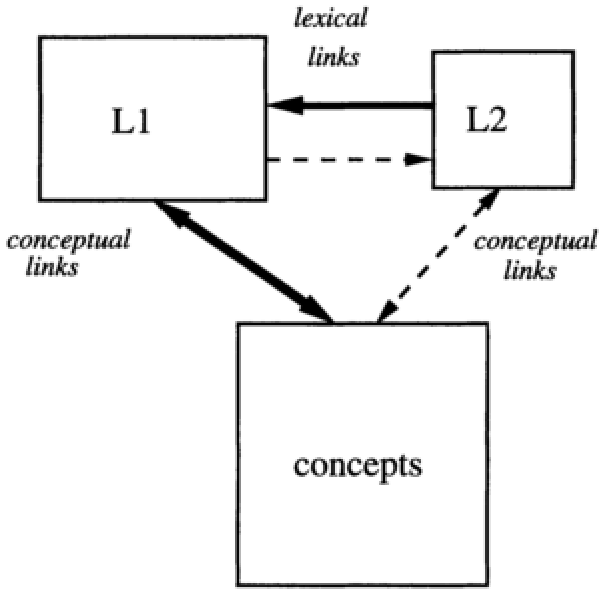

Figure 2. 1. Revised Hierarchical Model (Kroll & Stewart, 1994). L1 lexical is represented as larger compared to L2 for most bilinguals. Lexical associations from L2 to L1 are stronger compared to those of L1 to L2. This is because L2 to L1 direction is often used by L2 learners first in order to acquire new L2 words. The links that connect words and concepts, L1 and Concepts links are much stronger than links connecting L2 and Concepts

The first BIA model focused on the orthographic representations of words in order to assess the processes involved in word recognition among bilingual readers (see review Dijkstra & van Heuven, 1998; van Heuven & Grainger, 1998; van Heuven, Dijkstra & Grainger, 1998; and also Grainger & Dijkstra, 1992). The basic architecture of the BIA model is illustrated in **Figure 2.2.** This model is adapted from the monolingual word recognition model by McClelland and Rumelhart (1981) (i.e., Interactive Activation model) and assumes bottom-up flow of information from visual input. In such cases, elements such as letter features, letters and words compete for competition. The BIA model included an additional element which is the language nodes that will help bilingual readers to identify the language of the target word. The role of the language node is to facilitate processing of the target word/language while inhibiting the other language. This early version of the BIA model also assumes language nodes are sensitive to top-down influences. For example, factors such as external information including context words appear in and the bilingual's language proficiency can impact the activation level of the language nodes.

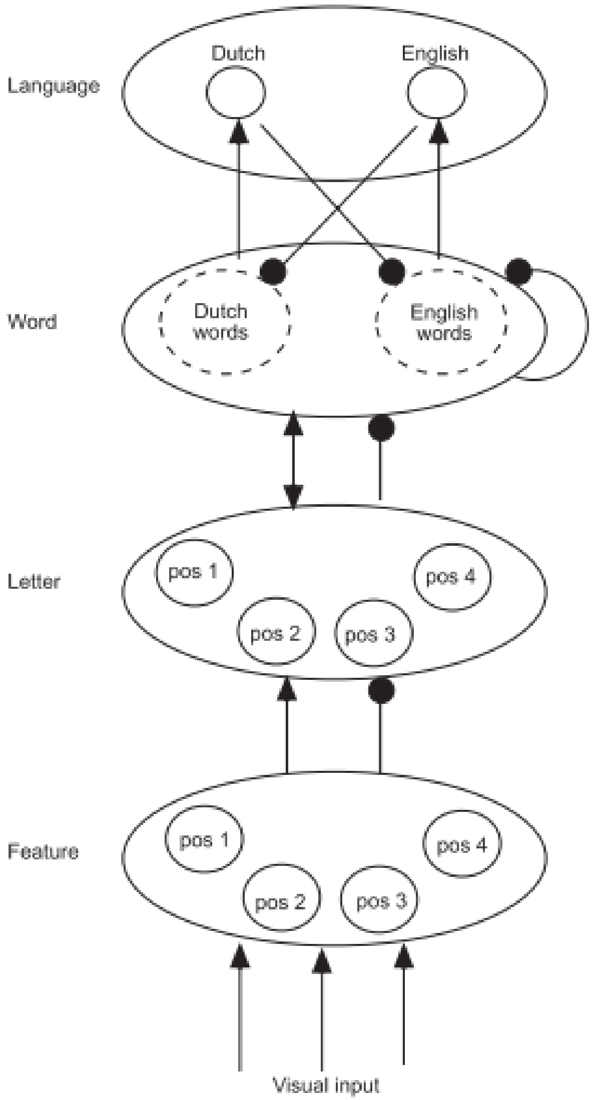

Figure 2. 2. The Bilingual Interactive Activation (BIA) model for word recognition. Arrowheads indicate excitatory connections; black filled circles indicate inhibitory connections.

The model claims that there is top-down language-to-word inhibition, suggesting that both activation and inhibition mechanisms aid word recognition. These mechanisms play a role at each stage (or node) starting from features, letters, words and languages. At the beginning when a word is presented (i.e., "music"), it appear as a string of features which would then form individual letters. This visual input would either inhibit dissimilar looking letters or facilitate activation of similar looking letters within the network, so certain features such as letter position would help facilitate word recognition. At this point, lexical access is not language specific at the word level and all words inhibit or facilitate one another regardless of which language it was from. These activated word nodes from the same language then send activation to corresponding language node. At the same time, activated language nodes send an inhibitory feedback to all nodes in the other language. In other words, the early stage of word recognition is thought to be perceptually driven. Orthography and phonology interacts across words in both languages (e.g., Brysbaert, van Dyck, & van de Poel, 1999; Dijkstra et al., 1999; Jared & Kroll, 2001; Jared & Szucs, 2002). For example, cognates are words that share similar meaning and (approximately) similar form (e.g., "winter" in English and Dutch; or "letter" in English and "lettre" in French), activating one word would result in easy access to the cognate word in another language (Lemhoefer, Dijkstra & Michel, 2004). Although word access is assumed to be non-selective, later stages of word production or output may be influenced by unintended language (Dijkstra & van Heuven, 2002).

The BIA model, however could not account for the role of how semantic, orthographical and phonological features are activated. In order to address these limitations, the BIA model was extended to include features such as language nodes, task/decision component and other representations. This revised word recognition model (BIA+) assumes interactivity within the word identification system and other higher order systems. More importantly, the BIA+ model include components or ideas from Green's (1998) Inhibitory Control (IC) model in which bilinguals exert control over processing their lexico-semantic systems under different task conditions.

2.2.2 Overview on word production

There is a consensus in language production studies that lexical access involves two stages (e.g., Bock, 1987; Dell & O'Seaghdha, 1992; Levelt, 1989). The first includes mapping of meaning onto an abstract representation of a word which is then followed by mapping of this representation on to a word's phonological characteristics. The WEAVER++ (Word-form Encoding by Activation and VERification) model describes lexical access in speech production (e.g., Levelt, Roelofs, & Meyers, 1999; Roelofs, 1992, 1997; Roelofs & Meyer, 1998). This model suggests speech production begins with a concept representation selected; it is then followed by lexical access selection with retrieval of a syntactic representation (lemma) from the mental lexicon. Later, the word form is accessed and its morphological and phonological forms are activated. Phonological representations are encoded into phonetic representations which specify how a word should be articulated. Once this phonetic plan is executed, the word is articulated. Spreading activation principle is adopted in this model such that the concepts and lemmas overlap or share similarities with the target will become activated and compete for selection. Other authors (Dell, 1986; Rapp & Goldrick, 2000) suggest cascading models like the interactive two-step model of word production (Dell, 1986; Dell, Schwartz, Martin, Saffran, & Gagnon, 1997) whereby the phonological encoding begins even before word selection is completed. Unlike two-stage models, the phonological encoding begins after a word or lemma is selected. In bilinguals, some studies favour this notion that when a concept is activated, it subsequently activates lexical representations in both target and non-target language (e.g., Colome, 2001; Costa, Caramazza & Sebastian-Galles, 2000; De Bot, 1992; Green, 1986; Hermans, Bongaerts, De Bot, & Schreuder, 1998).

2.2.3 Models of bilingual word production

As with models of bilingual word recognition, bilingual speech production models were adapted from monolingual speech models. Levelt and colleagues (1999) developed a monolingual speech production model that is conceptually driven and planning of spoken utterance proceeds from meaning to form. The process of how this occurs in bilingual speakers is illustrated in the figure below (see **Figure 2.3**). In this study, a Dutch-English bilingual attempt to produce the word "bike" (in English) that was initiated by a visual object (picture of a bike). This results in activation at the conceptual representations level, followed by lemmas or abstract lexical representations that corresponds to the word, and finally at the phonology associated with active lexical forms. Kroll and colleagues (2005) suggested it was the surprise word production experiments that provided evidence of the non-selective nature as word production is the result of concept-driven process. For example, the intention to speak an idea or name an object in a language is under the speaker's control. However, there is empirical evidence that show speaking in one language does not inhibit the other language from interfering as the related words from the other language may be activated as well (see review Kroll, Sumutka, & Schwartz, 2005).

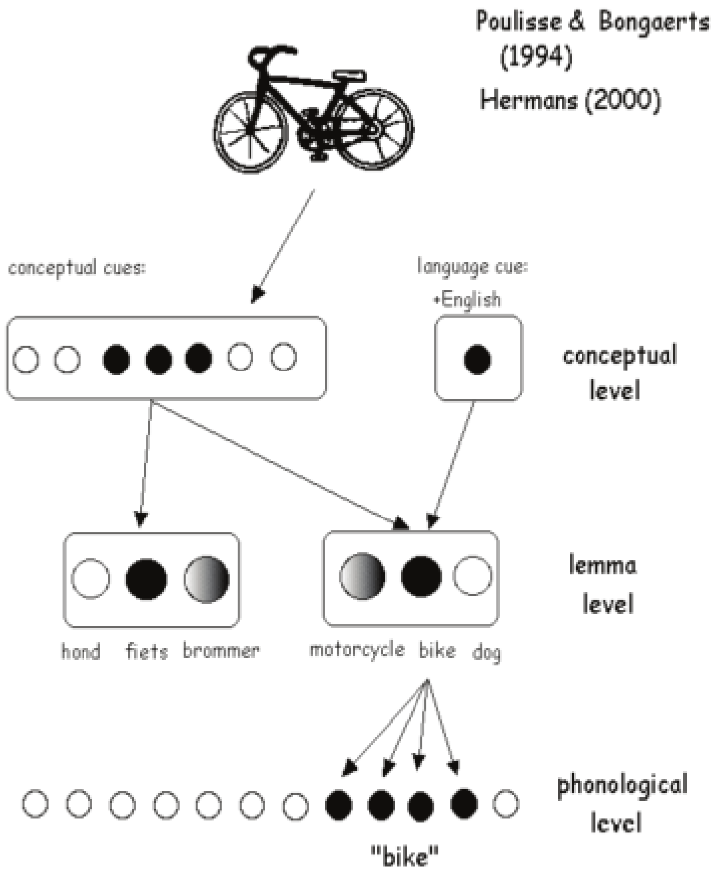

Figure 2. 3. Bilingual word production model. Adapted from Hermans, 2000; Poulisse & Bongaerts, 1994

It was deemed that presence of distractors in picture-naming studies can interfere with monolingual word production. For example, semantically related distractors produce interference while phonological related distractors produce facilitation effects (e.g., Levelt et al., 1991; Schriefers, Meyer, & Levelt, 1990). These effects were largely obtained in monolingual studies. However the question was whether these effects will surface if tested in bilinguals. These cross-language interactions would determine whether lexical access is selective or non-selective at word production level. If lexical access is selective at this stage, then distractors from the unintended language should have minimal effects. However, if lexical access is non-selective, then these distractors would influence participants' performance (see review Kroll et al., 2005). Studies testing these cross-language interactions show if a picture is presented with a spoken or written distractor word, interference is present at the semantic level if the word is related to picture's name and facilitation is present at phonological level (e.g., Costa & Caramazza, 1999; Costa, Miozzo, & Caramazza, 1999; Hermans, 2000; Hermans et al., 1998). Later studies showed the possibility that language selection occurs at an early stage when bilinguals who have stronger L1 than L2 language speak in their L1 (e.g., Bloem & La Heij, 2003; La Heij, 2005). Taken together, these results suggest, like word recognition, language is also non-selective in the initial stages of word production. For example, in simplest production task of naming familiar objects in one of the bilingual speakers' two languages phonological representations from both lexical sources become active which then influence their performance (e.g., Colome, 2001; Kroll, Bobb, & Wodnieckca, 2006). The next section focuses on mechanisms between L1 and L2 by reviewing empirical evidence during language switching.

2.3 Language switching

Bilingual and multilingual speakers demonstrate agility in transitioning or switching fluidly between languages (Gollan & Goldrick, 2016). Language switching induced by experimental conditions can influence word production in bilinguals. Meuter and Allport (1999) argue that the switch cost in a number naming task is greater if switching to dominant L1 from the weaker L2 language. The onset of speech is slower if speakers are cued to switch languages in comparison to being cued to continue speaking in the same language. The early explanation for this was based on Green's (1998) models of inhibitory control that preceding trial the naming the weaker L2 required stronger inhibition of the more active L1, therefore greater switch cost was observed. This view suggests a parallel activation of lexical candidates in both L1 and L2, and the degree of the activation is determined by the dominance of language and the bilingual's L2 proficiency.

Previous studies indicated that switch costs become smaller but not eliminated in conditions if the task is preceded by a longer preparation times (e.g., Costa & Santesteban, 2004; Fink & Goldrick, 2015; Philipp, Gade, & Koch, 2007; Verhoef, Roelofs, & Chwilla, 2009), if the upcoming switch is predictable (Declerck, Koch, & Philipp, 2015) or whether the speaker knows which words they will need to produce ahead of time (Declerck, Philipp, & Koch, 2013). The switch costs cannot be eliminated even when bilinguals make the switch voluntarily (Gollan & Ferreira, 2009) rather than induced by a cue in an experimental context (Gollan, Kleinman, & Wierenga, 2014). This cost is also present even if no overt switch is produced such that alternating between reading a word silently and producing a word in another language (Peeters, Runnqvist, Bertrand, & Grainger, 2014). Collectively, these results show switch costs persist in a variety of experimental settings.

Some studies argue that bilingual language control is achieved by using domain-general executive control processes (Abutalebi & Green, 2007; Hernandez, 2009; Kroll, Bobb, Misra, & Guo, 2008). This notion is further supported by other studies that suggest bilinguals are at advantage compared to monolinguals on tests of executive function (Bialystok, Craik, Green, & Gollan, 2009). These advantages are linked to language switching ability and frequency (Hartanto & Yang, *in press*; Prior & Gollan, 2011; Soveri, Rodriguez-Fornells, & Laine, 2011; Verreyt, Woumans, Vandelanotte, Szmalec, & Duyck, 2016) and ability to avoid unwanted switches (Festman & Munte, 2012). In neuro-imaging data, Green and Abutalebi (2013) identify areas in the brain region that increased in activation during language switching in bilinguals, including left inferior parietal gyrus (LIFG), anterior cingulate cortex (ACC), left inferior parietal lobe and left basal ganglia. Garbin et al. (2010) adapted a colour-shape switching tasks using fMRI which participants had to identify the colour or shape of figures presented onscreen, based on the cue word (e.g., "colour" or "shape") by pressing a pre-assigned button. In switch trials, these cue words were randomly assigned within a block, therefore this resulted in switch trials. In non-switch trials, each consisted of either all colour or shape cues. The results show that bilinguals showed activation in LIFG responding to switch-trials compared to non-switch trials, whereas monolinguals do not reflect such activation during these trials. Green & Abutalebi (2013) concluded that the increased activation in LIFG is an indication of bilinguals' ability to control incongruent responses presented during conflict tasks. The thesis will not directly test language switching, but instead observe how language switching during a refresh task can modulate other cognitive process such as reflective attention and later long-term memory (see Chapter 4 and 5). The languages used as word stimuli in experimental designs are English and Malay hence the next section is devoted to providing an overview on the Malay language and its influence on the background of Malaysian bilingual participants.

2.4 Bilinguals in Malaysia and language background

The Malaysian population is over 30 million. The Malay population form the largest ethnic group of Malaysia's demography (50.1%), followed by the Chinese population as the second largest (22.6%), the indigenous groups as the third (11.8%) and the Indian population coming in fourth (6.7%; Central Intelligence Agency, 2015). Malay language, or Bahasa Malaysia, is the official language in countries such as Malaysia, Indonesia, Brunei and Singapore (Noor, Sapuan & Bond, 2011) and it is widely used in these countries including The Philippines, Thailand, Burma, Sri Lanka, Cocos Island and Christmas Island. The Malay language was used as a national language in effort of uniting cultural and linguistically diverse groups in Malaysia during the mid-1950s (Heng & Tan, 2006).

According to the authors (Heng & Tan, 2006), Malaysia was once a British colony sometime in 1800s that led to a rapid growth of English schools in the urban areas. However, prior to the British era, the local community had established their own school systems based on ethnicity. The Malay schools focused on religious studies based on the Koran, The Chinese schools adopted the school curriculum from mainland China, while Tamil schools adopted curriculum from India. As early as 1816, English was used as the medium of instruction for schools and administrative purposes as a result of establishments of English schools by Christian missionaries (Pennycook, 1994). English medium schools were also mainly established within urban areas where majority of the students were non-Malays. The majority of the Malay group lived in rural areas and could not have access to English language education or benefit from opportunities for further education and employment in civil service (Gill, 2005). Asmah (2003) also noted that getting an education in English would pave way for a better future as it promised jobs in both government and private sectors and higher education. As a result, English was recognised as a high language status language whereas the local languages were sidelined.

The Malaysian politics and national aspirations had strong influence on the English language education post-independence. In 1956, The Razak Report (the Education Committee) introduced common content syllables in the first Malaysian educational Report which consequently reduced the role of status of English and gave Malay a legitimate role as the national language (Gaudart, 1987). The use of English was reduced as a medium of instruction in the education system during colonial era to being taught as a subject or second language. Moreover, English was regarded as a foreign language by residents in the rural areas that had very little exposure to the language (Gill, 2005). The language change from English to Malay was carried out in moderation. English remained as the official language for

10 years after independence in 1957. As a result, English was recognized as an important second language that was taught as a subject in national schools and was used as medium of instruction in former English schools (Heng & Tan, 2006). By 1983, Malay was used as the medium of instruction while English was taught as a complimentary subject. (Mahathir, 1991)

In 1991, Vision 2020 set by the former Prime Minister, Tun Mahathir Mohamad which aimed to transform Malaysia into a scientifically and technologically advanced country by the year 2020. As a result, the demand for English became more crucial as a tool for development and advancement towards to the goal of Vision 2020. Shortly in 2003, the English for Teaching of Mathematics and Science (ETeMS) policy was implemented in order to train teachers to use English as a medium of instruction to deliver their lessons (i.e., Mathematics and Science) in English. The aim of this policy was to improve Malaysian students' mastery of English which would allow them to have access to the latest information and knowledge in science and technology (Musa, 2003). ETeMS program used Science and Mathematics subjects to further enhance English language competency (MoE, 2012). However, due to poor returns in English achievements, the government decided to end ETeMS policy in 2012 (Pembina, 2009). A new policy known as "Merartabatkan Bahasa Malaysia dan Merperkukuhkan Penguasaan Bahasa Inggeris" (MBMMBI) or "To Uphold Bahasa Malaysia and to Strengthen the English Language" was introduced and replaced ETeMS in 2011. The change in policies meant Bahasa Malaysia was used as medium of instruction in all national schools (primary and secondary) to ensure all Malaysian students would be proficient both English and Malay well (MOE, 2012).

The shifts in educational policies resulted in a new generation of Malaysian bilinguals who are proficient in at least Malay and English and also in other languages such as

Mandarin or Tamil. In other words, Malaysian bilinguals have at least minimal proficiency in speaking Malay and English, depending on their learning accomplishment in schools. The Chinese community speaks a wide range of ancestral languages such as Cantonese, Hokkien, Hakka, Teochew and Hainanese as first languages, as well as Mandarin. Furthermore, the indigenous people from the Peninsular Malaysia and Borneo speak various native languages such as Iban, Kadazan, Bajau and Melanau; while a portion of the Malaysian Indians still maintain their ancestral languages such as Malayalam and Telegu. Malay remains the most widely-used language for inter-ethnic communication in Malaysia, followed by English then Mandarin (Heng & Tan, 2006)

The written form of Malay has shallow alphabetic orthography, simple syllable structures and transparent affixation (prefixes and suffixes are rule based). According to Yap, Liow, Jalil and Faizal (2010), Malay orthography (spelling) stands in contrast with English because its words contain more syllables but fewer letters per syllable. In addition, Malay words have simple orthographic units in terms of consonant (C) and vowel (V) arrangements such as CVC, CV, or VC syllables. In terms of orthography-phonology mappings, Malay contains a shallow structure in comparison to English. Most syllables in Malay words are very short. The Malay language consists of 25 letters and 34 phonemes whereas English consists of 26 letters and 44 phonemes. Despite this contrast, Yap et al., (2010) claim that the ratio of vowel letters to vowel phonemes is more likely to influence the performance in the naming task, not the orthography-orthography mappings. Both Malay and English have six vowel letters, but Malay has only 7 vowel phonemes while English has 20. The sharp contrast in word characteristics for these two languages influences word recognition in different ways. For example, Yap et al., (2010) claim that in the Malay language, word length predicts lexical decision and speeded pronunciation performance compared to word frequency effects.

Conversely, for the English language, word frequency effect predicts recognition times better than any other lexical variables. Even though both languages share similar alphabetic principles (Share, 2008), different features of the words influence behaviour in separable ways.

2.5 Central questions to the thesis

There is an ongoing debate on whether bilingualism directly enhances cognitive abilities or whether this advantage is an artifact induced by language associated tasks (Wu and Thierry, 2013). If the bilingual advantage is a permanent feature, then the enhanced cognitive control should be independent of language context. However, if bilingual advantage is context dependent, then enhancement would be observed when the bilingual speakers are exposed to both languages. Wu & Thierry (2013) suggest that there is an interaction between two cognitive factors (i.e., language processing context and non-linguistic executive interference) that were previously considered to be independent. In the study, Welsh-English bilinguals engaged in a non-verbal conflict resolution task (e.g., flanker task) and the language context was manipulated by embedding random words between trials but the participants were told to ignore them. In single language context, words were either in English or Welsh whereas in mixed language context, words presented were a mix between these two languages. Even though participants were told to ignore the words, they showed greater response accuracy and a reduced electrophysiological correlate for cognitive interference (P300) in the mixed language context. The explanation for the enhanced cognitive control in the mixed language context is that it shifted executive system to an enhanced functional level, and therefore the results in improved performance in non-verbal conflict resolution. This was also in line with other theories such as conflict adaptation in cognitive control that indicated processing conflict is further enhanced when the brain is primed to a higher state of cognitive control by previous tasks (Botvinick, Nystrom, Fissell, Carter, & Cohen, 1999; Gratton, Coles, & Donchin, 1992; Kerns, 2006; Kerns et al., 2004).

The current thesis explored the influence of language component within the reflective attention whether language would have an effect (lead to more facilitation or inhibition) on refreshed items. Previous refresh studies (e.g., M. K. Johnson et al., 2005; Mitchell, M. R. Johnson, Higgins & M. K. Johnson, 2010; M.R. Johnson et al., 2013) did not investigate the effect of language on IOR, thus denotes novelty of the current thesis as the combination of these two areas of refreshing and language processing. Chapter 4 and Chapter 5 consisted of experiments examines reflective attention by employing *refresh* experimental designs based on previous literature (M. R. Johnson et al., 2013).

Firstly, Chapter 4 addressed the question of whether reflective inhibition of return (rIOR) can be modulated by language or whether these two processes are autonomous mechanisms. The notion is tested by observing if rIOR is language specific or it is a more general mechanism that is non-language specific. Secondly, the thesis also investigated whether language switching would modulate reflective attention. Research on word recognition and production literature suggests asymmetrical cost will occur which would show stronger inhibition towards stronger language than to weaker language. One of the aims was to explore whether a brief cognitive effort (refreshing) between switching would have an overall impact on the language switching mechanism. This may result in a priming effect from L1 to L2 – instead of seeing greater inhibition, the result of switching may abolish the asymmetrical cost.

Chapter 5 addressed the issue of time course on its underlying influence on these processes. As mentioned bilinguals tend to be slower in picture naming (Gollan et al., 2004; 2005), thus this warrants further investigation if later time course would lead to a robust IOR.

Finally, a memory recall task was included in Chapter 4 and Chapter 5 to test whether is there long term memory benefit for refreshed items. M. R. Johnson and colleagues (2013) have shown the act of refresh obscures accessibility to the item but improves long term facilitation in later retrieval. I will explore this transition from a language perspective by investigating if using word stimuli with different languages and bilingual's language preference (i.e., stronger or weaker language) would facilitate refreshing in making refreshed words more memorable. For example, participants would be better at teasing apart real words (words they have seen and refreshed during the refresh task) from the equivalents (words that share similar meaning from another language) that did not appear during the task. Refreshing or seeing a word in the weaker language could impede later memory performance (false memory). According to the RHM logic, the inter-store links between L1, L2 and share conceptual store (CS) varies in terms of strength that connected these components together. In particular, in order to process a L2 word, learners required to translate it to L1 in order to access the meaning from CS. As a result, L2 to L1 link becomes stronger for bilinguals. It is possible that refreshing in L2 may strengthen the L2-L1 link or at the very least activate the same word in L1. This mechanism would lead to false memory performance in which participants would believe they seen the equivalent word.

CHAPTER 3

Temporal dynamics of reflective inhibition of return (IOR) effects

3.1 Preamble

This chapter examined whether temporal parameters can affect how accessing representations might be inhibited or facilitated by reflective attention. In the following three experiments, the timing between an instance of refreshing (thinking or directing attention towards an internal representation) an item and a subsequent probe of the refreshed item are manipulated, in order to observe whether this will affect response times to the probed item as a function of this temporal variation. M. R. Johnson and colleagues (2013) proposed that reflective attention could produce an Inhibition of Return (IOR) like effect similar to that produced by perceptual attention, whereby refreshed items would take longer to identify than unattended items because attention disengages after processing stimuli thus more inclined to orient towards new locations/items. The authors (M. R. Johnson et al., 2013) used a similar timing parameter (1500ms) for both perceptual attention (initial presentation of items) and reflective attention (refresh cue). It is possible that perceptual and reflective processes share similar neural correlates (M. R. Johnson & M. K. Johnson, 2009), therefore manipulating the refresh duration could help characterize IOR in reflective attention in relation to IOR in perceptual attention. The aim in Experiment 1 and Experiment 2 sought to investigate this.

The traditional IOR effect observed as a consequence of perceptual attention is highly sensitive to the duration of the delay between when a target is initially attended and when it is subsequently probed (e.g., Klein, 2000). However, it is hypothesized that the inhibition-of-return-like effect produced by reflective attention might share this susceptibility to temporal variation. At very short delays between an initial perceptual attention cue and a probe of the same item (most typically a spatial location), facilitation is observed, but if a delay of several hundred milliseconds is interposed between the cue and the probe, inhibition would be observed instead. At even longer delays, the IOR effect disappears, and there is no difference between response times to previously attended and unattended locations. Thus, if the perceptual and reflective inhibition of return (rIOR) effects indeed showed a similar pattern in their time courses, this would help to strengthen the argument that perceptual IOR effects and the putative rIOR effects indeed stem from similar mechanisms.

This predicted relationship between facilitation and inhibition behaviour would mirror the IOR mechanism that occurs in perceptual attention and would thus suggest that the IOR like effect previously observed for rIOR would share a mechanism with traditional perceptual IOR. This chapter includes three experiments and aimed to explore the onset of facilitation or inhibition mechanisms depending on the duration internal attention is allowed to fixate on a particular item represented (refreshed). The higher the intensity or the more attention spent on a representation should affect the subsequent verbal performance in identifying a representation that had a higher intensity (refreshed items), medium intensity (unrefreshed items) or low intensity (novel items). This premise is tested in Experiments 1 and 2 in which the temporal dynamics of the refresh cues were manipulated in order to examine onset of facilitation and inhibition mechanisms.

Experiment 3 examined another aspect of rIOR time course with a central fixation point that briefly terminates the orientation response in order to measure a more reliable IOR effect. Klein (2000) proposed the appearance of perceptual IOR effect depends on efficiency to remove attention from the cued location. The choice to remove attention from the processed stimuli or reorientation if left to endogenous control would be slower compared to exogenous control. Klein proposed providing a peripheral cue (exogenous control). For example, a central fixation automatically pulls attention away from the cued location. By eliminating the decision whether to remove attention or not, this then enhances the process of the reorientation of attention, therefore increasing the likelihood of an IOR effect. In Experiment 3, the functions of a central fixation in between refresh cue and probe task at different durations are examined and whether the introduction of a central fixation would increase the probability of observing an IOR effect within our reflective attention.

3.2 EXPERIMENT 1

Introduction

The motivation for this experiment was to examine the impact of unrefreshed and refreshed representations at different refresh durations (i.e., 1400ms, 1700ms or 2000ms). The current study is similar to M. R. Johnson and colleagues' (2013) experiment but differed in terms of the type of probes used. Participants saw two pictures, followed by an arrow that appear for 1500ms cuing them to visualize (refresh) one of the pictures, then a 100ms delay before the probe task appeared. The authors (M. R. Johnson et al., 2013) chose a brief 1500ms refresh duration in their original experiments in order to examine the common and distinct neural correlates of refreshing, the simple reflective process of turning one's attention to several active representations which is similar to basic perceptual attentional process. As established in previous studies, refreshing share some neural characteristics with perceptual attention. For example, refreshing and perceptual attention activate partially overlapping frontoparietal network, and both attentional processes can modulate activity in visual cortical areas relevant to the target item (M. R. Johnson & M. K. Johnson, 2009; M. R. Johnosn, Mitchell, Raye, D'Esposito, & M. K. Johnson, 2007; Lepsien & Nobre, 2007; Roth, M. K. Johnson, Raye, & Constable, 2009). For this reason, I chose to examine a range of refresh durations that is close 1500ms throughout this thesis. Additionally, refresh duration will be investigated again in Chapter 5.

The nature of the probe task is a series of scrambled noise fading to reveal a picture beneath which participants pressed a “stop” button as soon as they could identify the picture. The experimenters (M. R. Johnson et al., 2013) used key-press to measure detection of probe response but did not test if using verbal responses would produce similar results. In perceptual studies, speeded response times (RTs) to cued location are observed if the delay between cue onset and target onset is short (typically between 0 – 200ms) compared to uncued locations, reflecting a facilitation of cuing (Posner & Cohen, 1984). However, this facilitation changed to inhibition if the delay was longer (Klein, 2000). This pattern of facilitation followed by inhibition was proposed as attention oriented towards then away from attended stimuli in order to enhance efficiency of visual search. I proposed that this mechanism is similar to reflective attention in foraging for new information. Behavioural pattern would show early facilitation but later inhibition to cued (refreshed) items.

Method

Participants The University of Nottingham Malaysia Campus Research Ethics Committee approved all procedures. Twenty participants (mean age = 21.2; eight females and twelve males) were recruited from the University of Nottingham Malaysia Campus. One course credit was awarded to psychology students whereas RM10 were awarded to non-psychology students.

Procedure Eprime version 19.0 software was used to present stimuli in the current experiment. Participants sat approximately 40cm away from the computer screen as they performed the cognitive task. Participants were first shown two picture stimuli (chosen from the three categories of faces, chairs and houses; Newman & Norman, 2010) presented for 1500ms, followed by a brief delay (500ms) and an arrow pointing to either the right or left stimulus. While the arrow appeared, participants had to mentally refresh cued item while ignoring the other. Refresh in this experiment meant participants were instructed to briefly think of or visualize the cued item for as long as the arrow was on screen. Various refresh durations were tested in this experiment; thus the refresh cue (arrow) was presented for either1400ms, 1700ms, or 2000ms. A probe identification task followed immediately, in which participants saw a final picture stimulus and had a 1500ms time window to verbally name the category of the probe item ("Face", "Chair", or "House") aloud as quickly and accurately as possible [2]. **Figure 3.1** shows a sample of the sequence of events. Equal number of face, chair and house stimuli were used. All stimuli were greyscale images, 300 pixels by 300 pixels. Faces were forward-facing complete headshots of young to middle-aged individuals of various ethnicities, with neutral or pleasant expressions. The stimulus set contained both female and male faces, at a ratio of 3:1. A sample of the stimulus set for each category is in Appendix A.1.

The final probe item could either be a re-presentation of the stimulus that they were instructed to refresh (refreshed probe condition), a re-presentation of the stimulus that they had seen but ignored (unrefreshed probe condition), or a new stimulus (novel probe condition). The inter-trial interval was 3000ms. The two initial stimuli were always selected from two different categories and the stimulus used in the novel probe task was always chosen from the third category that was not previously shown on that trial. For example, if the two stimuli in the initial presentation were from house and chair category, the subsequent probe stimulus would be from the face category. Each stimulus was randomly selected from a large set of faces, houses and chairs images that were only used once per session. Each set of

[2] The current probe task differed from M. R. Johnson et al. (2013) design in terms of response modality. The current probe task used a voice key system whereas the authors used a key-press system to collect responses. Participants responded by pressing a "stop" button as soon as they could detect an image appearing from changing noise images (starting from 10% opacity and increasing to the rate of 60% opacity per second).

category contained 195 images, so a total of 585 images were used in the experiment. Therefore, each image was unique to a session and participants would have seen each image once, so the possibility of the priming effects was avoided.

This was a within-subject design. The task consisted of 216 trials (24 trials for each combination of condition and refresh arrow duration), divided into four blocks. Each block was 11 minutes long and participants were given short breaks between blocks. Participants were given several practice trials before starting on the actual task. Voice responses were recorded in two ways: using a voice key system and digitally in a separate built-in microphone from a laptop. The digital recording was analysed using a custom Matlab script (The MathWorks, Natick, MA) to detect the onset time of each verbal response. The script automatically detected sounds exceeding a specified amplitude and duration threshold but allowed for manual adjustments if automatic word detection was triggered early by noise or failed. Both the voice key and the digital recordings provided for comparable analysis; however, digital recordings were more sensitive and accurate in terms of detecting responses missed by the voice key. Thus, response times reported here will be those obtained from the digital recordings. The instructions in all the experiments throughout the thesis were delivered in English unless stated otherwise.

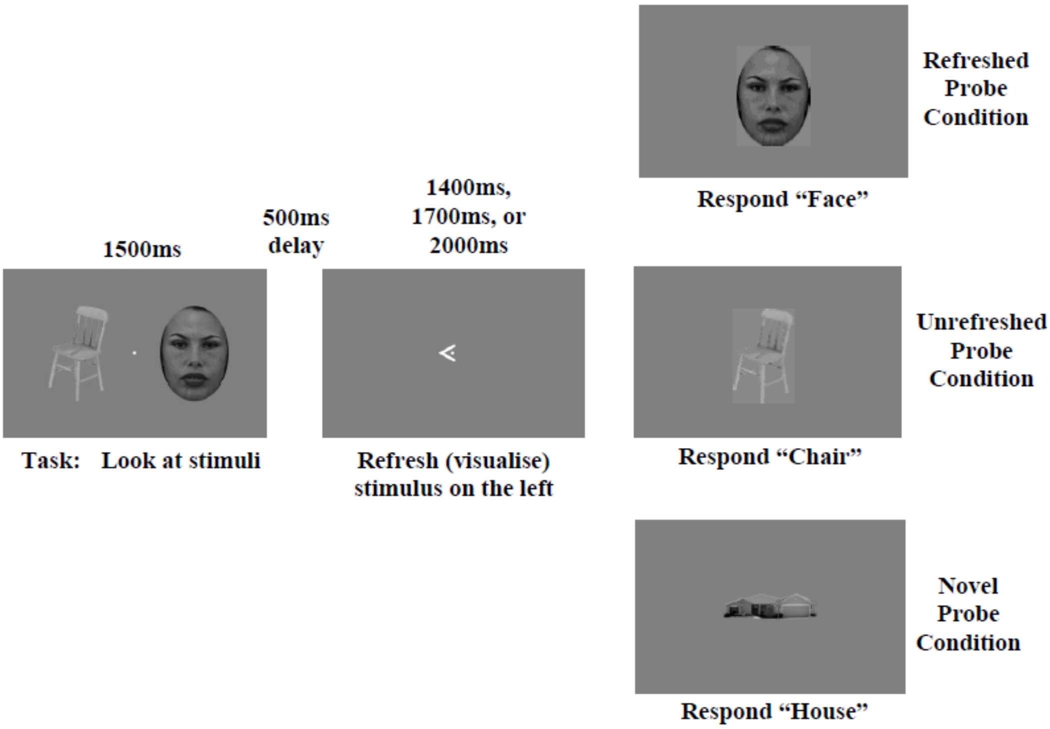

Figure 3. 1. Experiment 1 refresh task design. In this example trial, participants first saw a chair/face pair (1500ms), followed by a refresh cue (at 1400ms, 1700ms or 2000ms). The refresh cue indicates participants to selectively think about the chair. A "probe" identification task followed immediately after the refresh cue. Participants had to respond to the probe by naming the category of the item as quickly and as accurately as possible. Depending on the condition, the "probe" item could be an item that was presented earlier (chair or face) or a new item (house).

Results and discussion

Trials whereby participants provided incorrect responses were removed from the subsequent data set. A total of 7.15% of data were removed from the data set due to error such as incorrect responses or technical error in computer voice recording during data collection. Outliers were removed from each participant's data at 2.5 standard deviations from the mean and then per-condition means were calculated. Here as well as all the experiments throughout the thesis, I chose z-score 2.5 as the criteria for detecting potential outliers because there may be delays in verbal (naming) data. In analysing RT research for lexical decision task or naming task, 2, 2.5 and 3 standard deviation criteria are often used in defining outlier (Jiang, 2013). Mean response times (RTs) for each condition are presented in **Figure 3.2**.

Unless otherwise stated, Greenhouse-Geiser was used if sphercity was violated. Mean Square Error (MSE) and Partial Eta Squared (η_p^2) were provided in the analysis to address possible Type 1 errors. Additionally, post-hoc paired-sample two tailed t-tests with *p*-values adjusted according to Bonferroni corrections were used instead of simple main effect tests to directly compare between conditions. This test was applied in M. R. Johnson et al. (2013) refreshing experiments, thus it was deemed appropriate to apply in the current analysis and to address possible Type II errors. These analyses were applied throughout the thesis.

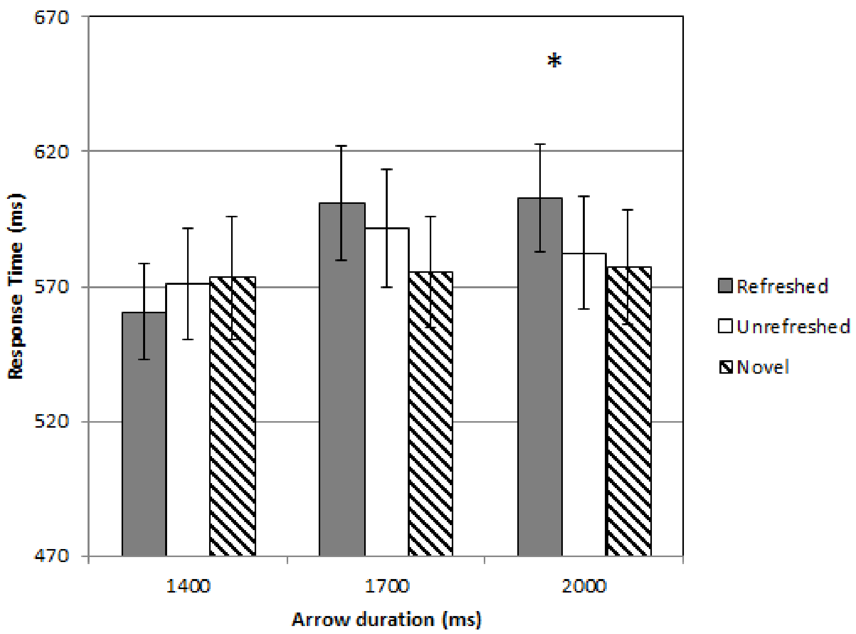

Figure 3. 2. Experiment 1 response times. Bar graphs show means for each condition at 1400ms, 1700ms and 2000ms arrow duration. Facilitation effect is apparent at 1400ms arrow duration but this effect gradually reverse as arrow duration increase. "*" denotes significant inhibition effect occurred at 2000ms arrow duration as unrefreshed condition produced shorter RTs instead compared to refreshed condition. Error bars represents standard error of mean.

A 3 (condition: refreshed probe, unrefreshed probe or novel probe) × 3 (arrow duration: 1400ms, 1700ms or 2000ms) repeated-measures ANOVA was performed. The results showed a main effect of condition (F (2, 38) = 4.07, MSE = 602.29, p = .025, η_p^2 = .176) indicating the novel probed condition (M = 575.24, SE = 21.00) produced shortest RTs, followed by unrefreshed condition (M = 581.67, SE = 20.67) and refreshed condition (M = 588.02, SE = 18.99). A significant main effect of duration (F (2, 38) = 9.43, MSE = 855.26, p < .001, η_p^2 = .332) showing that as the arrow duration increased the RTs increased. If participant had to refresh for 1400ms, the average response was fastest (M = 568.30, SE = 19.09) followed by 1700ms (M = 589.20, SE = 20.80) and 2000ms (M = 587.43, SE = 20.31). There was a significant interaction between condition and duration (F (4, 76) = 3.90, MSE = 700.66, p = .006, η_p^2 = .170).

In order to compare directly whether there is IOR-like effect, a reduced 2 (condition: refreshed probe and unrefreshed probe) × 3 (duration: 1400ms, 1700ms and 2000ms) repeated-measures ANOVA was used to compare between previously attended and unattended items. There was a significant main effect of duration (F (2, 38) = 11.76, MSE = 935.98, p < .001, η_p^2 = .382); there were faster RTs produced at 1400ms (M = 565.81, SE = 18.68), followed by 2000ms (M = 592.55, SE = 20.20) then 1700ms (M = 596.19, SE = 21.36). A significant interaction effect between condition and duration was also found (F (2, 38) = 3.67, MSE = 663.59, p = .035, η_p^2 = .162). Three post-hoc two-tailed paired sample t-tests (Bonferroni corrected p = .017) comparing refresh and unrefresh conditions at all three arrow duration did not significant results, at 1400ms (t (19) = 1.12, p = .277), 1700ms (t (19) = 1.51, p = .147) and 2000ms (t (19) = 2.47, p = .023). The condition effect was not significant (F (1, 19) = 1.97, MSE = 613.29, p = .176, η_p^2 = .094). A table reporting the mean RTs and standard deviation for each condition is included in Appendix A.2.

Figure 3.2 showed the mean RTs for all conditions across the different refresh durations. At the shorter refresh duration, responses to the cued target (refreshed item) were faster relative to the uncued target, suggesting a priming effect has occurred as attention towards the cued representation had yet to dissipate. As the duration increased and participants had to focus their attention (think about) an item longer, RTs for the refreshed probe condition increased while RTs for the unrefreshed probe condition decreased. At 2000ms refresh duration both conditions reached a cross-over point, where the response to unrefreshed probe was faster than refreshed probe. This is in line with the initial hypothesis the unrefreshed condition produced shorter RTs compared to refreshed condition at 2000ms arrow duration.

The explanation to this finding is in accordance to Dukewich's (2009) postulation on the impact of both short and long SOA on orienting response towards a target. At short SOA, activation of a representation generated by a cue is greater due to the short duration between cue and target in which attention had not sufficient time to dissipate. Therefore, the orienting response to target that is similar to the cue is much greater. If the reverse of this effect is true then, if there is a longer SOA, the orienting response generated by the cue would have longer time to dissipate. The overall activation towards the cued response appeared to be lesser. Similar to the current finding, if refresh duration was longer (at 2000ms) the response towards refreshed or cued item becomes slower relative to the unrefreshed items.

3.3 EXPERIMENT 2

Introduction

Reflective IOR suggests attention is encouraged to move towards new representations while slower response to the cued representations. Experiment 1 showed a slight pattern of IOR effect appearing at 1700ms arrow duration, as unrefreshed RTs were slower than refreshed RTs, although the effect was not significant unless arrow duration was longer (2000ms). The current experiment was designed to investigate the temporal parameters between 1700ms and 2000ms by providing a more sensitive time scale to test the IOR effect. A new set of refresh durations (i.e., 1600ms, 1900ms and 2200ms) was used and each interval was 200ms longer than the Experiment 1 refresh durations to see if that would result in a more robust IOR effect. Lupianez, Milan, Tornay, Madrid & Tudela (1997) compared between detection and discrimination tasks and found evidence suggesting that IOR can take longer (up to 1000ms SOA) to appear. Lupianez et al. (1997) suggested in detection tasks, one needs to process whether a target has been presented whereas, in discrimination tasks, one needs to take an extra step to identify the target after it has been detected. The extra cognitive effort required for a discrimination task could explain the longer lasting facilitation is observed is observed in Experiment 1. Also, a comparison of responses between Experiment 1 and Experiment 2 at short, medium and long refresh durations to see whether the extra refresh duration would have an impact on participants' overall performance.

Method

Participants The University of Nottingham Malaysia Campus Research Ethics Committee approved all procedures. Twenty participants (mean age = 19.15; sixteen females and four males) were recruited from the University of Nottingham Malaysia Campus. One course credit was awarded to psychology students whereas RM10 were awarded to non-psychology students.

Procedure The task used in this experiment is identical to the design of Experiment 1. The only change made was to add 200ms to all refresh durations. Thus, the refresh duration varied between 1600ms, 1900ms and 2200ms. The instructions to participants, initial stimulus presentation, probe presentation, data collection, and analysis were all carried out in the same way as in Experiment 1.

Results and discussion

Trials whereby participants provided incorrect responses were removed from the subsequent data set. A total of 7.04% of data were removed from the data set due to error such as incorrect responses or technical error in computer voice recording during data collection. Outliers were removed from each participant's data at 2.5 standard deviations from the mean and then per-condition means were calculated.

A 3 (condition: refreshed probe, unrefreshed probe or novel probe) × 3 (arrow duration: 1600ms, 1900ms or 2200ms) repeated measures ANOVA with RTs as the dependent variable. A significant main effect of condition was found (F (2, 38) = 23.95, MSE = 958.59, p < .001, η_p^2 = .558). Pairwise comparisons showed that the refreshed condition (M = 506.47, SE = 16.20) produced faster RTs compared to unrefreshed (M = 539.89, SE = 14.39) and novel conditions (M = 540.80, SE = 14.13). There was also a significant main effect of arrow duration (F (2, 38) = 3.87, MSE = 453.80, p = .029, η_p^2 = .169). Pairwise comparisons showed 1900ms (M = 531.03, SE = 14.50) produced fastest response, followed by 1600ms (M = 533.21, SE = 14.84) and 2200ms (M = 522.93, SE = 14.90). There was not a significant interaction was found (F (4, 76) = 1.44, MSE = 350.36, p > .05, η_p^2 = .070). Mean response times (RTs) for each condition were presented in **Figure 3.3**.

Similar to analysis in Experiment 1, a reduced 2 (condition: refreshed probe and unrefreshed probe) × 3 (duration: 1600ms, 1900ms or 2200ms) repeated-measures ANOVA was used to compare between the attended and unattended items. A significant main effect of condition was found (F (1, 19) = 35.11, MSE = 954.20, p < .001, η_p^2 = .169). Pairwise comparisons indicated shorter RTs in the refreshed condition (M = 506.47, SE = 16.20) compared to the unrefreshed condition (*M* = 539.89, *SE* = 14.39). A significant main effect of duration was also found (*F* (2, 38) = 3.34, *MSE* = 345.73, *p* =.046, η_p^2 = .150). Pairwise comparisons showed a pattern that as refresh duration increased the response became faster at 2200ms (*M* = 517.78, *SE* =15.17), 1900ms (*M* = 523.24, *SE* = 14.96) and 1600ms (*M* = 528.53, *SE* = 15.63). No significant interaction was reported (*F* (2, 38) = 2.01, *MSE* = 333.03, *p* = .147, η_p^2 = .096). A table reporting the mean RTs and standard deviation for each condition is included in Appendix A.3.

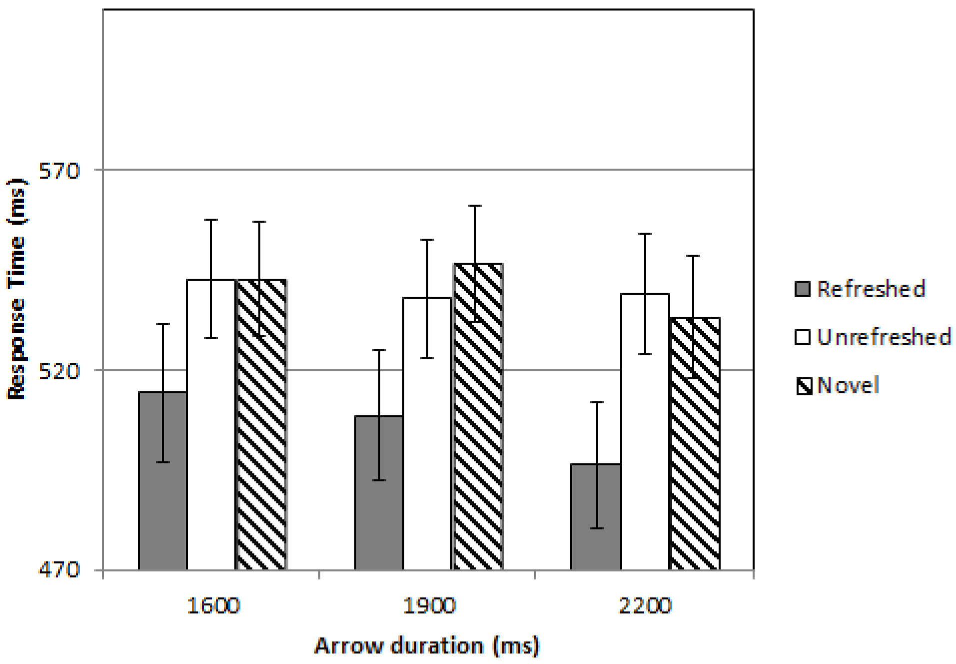

Figure 3. 3. Experiment 2 response times. Refreshed conditions showed significantly shorter RTs compared to unrefreshed conditions across all arrow durations. This pattern indicates a facilitation effect occurring at refreshed condition whereby participants selectively attended to one item, subsequent faster response to the same item was observed. Mean RTs in unrefreshed conditions were similar to the novel conditions, thus reflecting that attending to an encoded item but not attended item can be similar to experiencing a completely new item. Error bars presented here indicate standard error of means.

The results indicated more of a priming effect because participants were faster at identifying an item if the item was previously cued and participants were instructed to keep the item active by constantly thinking about it. Lupianez et al. (1997) suggested IOR appears if the cue-target stimulus onset asynchrony is longer as two events occur during a discrimination task including detecting then identifying the target. Therefore, a longer SOA would be needed in order to observe an IOR effect. The goal was to translate this characteristic from perceptual attention study to our current reflective attention study by varying the temporal dynamics. In addition to the results from Experiment 1, IOR was observed as the participants' responses to the same representation were slower, suggesting that attention was dissipated from that representation. Because IOR appeared with a longer refresh duration, we hypothesized longer duration will produce a more robust IOR effect. However, the current result indicated facilitation at cued target instead of an inhibition effect (see **Figure 3.3**). Comparison between RTs from both experiments indicated an overall enhanced response if refresh duration was increased (see **Figure 3.4**). There are two reasons for this finding: first longer attention allocation on the representation meant that the attention moves beyond IOR and starts to process the information hence speeded priming to the target was observed. Secondly no breaks were introduced between cue and target. Therefore in Experiment 3, I examined the function of a central fixation between cue and target and how it would enhance the appearance of IOR effect.

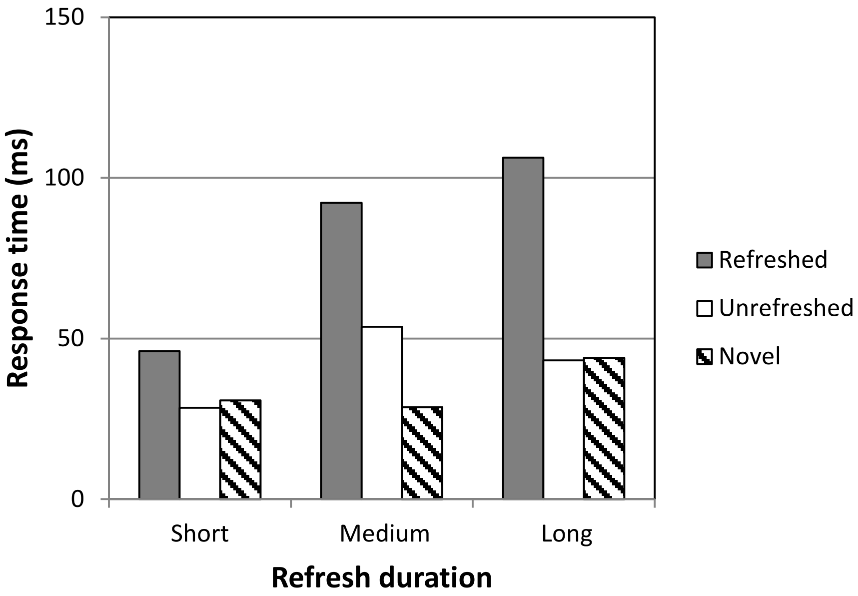

Figure 3. 4. Global Mean RTs Difference (VD1-VD2). The bars represent mean RT difference between Experiments 1 and 2.

3.4 EXPERIMENT 3

Introduction

The results from the previous experiments suggest that the rIOR effect could be sensitive to time in a way that its occurrence depends on changes in refresh durations. The results from Experiment 1 and 2 suggested that any refresh duration shorter or longer than 2000ms would bias attention to return to the refreshed item as shown by participants' faster verbal responses. However, refreshing at 2000ms demonstrated significant inhibition response to the refreshed item. Attention was biased to orient towards unrefreshed items that were encoded into the working memory but ignored subsequently. The next question addresses whether the overall 200ms extra refresh duration cause two different patterns: first an overall decrease in global RTs in Experiment 2 and secondly, absence of IOR or any hint of inhibition effect. The target probe task follows the refresh task immediately, therefore it is unknown when participants disengage attention from refresh the task before directing attention to performing the probe task. When looking at the global RTs between experiments, the response times in Experiment 1 were overall faster (200ms) compared to Experiment 2, and this would suggest that participants may have disengaged their attention more prematurely or held it for longer.

A review of IOR studies suggests cuing attention back to a fixation would produce a more reliable and stronger IOR effect (see reviews MacPherson, Klein, & Moore, 2003; Prime, Visser, & Ward, 2006). They argued that the onset of IOR varies among participants, hence introducing a fixation cue before presenting the next peripheral cue would terminate everyone's orienting response at the same time. As mentioned, in Experiments 1 and 2 there was no delay between refresh cue and target probe and participants had to make the probe response followed immediately after a refresh event. The fixation point functions as a brief interval to remove reflective attention from the representation that was just visualized mentally, setting an equal starting point for participants to respond. The current experiment employed three sets of delay intervals: 50ms, 350ms, and 650ms. This manipulation will produce overall same time intervals between refresh cue onset and probe onset as in Experiment 1. In other words, a fixed refresh duration is used while fixation delay was manipulated as opposed to the original design (Experiment 1) whereby refresh duration was manipulated and fixation delay was absent. The hypothesis was that longer fixation intervals would give participants more time to prepare for subsequent target probe would show a clearer IOR effect to take place or an overall decrease in response times.

Method

Participants The University of Nottingham Malaysia Campus Research Ethics Committee approved all procedures. Twenty participants (mean age = 21.75; twelve females and eight males) were recruited from the University of Nottingham Malaysia Campus. One course credit was awarded to psychology students whereas RM10 were awarded to non-psychology students.

Procedure The design in this experiment is similar to Experiment 1 except a central fixation point was introduced into the task between the refresh and probe events, while refresh duration was held constant at 1350ms. Participants were presented with two picture stimuli; as in Experiment 1, each item from this pair consisted of either “Face”, “House” or “Chair” for 1500ms. After a 500ms delay, a refresh arrow then appeared pointing to one of the picture stimuli locations for 1350ms, cuing participants to refresh one of the stimuli while ignoring the other. A fixation point was then presented in various delays of 50ms, 350ms, or 650ms. The instructions to participants, initial stimulus presentation, probe presentation, data collection, and analysis were all carried out the same way as in Experiments 1 & 2.

This was a within-subject design consisting of 216 trials in total with 24 trials for each combination of condition and fixation delay duration. Trials were divided into four blocks; each block was 11 minutes long and participants were given short breaks between blocks. All procedures and instructions given to participants were carried out in the same way as the previous experiments. **Figure 3.5** shows an example of the new experimental design with a central fixation point appearing between the refresh cue and probe task.

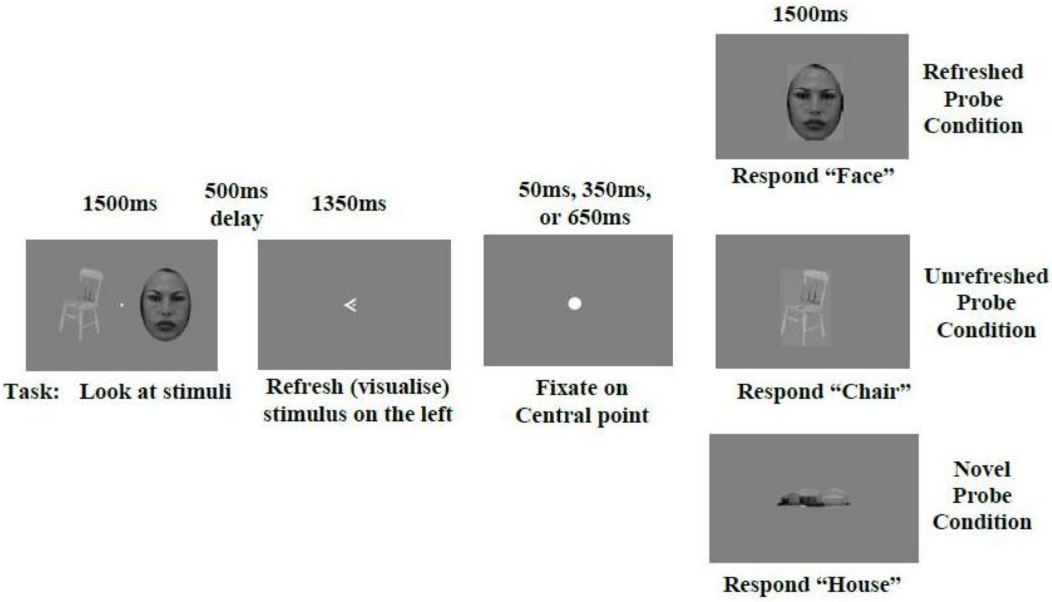

Figure 3. 5. Experiment 3 refresh task design. In this trial, participants are presented with a chair/face pair (1500ms), a refresh cue directs them to refresh the chair for 1350ms, and that is followed by a central fixation point. A "probe" identification task follows immediately and participants must respond by naming the item as quickly and as accurately as possible. Depending on the condition, the "probe" item can be an item that was presented earlier (chair or face) or a new item (house).

Results and discussion

Trials whereby participants provided incorrect responses were removed from the subsequent data set. A total of 13.06% of data were removed from the data set due to error such as incorrect responses or technical error in computer voice recording during data collection. Outliers were removed from each participant's data at 2.5 standard deviations from the mean and then per-condition means were calculated.

A 3 (condition: refreshed probe, unrefreshed probe or novel probe) × 3 (delay time: 50ms, 350ms or 650ms) repeated-measures ANOVA with RTs as the dependent variable. There was a significant main effect for condition (F (2, 36) = 4.88, MSE = 1142.53, p = .013, η_p^2 = .213), indicated the refreshed condition produced (M = 536.94ms, SE = 19.60) shorter RTs compared to unrefreshed (M = 552.520, SE = 18.44) and novel condition (M =555.28, *SE* = 16.63). A significant main effect of fixation duration was also found (*F* (2, 36) = 14.33, *MSE* = 566.83, $p < .001$, $\eta_p^2 = .443$) showed that the longer delay time the shorter the RTs were at 50ms (*M* = 561.86, *SE* = 17.54), 350ms (*M* = 543.30, *SE* = 18.16) and 650ms (*M* = 539. 57, *SE* = 18.52. No significant interaction was reported (*F* (4, 72) = 1.81, *MSE* = 364.78, $p = .137$, $\eta_p^2 = .091$) (see **Figure 3.6**)

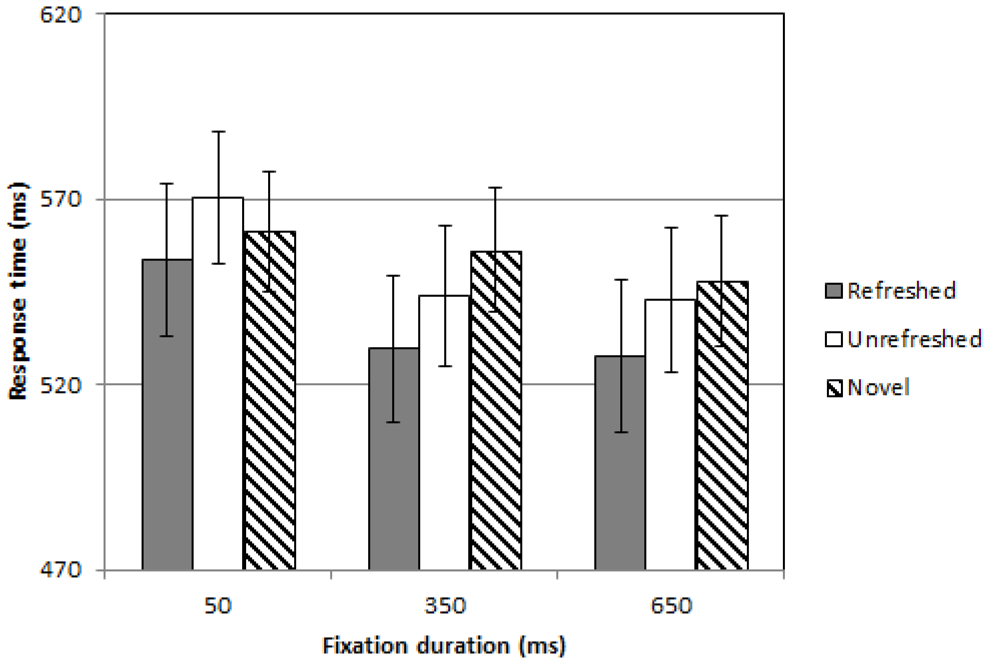

Figure 3. 6. Experiment 3 response times. In each condition, faster response to probes is observed when central fixation point becomes longer between. Error bars represent standard error of that mean.

A 2 (condition: refreshed or unrefreshed) × 3 (fixation duration: 50ms, 350ms or 650ms) reduced ANOVA with RTs as dependent variable demonstrated a significant main effect of fixation duration (*F* (2, 36) = 14.76, *MSE* = 579.77, $p < .001$, $\eta_p^2 = .451$), at 350ms (*M* = 536.85, *SE* = 19.08) produced the shortest RTs, followed by 650ms (M = 535.30, SE – 19.16) and 50ms (M = 562.03, SE = 18.48). The main effect of condition (*F* (1, 18) = 4.13, *MSE* = 1676.48, $p = .057$, $\eta_p^2 = .187$) and interaction (*F* (2, 36) = .033, *MSE* = 500. 89, $p = .967$, $\eta_p^2 = .002$) were not significant. A table reporting the mean RTs and standard deviation for each condition is included in Appendix A.4.

The purpose of including a brief break between refresh cue and probe was to terminate the orientation response and set an equal start point for response to occur which would yield a reliable IOR. However, the lack of an inhibition effect in the current results suggests this strategy would be of most advantage in perceptual IOR studies and more challenging in measuring mechanisms in our reflective attention. Instead of an IOR-like effect, a priming effect appeared to emerge and participants' overall performance was enhanced as RTs were decreased if the duration of the break between cue and target increased. One possibility for this priming effect is the participants did not follow instructions as they were supposed to. As instructed, during refresh arrow appeared for 1350ms cuing them to visualize initially presented picture stimulus, they might have been rehearsing its category name of the items or trying to predict the outcome of the target probe. This anticipation or expectation ought to hinder them from performing the task properly and could lead to priming-like effects. For this reason, the type of stimuli was manipulated in order to replicate inhibition effect and decrease the possibility of participants' tendency to rehearsing items instead of refreshing as instructed. M. R. Johnson and colleagues (2013) also demonstrated rIOR using refresh experiment with word stimuli.

3.5 GENERAL DISCUSSION

The current experiments aimed to examine different time frames and how it might influence attention allocated on a particular representation which could either enhanced subsequent inhibition or facilitation effects. Participants were shown two pictures from three categories (i.e., face, chair or house) and were cued to selectively refresh (think about) one of the two presented items. The activity between cued (refreshed) and uncued (unrefreshed) items was compared in order to examine facilitation or suppression in a subsequent verbal probe task. Keeping a perceived item active in the working memory (refreshed representation) would lead to faster recognition later on because refresh keeps that representation constantly active, therefore responding to it subsequently would be facilitated. However, uncued (unrefreshed) representations that participants were instructed to ignore would become inactivated, therefore responding to unrefreshed representations in subsequent probe task would produce slower RTs. Results from these experiments supported these premises while also indicating the duration internal attention spent on a representation would subsequently affect the appearance of inhibition or facilitation effects as reflected by participants' RTs to cued or uncued representations.

M. R. Johnson and colleagues (2013) showed evidence that our reflective attention is able to produce an inhibition of return like effect that is analogous to the mechanism found in perceptual attention. They suggested the reason for this novel finding is that this IOR effect will facilitate foraging for thoughts in our working memory the same way our perceptual attention searched for information within to the visual field. With this trait of active mobility it enhances reflective attention efficiency in searching for new thoughts, boosting creativity and allowing for stream of consciousness to flow. Experiments in their study were a close analogue to experimental designs used in perceptual attention studies. They also closely examined the immediate access to refreshed items and if the IOR mechanism reduces accessibility of refreshed items.

Results in Experiment 1 demonstrated the participants responded faster to targets that were refreshed at a shorter duration, namely 1400ms. The reverse effect was observed at longer refresh duration (2000ms) where participants responded faster to unrefreshed representations relative to refreshed ones. Interestingly, at refresh duration of 1700ms, there is a shift in facilitation and suppression effects where the unrefreshed condition showed a slightly shorter response time relative to refreshed condition. This subtle pattern was not significant but it became significant when participants had to refresh at 2000ms, suggesting that a change towards inhibition of return was occurring if a representation was selectively focused on between 1700ms and 2000ms. This finding provided support for M. R. Johnson et al.'s (2013) notion of a rIOR effect.

Experiment 2 aimed to further investigate this notion by looking at a different set of refresh duration that is an increment of 200ms in duration for each refresh cue (i.e., 1600ms, 1900ms and 2200ms). This adjustment allowed us to look at the facilitation and inhibition effects at a more specific time lens as well as gave a clearer timeline of when these mechanisms would become significantly enhanced. Evidence pointed towards a significant priming effect. At conditions where participants had to think about an item, their subsequent response to that representation becomes faster. As a result, there was a trend of longer refresh duration leading to enhanced facilitation. A lack of inhibition effect provides evidence to support the initial hypothesis in Experiment 1 that timing was the key in this controlled manipulation of conditions in order to observe a robust rIOR effect. Additionally, a small change in refresh duration between Experiments 1 and 2 shifted inhibition effect to priming effect as seen in the differential data. This pattern further suggested that timing is important in observing a strong rIOR effect. Therefore, this warrants further investigation if disengaging this mental refresh would enhance these mechanisms.

Experiment 3 introduced a break between the refresh cue and probe task for internal attention to disengage, and how this would impact the subsequent inhibition and facilitation mechanisms. Results showed an enhanced facilitation in the refreshed condition compared to the unrefreshed condition, indicating a priming effect. There is a longer break and sufficient time to dissipate the refreshed representation; target response produces the greater level of activation whereas the shorter break produced weaker activation. This pattern is consistent in both refreshed and unrefreshed conditions. The current results contradicted many perceptual IOR studies (see Dukewich, 2009, for a review) that the orienting response to processed stimuli will be slower due to limited processing capacity and that our attention needed to be distributed efficiently. For this reason, attention should be biased towards new and novel information instead of fixating on the same information over a long period of time. However, results from Experiment 2 and 3 did not replicate this effect. The explanation for this is the limited stimuli may have delayed IOR from developing but facilitated priming in further processing the stimuli.

A related possibility is that the task was in English, and although all of the participants in the current experiments were fluent in English, it was probably not their first or dominant language for many of them the way it was for the vast majority of the American participants (as tested by M. R. Johnson et al., 2013). If the English category naming task is not as automatic for them as it would be for monolingual English speakers, that might encourage them (consciously or unconsciously) to adopt a different strategy. The participants in this study comprised mainly bilinguals and multi-linguals that could vary in terms of their English language proficiency. This may have an impact on the results – there are more robust IOR effects in Experiment 1 but stronger priming-like effects in Experiment 2 and Experiment 3. This discrepancy warranted further exploration of possible impact on language input and production among multi-lingual individuals. The next question is whether IOR mechanism functioning in the working memory is susceptible to influences of language switching and whether this played a role in bilinguals' executive function (e.g., in this case ignoring irrelevant stimuli and maintaining tasks goals).

CHAPTER 4
The effects of Language on
the reflective Inhibition of Attention (IOR) mechanism

4.1 Preamble

The findings from the Chapter 3 suggested that there is a reflective Inhibition of Return (rIOR) effect present as a reflective function within our working memory. It is possible that internal attention is biased towards new information while attention to the active representation was inhibited which is in line with M.R. Johnson et al.'s (2013) findings. Although the participants' demography in the M.R. Johnson et al. (2013) experiments and my experiments reported in Chapter 3 were different in that the authors recruited monolingual English speakers I used bilingual speakers in my experiments. Despite the differences, both studies successfully produced an Inhibition of Return (IOR) like effect. Previous refreshing studies discussed in Chapter 1 did not investigate language proficiency (dominant or non-dominant language) as a factor that can play a role in reflective attention. It is possible that IOR is a general mechanism and is not modulated due to language proficiency. However, does the rIOR mechanism persist when bilingual speakers switch between languages? Furthermore, would this inhibition mechanism be affected in a mixed language context, switching either to a stronger language or to weaker language? Altogether, these are questions contribute to the novelty of the current experiments.

This chapter consisted of three experiments that investigate rIOR in word representations and also whether the rIOR effect would be affected by language representations among bilingual speakers. In order address these questions, the first step was to determine whether it was possible for rIOR to occur in word representations by directly comparing refreshed and unrefreshed word stimuli (Experiment 4). The second part of this chapter (Experiment 5 and 6) aimed to compare the robustness if rIOR in participant's weaker and stronger language as well as in mixed and single language contexts that involved switching between languages.

One of the main questions I am interested in investigating was whether early language processing would impact reflective attention in bilingual speakers. Previous literature (Meuter & Allport, 1999) on the asymmetrical cost associated with language switching suggests there is a switch cost moving from the non-dominant language (L2) to the dominant language (L1). Switching from L1 to L2 produces a facilitation effect because compared to L2 to L1 the L1 is much more dominant compared to L2. Therefore, the weaker L2 should be easier to suppress and so switching to the dominant L1 would also be easier (MacNamara, 1967). The switch cost was argued to occur because naming in L2 requires a stronger suppression of L1, and this suppression effect would persist, thus producing a form of "negative priming" in L1. Based on this model, it was hypothesized the switch event would offset rIOR effects and give rise to a stronger asymmetrical cost. A behavioural pattern would show a stronger inhibition if the language direction moved from weaker language to stronger language compared to the reversed pattern.

Additionally, reflective attention may be affect by the language context it operates in. A related study by Wu and Thierry (2013) found an enhancement associated with executive control among bilinguals. The experiment comprised of a flanker task with random words introduced between each trial, but the participants were instructed to ignore the random words while focusing exclusively on the flanker task. They found if exposed to mixed language context (two languages, English or Welsh) compared to a single language context (only English or only Welsh), participants showed enhanced executive capacity to resolve interference in a flanker task. The authors suggested that the mixed-language context shifted the executive system to an enhanced functional level, therefore enhancing the effectiveness of conflict resolution. This was in line with aforementioned theories (in Chapter 2) including reactive adjustment in human cognition whereby processing a conflict is enhanced if the brain is primed to a state of higher cognitive control engaged by previous tasks (Gratton, Coles & Donchin, 1992; Botvinick, Nystrim, Fissell, Carter, & Cohen, 1999; Kerns et al., 2004; Kerns, 2006). Due to this advantage in conflict resolution, it is possible this effect may offset previous asymmetric switch cost and show more of a priming-like effect in language switching in the refresh task.

Experiment 5 and 6 aimed to investigate mixed language context and single language context affect the robustness of rIOR development. In order to test this switch, the input language during initial and refresh presentation is different from the output language presented during target probe task. A stimuli list consisting of noncognate word pairs were created for the purpose of creating the language switching between cued word presentation and target word. As mentioned in Chapter 2, noncognate words are translation equivalents that only share similar meaning (e.g., “house” in English is “rumah” in Malay”) Cognates are word pairs in different languages that share similar historical origins, meaning and similar spelling (e.g., “honest” and “sincere” in English is “honnête” and “sincere” in French) (Hipner-Boucher, Pasquarella, Chen, & Deacon, 2016). Therefore, the term equivalent will be used hereafter to refer to English-Malay noncognate words.

The current also chapter explored the influence of participants’ strong and weak languages on rIOR behavioural performance by comparing it with L1-L2 links as noted in the switch cost models. As noted in Chapter 2, language background for Malaysians is an amalgamation of different languages due to different school systems, changes in educational policies and cultural differences, thus it was a challenge to determine which was each participants' L1 and L2. In order to address this problem, in each experiment (Experiments 5, 6 and 7 (in Chapter 5)), a self-report language background questionnaire was used to indicate whether English or Malay was the language that they deemed to be the strongest or the weakest. Hereafter, terms such as stronger and weaker language were used in the interpretation of results while terms such as first/dominant language (L1) and second/non-dominant language (L2) were reserved in reference to language models in previous literature.

4.2 EXPERIMENT 4

Introduction

Experiments in Chapter 3 involving picture stimuli resulted in a strong facilitation effect for refreshed items but a weak inhibition effect in Experiment 1 and almost absent in Experiments 2 and 3. Using picture stimuli which only comprised the categories of chair, face and house could cause a saturation effect where the activation for the concept was heightened, thus reducing the likelihood of finding an IOR effect. Experiment 4 expanded the study by using word stimuli by adapting experimental design by M. R. Johnson et al. (2003) (Experiment 1a). The aim was to if investigate English word presentations would show inhibition effect in reflective attention similarly to picture representation. It was hypothesized that unrefreshed RTs will be shorter than refreshed RTs. As noted, a perceptual IOR effect was observed if the interval between cue and target is at least 300ms or more (Klein, 2009). However, the interval for refresh here could not be further reduced because the extra time needed for participants to speak the refreshed word aloud. Similar to Experiment 1, a set of refresh durations (i.e., 900ms, 1200 and 1500ms) was also included to investigate the onset of rIOR effect. The justification for testing a variation of refresh duration resonated with Dukewich's (2009) finding that activation of representation is stronger at a shorter duration between cue and target because the orienting attention has yet to dissipate from the cue.

Conversely, the activation of representation would decline over time and show weaker attentional orienting to cued representation at longer duration. Based on this rationale, it was hypothesized that rIOR would be stronger at longer (1500ms) refresh duration.

Method

Participants The University of Nottingham Malaysia Campus Research Ethics Committee approved all procedures. Twenty participants (mean age = 20; 16 females and four males) were recruited from the University of Nottingham Malaysia Campus. One course credit was awarded to psychology students whereas RM10 were awarded to non-psychology students.

Procedure The design of this task is similar to Experiment 1 (Chapter 3), except that picture stimuli were replaced with words and refresh durations were shortened. A pre-task fixation was presented for 1000ms to help participants focus on a central point. Two words were presented above and below the fixation in the initial presentation for 1500ms; participants had to read the words silently. This was followed by a brief 500ms fixation point before a refresh arrow appeared indicating the location of one of the words presented earlier in various duration (i.e., 900ms, 1200ms, or 1500ms). The refresh arrow cued participants to refresh words they had just seen by saying them aloud as quickly as possible due to short duration of the refresh window. Immediately after the refresh cue, a final probe word was presented onscreen for 1500ms, to which participants had to respond by reading the word aloud as quickly and as accurately as possible. During the final probe, words could have been either presented initially and refreshed (refreshed probe condition), presented but not refreshed (unrefreshed probe condition), or a new word (novel probe condition). The inter-trial interval was 3000ms. **Figure 3.7** showed sequence of events for the current experiment.

This was a within-subject design. The task consisted of 216 trials (24 trials of each combination of condition and refresh arrow time), divided into four blocks; each block was 6 minutes long and participants were given short breaks in between blocks. Stimulus lists were equated for length (Mean length = 6.31), frequency (log transformed, mean frequency = 7.23), number of phonemes (Mean phonemes = 5.11), number of syllables (Mean syllables = 1.75), and average RT to read the words aloud (average RT = 650.99) (value taken English Lexicon Project, ELP, Balota et al., 2007), and counterbalanced across participants. A total of 2814 word items were used in the experiment. Each word was unique to a session and participants would have seen each word item once, so the possibility of priming effects was avoided.

Screen **Start of task** ---→ **End of task**					
First fixation (1000ms)	**Initial Display (1500ms)**	**Second fixation (500ms)**	**Refresh (900ms; 1200ms or 1500ms)**	**Probe Task (1500ms)**	**Condition**
+	crypt + medal	+	^ (say "crypt")	crypt	*Refreshed*
+	crypt + medal	+	^ (say "crypt")	medal	*Unrefreshed*
+	crypt + medal	+	^ (say "crypt")	subplot	*Novel*

Figure 3. 7. Experiment 4 refresh task design. Words were used instead of pictures for this experiment. Participants had to first fixate their eyes on the central point for 1000ms before reading both words presented onscreen. The words disappeared and participants had to focus their eyes on another fixation point for a brief 500ms before refreshing by saying the word indicated by the arrow (in this trial, the participant had to say "crypt"). The time window for refreshing varies, it can be either 900ms, 1200ms or 1500ms. For the subsequent probe task, participants had to say the word presented onscreen as soon and as accurately as they could. The probe task consisted of words they had seen before (crypt or medal) or a novel unseen word (subplot).

Results and discussion

Trials whereby participants provided incorrect responses were removed from the subsequent data set. A total of 5.42% of data were removed from the data set due to error such as incorrect responses or technical error in computer voice recording during data collection. Outliers were removed from each participant's data at 2.5 standard deviations from the mean and then per-condition means were calculated.

A 3 (condition: refreshed, unrefreshed or novel) × 3 (arrow duration: 900ms, 1200ms or 1500ms) repeated-measures ANOVA with response time (RTs) to probed items as the dependent variable. The analysis showed a significant main effect for condition (F (2, 36) = 27.24, MSE = 1684.24, p < 0.001, η_p^2 = .602) that unrefreshed condition (M = 516.12, SE = 19.80) compared to refreshed (M = 543.39, SE = 18.92) and novel (M = 572.85, SE = 19.09) conditions. A significant main effect of arrow duration (F (2, 36) = 5.79, MSE = 1501.78, p = .007, η_p^2 = .243) indicated longer refresh at 1500ms (M = 534.69, SE = 18.91) duration produced shorter RTs compared to 900ms (M = 558.11, SE = 21.12) and 1200ms (M = 539.56, SE = 17.44). A significant interaction effect (F (4, 72) = 2.71, MSE = 408. 09, p =.036, η_p^2 = .131) between condition and arrow duration was also present. The RTs for each condition is shown in **Figure 3.8**.

A 2 (condition: refreshed or unrefreshed) × 3 (arrow duration: 900ms, 1200ms or 1500ms) repeated-measures reduced ANOVA with response time (RTs) to probed items as the dependent variable. A significant main effect of condition (F (1, 18) = 12.54, MSE = 1689.36, p = .002, η_p^2 = .411) showed unrefreshed condition (M = 516.12, SE = 19.80) produced shorter RTs compared to refreshed condition (M = 543.39, SE = 18.92). There was also significant main effect of duration (F (2, 36) = 6.61, MSE = 1370.16, p = .003, η_p^2 = .274) that showed longer refresh duration 1500ms (M = 517.20, SE = 18.88) produced the shortest RTs compared to 900ms (*M* = 547.31, *SE* = 21.48) and 1200ms (*M* = 524.75, *SE* = 18.29). There interaction between condition and duration was not significant (*F* (2, 36) = 2.49, *MSE* = 369.44, *p* = .097, η_p^2 = .122). Three two-tailed paired sample post-hoc t-tests (Bonferroni corrected *p* = .017) comparing refreshed and unrefreshed conditions at three refresh durations showed significant differences at 900ms (*t* (18) = 5.23, *p* < .001) and at 1200ms (*t* (18) = 2.79, *p* = .012). There was not significant difference between conditions at 1500ms (*t* (18) = 1.49, *p* = .155). A table reporting the mean RTs and standard deviation for each condition is included in Appendix A.5.

If the mean RTs for the unrefreshed items are much shorter than for refreshed items, this denotes the presence of an inhibition of return (IOR) effect. The RTs for the unrefreshed probe condition were consistently shorter than the refreshed probe condition across all arrow durations thus reflecting a strong inhibition effect to return attention to refreshed words (see **Figure 3.8**).

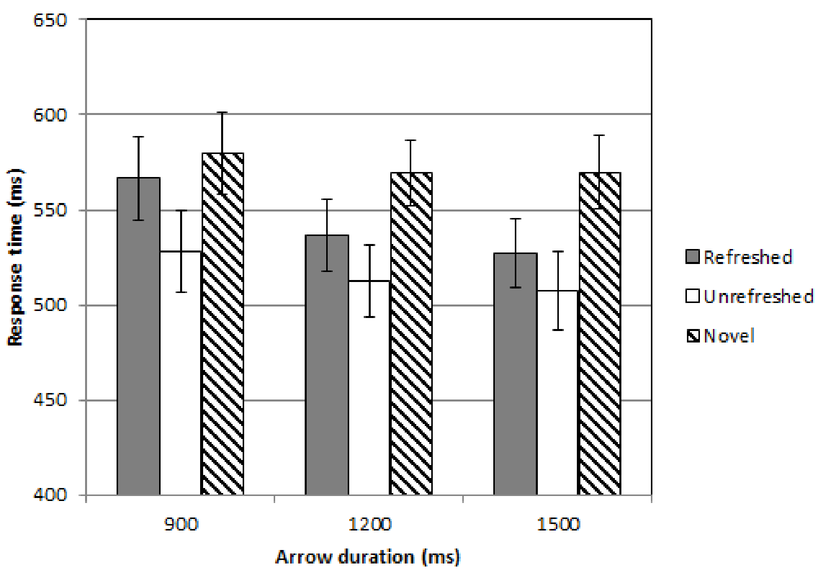

Figure 3. 8. Experiment 4 response times. RTs in unrefreshed condition were consistently shorter than refreshed trials across all arrow durations (900ms, 1200ms and 1500ms) indicating an inhibition effect. Error bars represent standard error of means.

This pattern of inhibition replicates previous work using word stimuli (M. R. Johnson et al., 2013). The IOR effect appears to be stronger at the shorter refresh intervals and it decreases as refresh duration increases and finally disappears at the longer (2000ms) refresh duration. This appearance of an IOR-like pattern during the 2000ms refresh duration is consistent with the results found in Experiment 1 (Chapter 3). The result confirmed rIOR effect in reflective attention with English word representations as observed in such behavioural pattern: faster response to unrefreshed representations and slower response to refreshed representations. The next aim in this chapter extended this finding by comparing magnitude of strong and weak language proficiency that will impact the robustness of IOR effect in the reflective attention.

4.3 EXPERIMENT 5

Introduction

Experiment 4 showed evidence of rIOR in English word representations at all refresh durations which are similar to previous refresh studies (e.g., M.K. Johnson, Reeder, Raye, & Mitchell, 2002; M.R. Johnson et al., 2013). However, these experiments did not test for language switching during refreshing in bilingual speakers. Refreshing was proposed to be a mechanism by which mental representations are brought into the focus of attention (Cowan, 1999; Oberauer & Kliegl, 2006). It is possible that switching between strong and weak language (in this case English or Malay) during the refresh period can give rise to other mechanisms other than the rIOR. The first aim was to show rIOR in both English and Malay words but priming in language switching trials. Although refreshing result in short term negative outcomes such as slower responses to refreshed representations, refreshed items were found to be better remembered at later memory test (e.g., M.K. Johnson, Reeder, Raye, & Mitchell, 2002; M.R. Johnson et al., 2013). The second aim was to investigate refresh effect on long term memory retrieval. The novelty in this experiment is the investigation on participants' strong and weak language fluency on the typical refresh studies and its later outcome on memory performance. If both languages were active during the refreshing task, would this activation result in participants falsely identifying words they had not initially seen? I predicted two outcomes from this design. First, performance in non-switch trials would be able to replicate previous findings that refreshed items would increase long term retrieval compared to unrefreshed ones. Secondly, whether refreshing would have similar effect on switch trials as both languages to the same concept will be activated.

Method

Participants The University of Nottingham Malaysia Campus Research Ethics Committee approved all procedures. Twenty-five participants (mean age = 23; 19 females and six males) were recruited from the University of Nottingham Malaysia Campus. One course credit was awarded to psychology students whereas RM10 were awarded to non-psychology students. Participants' language background and self-rated proficiency were collected using a language history questionnaire (see Appendix A.6) in order to control for language proficiency. All procedures were approved by the Ethics Review Board Committee in UNMC.

A breakdown of participants' age and self-rated proficiency score, years of experience using the languages and their age of acquisition (AoA) are listed in the table below (see **Table 4.1**). Participants had to rate their proficiency of the language (English or Malay) on a scale of 1 to 7, with 1= "Very poor" to 7 = "Native-like" (see **Table 4.1**). Two-tailed paired sample t-test comparing proficiencies namely, reading (t (23) = .137, p = .892), writing (t (23) = 1.33, p = .195), speaking (t (23) = .194, p = .848) and listening (t (23) = .492, p = .627) for both languages were not significant. The data from these self-report language proficiency questionnaire suggested that participants were equally fluent in both English and Malay. However, note that participants rated English as a slightly stronger language compared to Malay.

	Self-Rated Language proficiency					AoA			Years of experience
	R	W	S	L	Overall	S	R	W	
English	5.92	5.63	5.50	5.75	5.70	4.48	4.58	4.75	13.71
Malay	5.96	5.21	5.42	5.58	5.54	4.61	6.0	6.04	12.74

Table 4. 1. Experiment 5 Participant's self-rated proficiency and age of acquisition (AoA). Self-rated proficiency score on a scale of 1 to 7, age of acquisition (AoA) of the language and how many years they have been using the language (R = reading; W = writing; S = speaking; L = listening). Although no significant differences between proficiencies were reported, English appears to be the stronger language.

Materials Word stimuli were selected from the English Lexicon Project (ELP, Balota et al., 2007) and Malay Lexicon Project (Yap, Liow, Jalil & Faizal, 2010). The ELP comprised of normative data for speeded naming and lexical decision for over 40,000 words across 1200 subjects at 6 different universities. The Malay Lexicon Project compiled a dataset of lexical variables for 9,592 Malay words.

To create a list of word pairs that contained the equivalent meaning but were expressed in both English and Malay, back translations were done between both English and Malay, and three proficient English-Malay speakers validated the translations of each word pair. Word pairs that begin with the same letter or words that contained ambiguous meaning were removed from the list. Words in contemporary colloquial Malay that were borrowed from the English language (e.g., "fokus", "analisis" and "target" in Malay are "focus", "analysis" and "target" in English) were also removed from the list. Since word frequency, length, phoneme and syllable might influence the results, these variables were matched across English and Malay. Due to the intrinsic differences and lexical differences between English and Malay, values for each item were transformed into Z-scores before equating into individual word stimuli list. Two-tailed paired sample t-tests were performed on the Z-scores to compare lexical variables frequency (t (611) = .003, p = .997), length (t (611) = .009, p = .993), phoneme (t (611) = .057, p = .954) and syllable (t (611) = .042, p = .967) across both English and Malay showed no significant difference. Mean averages of Z-scores for both languages are included in the table below (**Table 4.2**) and the full list is included in appendices (see Appendix A.7). A total of 612 word pairs were created and each word pair is unique per session. In other word, each participant would see each word pair once, so the possibility of priming effects was avoided. Counterbalanced word lists for each participant were all $p > 0.7$. This is was in order to ensure that all the word lists did not differ based on these factors.

	Length	Frequency	Number of Phonemes	Number of Syllables
English	0.000000000214	-0.0000000016340	-0.0000000000294	-0.0000000001748
Malay	0.0000000000784	0.0000000212418	-0.0000000000065	-0.0000000001912

Table 4. 2. Word characteristics for both English and Malay. The word characteristics for all words used in the experiment and across the different word lists in average Z-scores

Procedure The study consists of four separate tasks, (1) word refresh task, (2) language survey, (3) surprise memory recall test and (4) post-check language test.

The experimental design for the first refresh task is similar to Experiment 4, except the current design used two languages (i.e., English and Malay) and the refresh duration was held constant at 1500ms. Participants sat in a dark room and 40cm away from the computer screen. Participants first focused on a central fixation point for 1000ms, then two words appeared above and below the fixation point. The words would stay on screen for 1500ms then disappear. During the initial presentation of the trial, word pairs appeared at this point consisted of the same language. After a 500ms gap, a refresh arrow, either pointing to the top or bottom word, appeared for 1500ms. The refresh arrow cued participants to refresh the indicated word by saying it out loud. A probe identification task followed, one of the words from initial display was presented again, and participants had to make a speeded response. The target word could either be the word that they had just refreshed (refreshed probed) or seen at the initial display but were instructed to ignore (unrefreshed probed). In addition to this manipulation, language switching during target words was introduced. For example, the target word could be identical to the initial presentation or in the alternative language (i.e., Malay or English) therefore producing four types of target probes and conditions (see **Figure 4.1**). Participants were instructed to make their responses as quickly as possible without sacrificing the accuracy of each trial.

Screen **Start of task** --→ **End of task**					
First fixation (1000ms)	**Initial Display (1500ms)**	**Second fixation (500ms)**	**Refresh (1500ms)**	**Probe Task**	**Condition**
Non-switch trial					
+	cat + house	+	^ (say "cat")	cat	*Refreshed*
+	cat + house	+	^ (say "cat")	house	*Unrefreshed*
Switch trial					
+	cat + house	+	^ (say "cat")	kucing	*Refreshed*
+	cat + house	+	^ (say "cat")	rumah	*Unrefreshed*

Figure 4. 1. Experiment 5 refresh task design. The sequence of events is similar to Experiment 4, except the type of language used is manipulated in the design. In the non-switch language trials, the language participants refreshed and subsequently respond in the probe task are the same. In the switch language trial conditions, words appeare in the probe task would be in the alternative language.

This was a within-subject design. The task consisted of 192 trials (24 trials per condition) were randomized and divided into four blocks. The four types of probe type conditions that were mentioned were randomized within four blocks and were not separated according to conditions. Each block was approximately six minutes long and short breaks were given within each block. Voice responses were recorded by the experimenter using a check-list and digitally with a separate built-in microphone from a laptop. Response Times (RTs) were analysed from the digital recordings using a customized Matlab script (The MathWorks, Natick, MA).

This was followed by the second task. Participants were given the Language History Survey which took around 20 minutes to complete. This was followed by a surprise memory recall test (task 3). A series of words were presented at the centre of the screen that the participants had to identify if they had seen the words in the experiment. Participants had to choose between "Definitely Yes", "Maybe Yes", "Definitely No" or "Maybe No". These responses were converted into numeric confidence ratings for further analysis. The purpose of using a scale in this recall test was to provide a sensitive measurement to investigate long-term memory that corresponded with refresh effect. The task contained 480 words consisting of 96 words which they had not previously seen (foils), a set of 384 words randomly selected from the refresh task. Within the pool of these refreshed words, 192 items were equivalents, the words that were presented in another language which the participants had not seen.

A post-check test (task 4) was administered at the end of the experiment. Participants were presented with 384 word pairs (i.e., English and Malay) and were asked if they knew the words they knew prior to participating the experiment and rate if they agree with the translations between the words in each pair. This was a forced choice format and participants had to choose between “Yes” or “No”. Responses were converted into confidence ratings for further analysis.

Results and discussion

Post-check analysis

Mean confidence ratings for the post-check survey was 81.09%, in which participants had seen both English and Malay word stimuli and agreed that both words were equivalent in meaning.

Refresh task

Trials whereby participants provided incorrect responses were removed from the subsequent data set. A total of 7.67% of data were removed from the data set due to error such as incorrect responses or technical error in computer voice recording during data collection. Mean Response Times (RTs) for correct responses per participant for all conditions were calculated after outliers were removed (Z-score > 2.5).

Two separate ANOVA analyses was performed: the first (1) aimed to investigate reflective inhibition of return (rIOR) effect by examining the condition and trial effects whereas the second (2) aimed investigate the language switching effect by comparing non-switch trials and switch trials directly for both language directions.

Condition effect

To investigate rIOR effect, a 2 (trial: non-switch, switch) × 2 (output: English, Malay) × 2 (condition: refreshed, unrefreshed) repeated measures ANOVA of probed reaction times (RTs) was conducted. A significant main effect of trial (F (1, 19) = 29.15, MSE = 622.12, p <

0.001, η_p^2 = .605) showed that participants responded faster in the non-switch trials (*M* = 504.45, *SE* = 15.45) compared to the switch trials (*M* = 525.74, *SE* = 17.36). This was expected because the transition from refresh to probe tasks using the same language will induce less cognitive interference compared to switching between languages. There was also a main effect of output (*F* (1, 19) = 5.93, *MSE* = 1179.75, *p* = .025, η_p^2 = .238) which showed that English words (*M* = 508.48, *SE* = 15.05) produced shorter RTs compared to Malay words (*M* = 521.70, *SE* = 17.91). Trial × condition interaction (*F* (1, 19) = 6.26, *MSE* = 235.41, *p* = .022, η_p^2 = .248) was significant. Graphs below (see **Figure 4.2**) showed condition effect in non-switch trials for both English and Malay separately while **Figure 4.3** showed RTs for switch trials such as switch to English and switch to Malay.

Four post-hoc two-tailed paired sample t-tests (Bonferroni corrected *p* = .0125) comparing refreshed and unrefreshed conditions across each language pair, English → English (*t* (19) = .757, *p* = .46), Malay → Malay (*t* (19) = .049, *p* = .962), English → Malay (*t* (19) = 1.97, *p* = .064) and Malay → English (*t* (19) = 1.68, *p* = .11). However, while all comparisons were not significant (*p*s > .05), it seems that the interaction could be driven by the switch from English to Malay.

Main effect of condition was not significant (*F* (1, 19) = 1.06, *MSE* = 538.04, *p* = .315, η_p^2 = .053) or interactions including trial × output (*F* (1, 19) = 1.36, *MSE* = 341.56, *p* = .258, η_p^2 = .067), output × condition (*F* (1, 19) = .249, *MSE* = 244.34, *p* = .624, η_p^2 =.013) and trial × output × condition (*F* (1, 19) = .085,*MSE* = 267.82, *p* = .773, η_p^2 = .004) were not significant. A table reporting the mean RTs and standard deviation for each condition is reported in Appendix A.8.

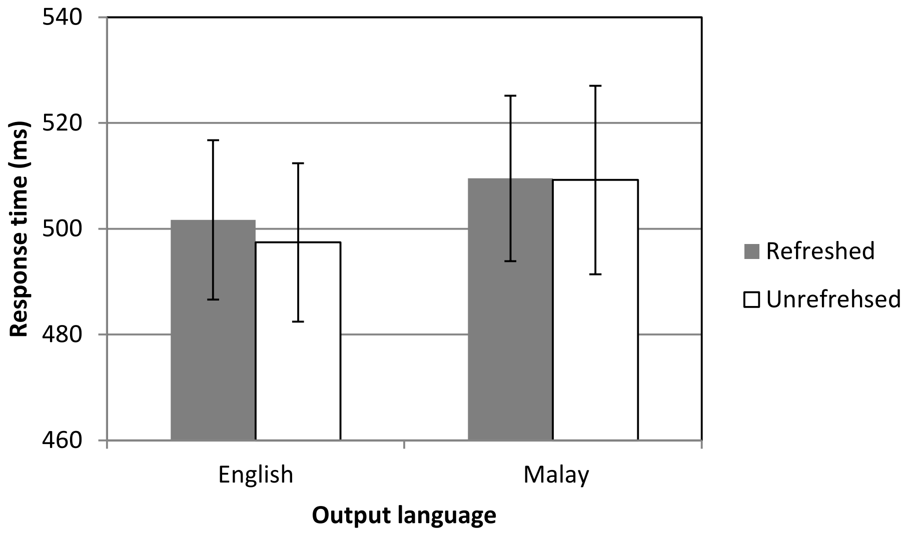

Figure 4. 2. Experiment 5 response times for non-switch trials. Although this was not significant, a reflective Inhibition of return (rIOR) trend can be seen as unrefreshed items produced shorter or comparable RTs to refreshed items. Error bars represent standard error of mean. In this graph, input and output language are the same.

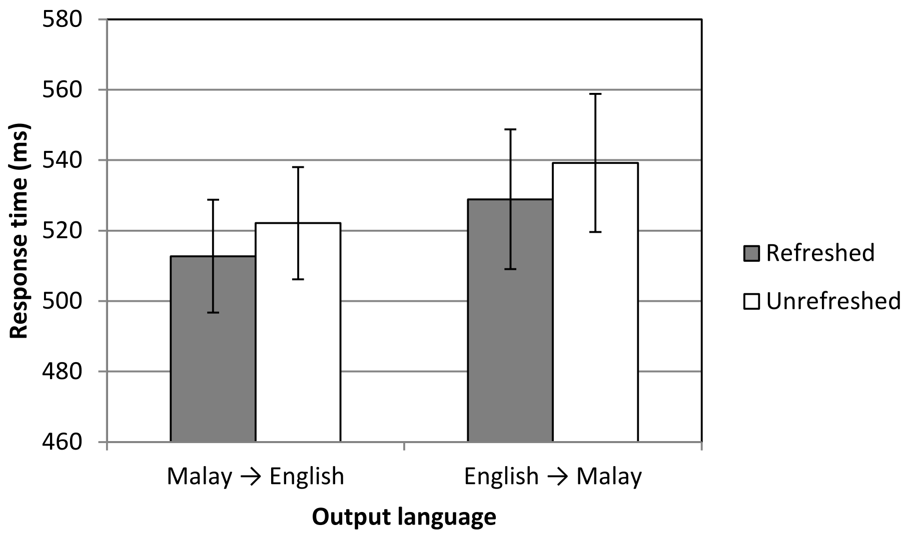

Figure 4. 3. Experiment 5 response times for switch trials (Malay → English and English → Malay). In switch trials, input and output languages are incongruent, for example if the output language is English this meant participants had seen and refreshed in Malay. Refreshed is faster than unrefreshed, indicating a priming effect such that participants were faster at responding to items that they previously refreshed in a different language. Error bars represent standard error of means.

Switch cost analysis

This analysis examined the asymmetrical switch cost by comparing whether input and output languages would enhance or suppress behavioural performance in RTs. The language used during input and condition was similar, but may differ during output as a switch may occur depending on trial type. If no switch was involved, then the input-output language is congruent. If a switch was present, then input-output language would be incongruent. The switch cost was measured by comparing congruent trials against incongruent trials which will show delayed RTs in incongruent trials. For example, congruent input-output language (i.e., English input → English-output or Malay-input → Malay-output) were compared against incongruent language direction (i.e., English input → Malay output or Malay input → English output).

Four two-tailed paired sample t-test examining language direction for both conditions (i.e., refreshed or unrefreshed) were performed. In refreshed condition, the switch from English → English (M = 501.68, SD = 67.31) was significantly shorter compared to the switch English → Malay (M = 528.89, SD = 88.65; t (19) = 3.09, p = .006). However, there was no significant difference between the switch from Malay → Malay (M = 509.50, SD = 70.02) and switch from Malay → English (M = 512.74, SD = 71.53; t (19) = .55, p = .589). In unrefreshed condition, switch from English → English (M = 497.40, SD = 66.90) was significantly shorter compared to switch from English → Malay (M = 539.22, SD = 87.72; t (19) = 5.08, p < .001). However, there was no significant difference between the switch from Malay → Malay (M = 509.20, SE = 79.73) compared to Malay → English (M = 522.12, SD = 72.28; t (19) = 1.86, p = .078). The RTs for language direction English → English and English → Malay in both refreshed and unrefreshed conditions are portrayed in the graph below (see **Figure 4.4**).

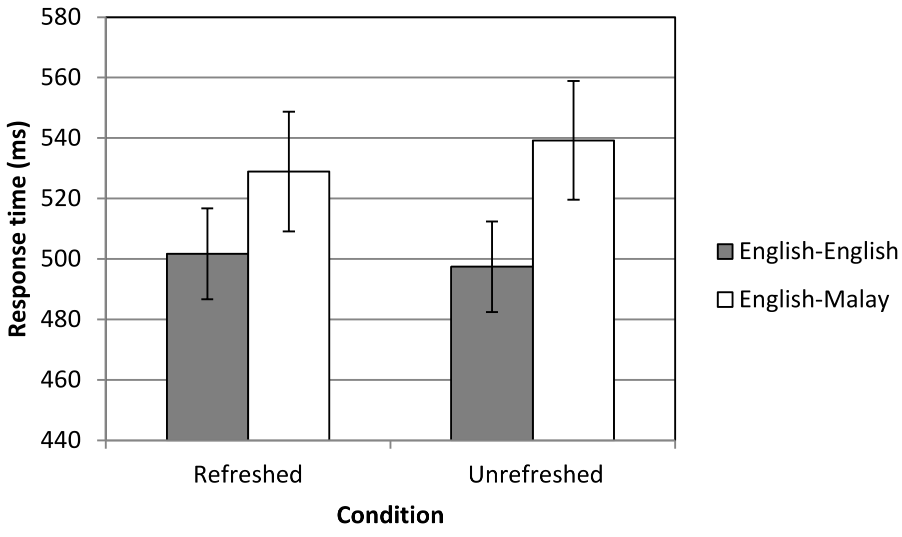

Figure 4. 4. Experiment 5 response times comparing English → English and English → Malay. The cost of English → Malay was significant for both refreshed and unrefreshed condition. Moving within the same language produced a shorter response time compared to a switch to Malay, indicating a switch cost. Error bars represent standard error of means.

Further analysis examining the main effects of input and output languages was conducted by performing a 2 (input: English, Malay) × 2 (condition: refreshed, unrefreshed) × 2 (output: English, Malay) repeated measures ANOVA on the RTs (see Appendix A.9 for further details) to give an overall pattern for completeness. This additional analysis provides further exploration of refresh effects on the interactions between input and output languages but it is beyond the scope of the research question.

Memory test

Participants' responses were converted into numeric scales (i.e., "Definitely No" = 1, "Maybe No" = 2, "Maybe Yes" = 3 and "Definitely Yes" = 4) and used as confidence ratings in the analysis described below. Word stimuli used in the memory task were categorized based on three categories: (1) real words, which appeared during the refresh task, (2) equivalent words, which are real words presented in another language and (3) foil words that did not appear during the refresh task, thus serve as a baseline comparison for this analysis.

The first aim was to examine if refreshing enhances the memory retrieval of the real words. The second aim was to test whether refreshing or probe effects would lead to signs of false memory; confidence ratings for equivalent words would increase. This analysis is divided into two sections (1) non-switch and (2) switch, using a similar structure to the refresh task analysis. A table reporting the mean RTs and standard deviation for each condition is reported in Appendix A.10.

Non-switch trials

A 3 (type: foil, real or equivalent) × 2 (language: English or Malay) repeated measures ANOVA was conducted with the confidence ratings as the dependent variable. There was a significant main effect for type (F (2, 34) = 129.77, MSE = .086, p < .001, η_p^2 = .884) which revealed that participants correctly identified real words (M = 1.71, SE = .092) compared to foils (M = 1.71, SE = .092) and equivalents (M = 1.84, SE = .078). In other words, real words were better remembered. A significant main effect of language (F (1, 17) = 20.87, MSE = .297, p < .001, η_p^2 = .551) showed that English words (M = 2.15, SE = .089) produced higher confidence ratings compared to Malay words (M = 2.05, SE = .080). There was also a significant type × language interaction (F (2, 34) = 4.79, MSE = .039, p = .015, η_p^2 = .220).

Three post-hoc two-tailed paired sample t-tests (Bonferroni corrected p = .017) comparing languages (i.e., English or Malay) for each word type (i.e., real, foil or equivalent). There was a significant difference for real words (t (17) = 5.37, p < .001) that showed English real words (M = 2.87, SD = .486) produced higher confidence ratings than

Malay real words (*M* = 2.60, *SD* = .443). The results showed that English real words were better remembered compared to foils and equivalents. These results are presented in the graph below (see **Figure 4.5**). However, there were no significant differences for foils (*t* (17) = .532, *p* = .601) or equivalents (*t* (17) = .212, *p* = .835).

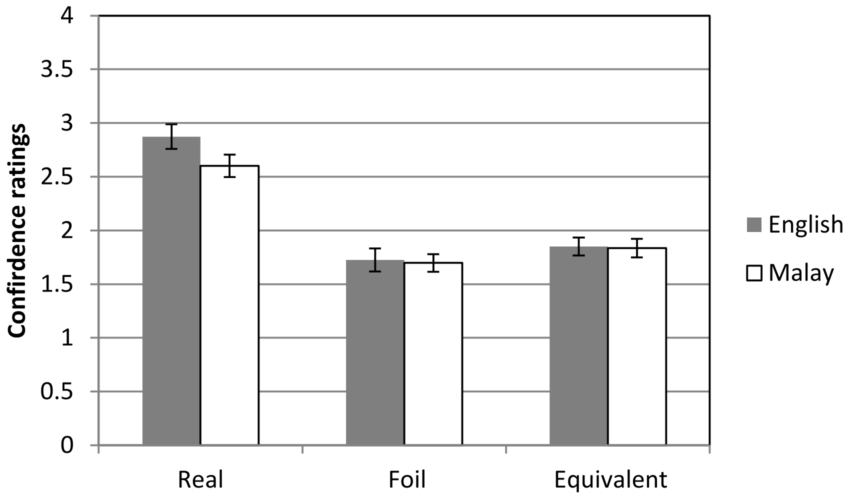

Figure 4. 5. Experiment 5 confidence ratings for word types. Word types (i.e., real, foil and equivalent) across both English and Malay. Real words were correctly identified. Error bars represent standard error of means.

The following analyses compared between refresh and probe effects on real and equivalent words for both languages (i.e., English and Malay) separately.

i. Non-switch English trials

Real words A 2 (refresh: refreshed or unrefreshed) × 2 (probe: probed or unprobed) repeated measures ANOVA was conducted with confidence rating as the dependent variable. There was a significant main effect for refresh (*F* (1, 17) = 51.38, *MSE* = .086, $p < 0.001$, η_p^2 = .751) producing higher confidence scores (*M* = 3.12, *SE* = .119) than unrefresh (*M* = 2.63, *SE* = .120). There was also a significant main effect of probe (*F* (1, 17) = 48.69, *MSE* = .094, $p < .001$, η_p^2= .741) which showed words that were later probed (*M* =

3.13, *SE* = .107) also produced higher confidence ratings than unprobed (*M* = 2.62, *SE* = .132). There was significant probe × refresh interaction (*F* (1, 17) = 7.91, *MSE* = .067, *p* = .012, η_p^2 = .318).

Two post hoc two-tailed paired sample t-tests (Bonferroni corrected *p* = .025) comparing refresh effect in both probed and unprobed words. For probed words, refreshed (*M* = 3.29, *SD* = .465) showed higher confidence levels compared to unrefreshed (*M* = 2.96, *SD* = .515; *t* (17) = 3.78, *p* = .001). For unprobed words, refreshed (*M* = 2.95, *SD* = .627) showed higher confidence levels compared to unrefreshed (*M* = 2.29, *SD* = .563; *t* (17) = 6.8, *p* < .001). These comparisons suggest the act of refreshing increased the confidence rating, suggesting later memory retrieval of the word was enhanced. These results are presented in the graph below (see **Figure 4.6**).

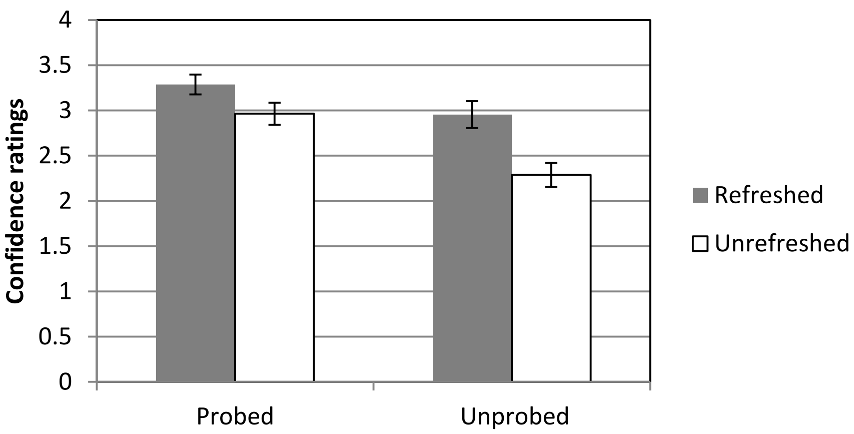

Figure 4. 6. Experiment 5 memory test – refresh effect on non-switch English words. Refreshing produced significantly higher confidence ratings in both probed and unprobed conditions. Error bars represent standard error of means.

Equivalent words Similar ANOVA analysis was performed on equivalent words to test if refresh and probe treatment had any subsequent effects on later recognition of equivalent words. However, no significant effects were reported (*p*s > .05). The refresh × probe ANOVA revealed main effect of refresh (*F* (1, 17) = 1.00, *MSE* = .060, *p* = .331, η_p^2 =

.056), main effect of probe (F (1, 17) = .062, *MSE* = .039, p = .807, η_p^2 = .004) and interaction refresh × probe (F (1, 17) = 1.32, *MSE* = .026, p = .267, η_p^2 = .072).

ii. Non-switch Malay trials

Real words A 2 (refresh: refreshed or unrefreshed) × 2 (probe: probed or unprobed) repeated measures ANOVA was conducted with the confidence rating as the dependent variable. A significant main effect of refresh (F (1, 17) = 22.87, *MSE* = .170, p < .001, η_p^2 = .574) showed that refreshed words (M = 2.83, *SE* = .124) produced higher confidence rating compared to unrefreshed words (M = 2.37, *SE* = .106). A significant main effect of probe (F (1, 17) = 39.94, *MSE* = .063, p < .001, η_p^2 = .701) showed that probed words (M = 2.79, *SE* = .113) produced higher confidence ratings compared to unprobed words (M = 2.41, *SE* = .104). The pattern of results found in this analysis was also similar to effects in non-switch English trials. No significant interaction was reported (F (1, 17) = .112, *MSE* = .069, p = .742, η_p^2 = .007).

Equivalent words A similar refresh × probe ANOVA analysis was performed on equivalent words. There was a significant main effect of refresh (F (1, 17) = 6.20, MSE = .039, p = .023, η_p^2 = .267) indicating that refreshed words (M = 1.89, *SE* = .089) produced higher confidence ratings than unrefreshed words (M = 1.78, *SE* = .092). This pattern suggests an indication of false memory as refreshing the real words in Malay. Participants mistakenly think that they have also seen the equivalent word in English which did not appear during the refresh task. There were no significant main effect of probe (F (1, 17) = 1.29, *MSE* = .059, p = .273, η_p^2 = .07) and refresh × probe interaction effect (F (1, 17) = .168, *MSE* = .037, p = .687, η_p^2 = .01).

Switch trials

Real and equivalent words from switch trials Participants would have seen some version of the real word during the refresh trials that were then used in the memory task. They may have been exposed to both the real word during the initial presentation and the equivalent words during the probe task. However, if there were no probe effect on the word, it meant participants were only exposed to the real word during the initial presentation. The equivalent words in this switch trial context differed from non-switch trials because participants would have been exposed to equivalents during the probe task. In order to examine whether refresh leads to an enhancement on memory retrieval, conditions were collapsed across languages for further analysis.

To test whether participants were able to identify real words from foils, refresh and probe words were collapsed in order to compare between real and equivalent words. A One-way ANOVA was conducted comparing foil, real and equivalent indicated real words (M = 2.92, SE = .087) which found higher confidence ratings compared to foils (M = 1.71, SE = .092) and equivalents (M = 1.87, SE = .104; F (2, 34) = 185.16, p < .001, η_p^2 = .916). This indicated participants were able to correctly identify words that they had seen during refresh trials. In the following analyses, confidence ratings of real and equivalent words were collapsed across conditions in order to test whether refreshing or probing treatment would impact memory retrieval.

To test for refresh and probe effects in switch trials, languages were collapsed across the real and equivalent words. A 2 (probe: probe or unprobe) × 2 (refresh: refreshed or unrefreshed) × 2 (type: real or equivalent) repeated measures ANOVA was conducted with confidence ratings as the dependent variable. A significant main effect of probe (F (1, 17) = 190.78, MSE = .272, p < .001, η_p^2 = .918) showed that probed words (M = 3.12, SE = .087) produced higher confidence ratings compared to unprobed words (*M* = 2.20, *SE* = .095). A significant refresh effect (F (1, 17) = 45.24, MSE = .071, p < .001, η_p^2 = .727) also showed that refreshed words (*M* = 2.81, *SE* = .086) produced higher confidence ratings compared to unrefreshed words (*M* = 2.51, *SE* = .089). The significant main effect of type (F (1, 17) =26.76, *MSE* = .052, p < .001, η_p^2 = .612) suggested that real words (*M* = 2.76, *SE* = .091) produced higher confidence rating compared to equivalent words (*M* = 2.56, *SE* = .082). There were two significant interactions, including probe × type (F (1, 17) = 112.65, MSE = .071, p < .001, η_p^2 = .869) and refresh × type (F (1, 17) = 24.94, MSE = .046, p < .001, η_p^2 = 595). Other interactions were not significant (*p*s > .05) including probe × refresh (F (1, 17) = .55, *MSE* = .035, p = .470, η_p^2 = .031) and probe × refresh × type (F (1, 17) = 0, *MSE* = .032, p = 1, η_p^2 = 0).

Four post-hoc two-tailed paired sample t-test (Bonferroni corrected p = .0125) compared refresh effect across the probed real words and probed equivalent words. Two significant effects were present. For probed real words, refreshing (*M* = 3.21, *SD* = .371) produced higher confidence ratings than unrefreshing (*M* = 2.76, *SD* = .470; t (17) = 6.05, p < .001). However, there was not a significant refresh effect in unprobed equivalent words (t (17) = 1.43, p = .172). For unprobed real words, results showed that refreshed (*M* = 2.78, *SD* = .419) produced higher confidence ratings than unrefreshed ones (*M* = 2.28, *SD* = .467; t (17) = 6.25, p < .001). However, there was not a significant unprobed equivalent words (t (17) = 2.34, p = .032). Confidence ratings for refresh effects on real words are shown in graph below (see **Figure 4.7**). A table reporting the mean RTs and standard deviation for each condition is reported in Appendix A.11.

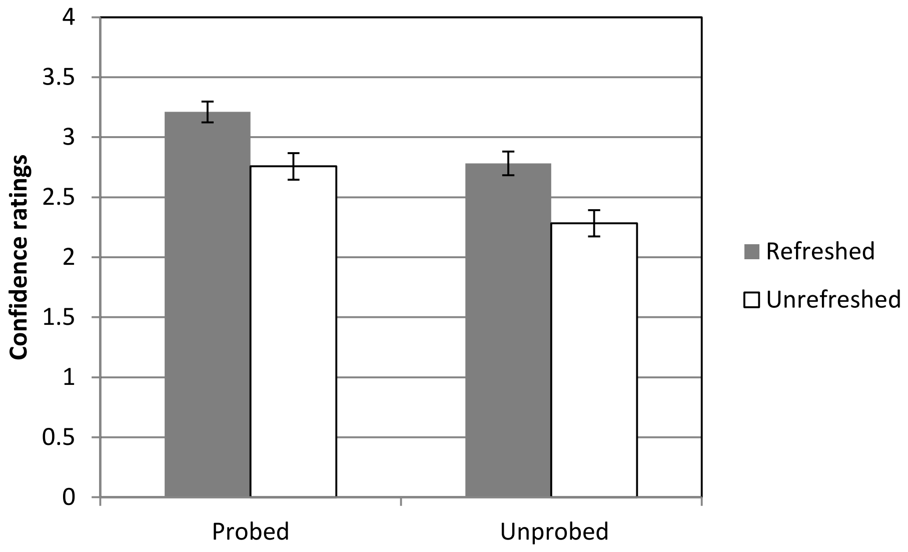

Figure 4. 7. Experiment 5 memory test – refresh effect on real words during switch trial. Real words that were refreshed produced significantly higher confidence in both probed and unprobed conditions. Error bars represent standard error of means.

Experiment 5 investigated a compound of refresh effect and long-term memory of refreshed items as well as participants' strong and weak languages interacted with these mechanisms. In the refresh task, there was an absence of significant rIOR effect characterized by significant slower RTs to recently activated word representation (refreshed condition) but faster RTs to the ignored one (unrefreshed condition). Experiment 6 focused on investigating the language context in which a successful rIOR could take effect. Nevertheless, two significant effects noted in the analyses. Firstly, participants responded to non-switch trials faster than switch trials. This behavioural pattern is expected because language switching was involved. Secondly, participants' responded to English word representation significantly faster compared to Malay. This behavioural performance corresponded with their self-rated language proficiency scores in which English was rated as the stronger or much preferred language.

Although refreshing temporarily impeded access to the representation, it showed evidence of improved long-term memory retrieval. The surprise memory test was administered approximately 20 minutes after participants completed the refresh task. The analyses showed three points about the refresh effect on long-term memory. First, participants successfully identified real words that appeared in the refresh task from foil and equivalent words. Separate analyses were performed based on language in order to examined refresh effects and the presence of equivalent words. The second finding was that refreshed English and Malay words showed enhanced long-term memory retrieval. Additionally, refreshing a Malay word led participants to think they saw the English equivalent that corresponded to the Malay word. This finding is interesting because it is an indication of false memory. Refreshing in a weaker language activated other bilingual word recognition processes which led to this mistake

4.4 EXPERIMENT 6

Introduction

The aim of this experiment was to categorize blocks of trial based on output languages (English or Malay) and language direction (non-switch or switch). In Experiment 5, trials were randomized created an overall mixed language context that may have improved overall executive control performance but reduced the robustness of the rIOR effect. Therefore, blocking the trials the effects of the two types of language modes will be tested more definitively. First, it was hypothesized that a stronger rIOR effect to occur during the non-switch trials in which RTs in refreshed condition would become slower than unrefreshed condition. The second aim was to investigate the switch cost effect more consistently. A slower response to the target would be observed because more cognitive effort is employed in managing the switch between two language domains (Meuter & Allport, 1999). Analogous to predictions in Experiment 5, the inhibition effect when switching to stronger language would be larger compared to switch to weaker language.

Method

Participants The University of Nottingham Malaysia Campus Research Ethics Committee approved all procedures. Twenty-five participants (mean age = 21; 20 females and five males) were recruited from the University of Nottingham Malaysia Campus. One course credit was awarded to psychology students whereas RM10 were awarded to non-psychology students.

A breakdown of participants' ages and self-rated proficiency scores, years of experience and age of acquisition of the languages are listed in the table below. Participants had to rate their proficiency of the language (English or Malay) on a scale of 1 to 7, with 1= "Very poor" to 7 = "Native-like" (see **Table 4.3**). Two-tailed paired sample t-test comparing proficiencies namely, reading (t (24) = .569, p = .547), writing (t (24) = .238, p = .814), speaking (t (24) = 0, p = 1) and listening (t (24) = .891, p = .382) for both languages were not significant suggesting that participants were equally fluent in both. However, note that participants rated Malay as a slightly stronger language compared to English.

	Self-Rated Language proficiency					AoA			Years of experience
	R	W	S	L	Overall	S	R	W	
English	6.04	5.76	5.64	6.0	5.86	4.52	5.08	5.36	13.32
Malay	6.12	5.72	5.64	6.16	5.91	3.44	4.83	5.33	13.17

Table 4. 1. Experiment 6 participants' self-rated proficiency and age of acquisition (AoA). Self-rated proficiency score on a scale of 1 to 7 age of acquisition (AoA) of the language and how many years the participants have been using the language. Although no significant differences between proficiencies were reported, English scores appear to be the lower than the Malay scores.

Materials Stimuli such as English and Malay word items created in Experiment 5 were used in the current design.

Procedure This experiment is similar to the previous design in Experiment 5. The refresh task, post-check task and language background survey were administered for the current experiment. Memory task was excluded in this study as I was focused on obtaining and examining the IOR effect. In the refresh task, trials were categorized into four blocks based on trials (i.e., non-switch or switch). Non-switch trials consisted of both refresh words and probe words derived from the same language (presented in either English or Malay) hence the participants did not have to switch between languages while doing the task. However, during switch trials, the language for both refresh and probe words were different but the words were equivalent. Participants had to either first refresh a word in English then respond in Malay or refresh in Malay then probed in English. Similar to Experiment 5, within each block of trials, participants had to respond to words that were either refreshed or unrefreshed.

This was a within-subject design; the refresh task consisted of 192 trials categorized into four blocks of 48 trials (24 trials per condition). Trials within each block were randomized and the order of each block was randomized. Each block was 6 minutes long and short breaks were given in between blocks. Participants' voice responses were recorded to measure the RTs. A post-check task was used to see if participants were familiar with the word stimuli presented in the experiment and if they would agree that the word pairs were equivalent.

Results and discussion

Post-check analysis

Mean confidence ratings for the post-check survey were 95.70%, in which participants had seen both English and Malay word stimuli and agreed that both words were equivalent. There was one participant who scored lower than 60% which was discarded from analysis.

Refresh task

Outliers were removed from each participant's data at 2.5 standard deviations from the mean and then per-condition means were calculated. Trials whereby participants provided incorrect responses were removed from the subsequent data set. A total of 16.81% of data were removed from the data set due to error such as incorrect responses or technical error in computer voice recording during data collection.

Condition effect

A similar analysis used in Experiment 5 was conducted for the refresh task data. A 2 (trial: non-switch or switch) × 2 (output: English or Malay) × 2 (condition: refreshed or unrefreshed) repeated-measures ANOVA was conducted with response times (RTs) as the dependent variable. There was a significant main effect of trial (F (1, 20) = 18.57, MSE = 2903.95, p < .001, η_p^2 = .481) that indicated non-switch trials (M = 463.05, SE = 10.20) produced shorter RTs compared to switch trials (M = 498.89, SE = 10.38). A significant main effect of condition (F (1, 20) = 15.75, MSE = 231.39, p =.001, η_p^2 = .441) showed shorter RTs in the unrefreshed condition (M = 476.31, SE = 9.33) than in refreshed condition (M = 485.63, SE = 9.63). Participants responded faster to unrefreshed words but slower to refreshed words that they had paid attention to. Two-way trial × condition interaction (F (1, 20) = 39.50, MSE = 225.99, p < .001, η_p^2 = .664) was significant.

Four post-hoc two-tailed paired sample t-tests were conducted (Bonferroni corrected p = .0125) comparing unrefreshed and refreshed conditions across each language pair (e.g., English → English, Malay → Malay, English → Malay and Malay → English). For the

English → English, unrefreshed condition (*M* = 444.84, *SD* = 49.32) was significantly shorter than refreshed condition (*M* = 467.54, *SD* = 55.76; *t* (22) =3.49, *p* = .002). Significant effects were reported for Malay → Malay pair (*t* (23) = 4, p = .001); unrefreshed condition (*M* = 457.03, *SD* = 59.09) produced shorter RTs than refreshed condition (*M* = 475.75, *SD* = 50.92). The faster response to unrefreshed condition confirmed an inhibition effect on refreshed items. RTs for both languages are presented in the graph below (see **Figure 4.8**). The other comparisons that involved a switch (i.e., English → Malay and Malay → English) showed no significant difference between refreshed and unrefreshed conditions. The t-test results for each pair follows: English → Malay pair (*t* (20) =.137, *p* = .893) and Malay → English (*t* (21) = 1.93, *p* = .068). Although there were no significant effects, there was an indication of a priming-like effect whereby the refreshed condition produced shorter RTs compared to unrefreshed condition (see **Figure 4.9**).

Main effect of output was not significant (*F* (1, 20) = 2.99, *MSE* = 2201.33, *p* = .099, η_p^2 = .130). Other two-way interactions including trial × output (*F* (1, 20) = .029, *MSE* = 6387.14, *p* = .868, η_p^2 = .001) and output × condition (*F* (1, 20) = .071, *MSE* = 382.77, *p* = .793, η_p^2 = .004) were not significant. Three-way interaction trial × output × condition was also not significant (*F* (1, 20) = 3.94, *MSE* = 263.19, *p* = .06, η_p^2 = .166). A table reporting the mean RTs and standard deviation for each condition is included in Appendix A.12.

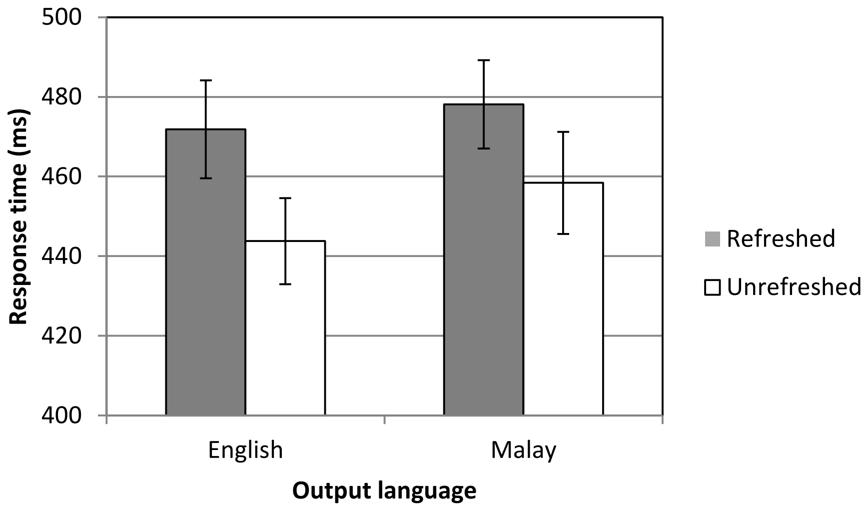

Figure 4. 8. Experiment 6 response times – refresh effect on non-switch trials. For both languages, unrefreshed condition produced significantly shorter RTs than refreshed condition, indicating an inhibition (IOR) effect. This rIOR effect is not language specific as it appears in both English and Malay trials. Error bars represent standard error of means.

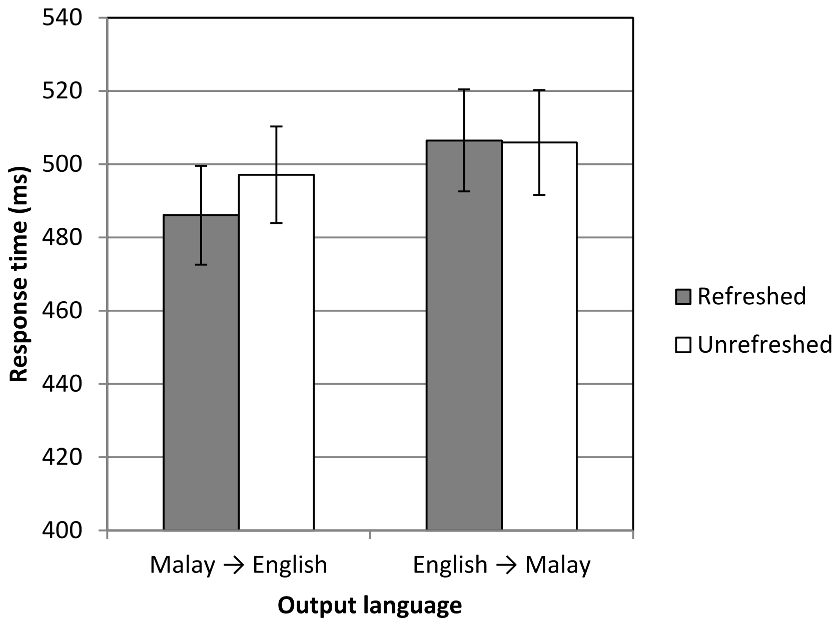

Figure 4. 9. Experiment 6 response times – refresh effect on switch trials (Malay → English and English → Malay). A switch cost appears when participants had to switch between languages during the refresh task. Error bars represent standard error of means.

Switch cost analysis

Similar to language effect analysis conducted in Experiment 5, four two-tailed paired sample t-tests examining language direction (i.e., English → Malay or Malay → English) for both conditions (i.e., refreshed or unrefreshed) were performed. In the refreshed condition, English → English (*M* = 471.87, *SD* = 56.37) produced significantly shorter RTs than English → Malay (*M* = 506.46, *SD* = 63.78; t (20) = 2.63, p = .016). However, there was no significant difference comparing Malay →Malay (*M* = 477.77, *SD* = 49.65) and Malay → English (*M* = 487.25, *SD* = 60.46; t (21) = 1.09, p = .288). In unrefreshed condition, English → English (*M* = 443.79, *SD* = 49.42) produced significantly shorter RTs than English → Malay (*M* = 505.93, *SD* = 65.62; t (20) = 4.95, p < .001). In addition, Malay → Malay (*M* = 459.60, *SD* = 57.53) also produced significantly shorter RTs than Malay → English (*M* = 498.25, *SD* = 59.16; t (21) = 3.52, p = .002). RTs comparison between English → English and English → Malay for both refreshed and unrefreshed conditions are presented in the graph below (see **Figure 4.10**). Similarly, RTs for Malay switching comparisons in both refreshed and unrefreshed are presented in the graph below (see **Figure 4.11**).

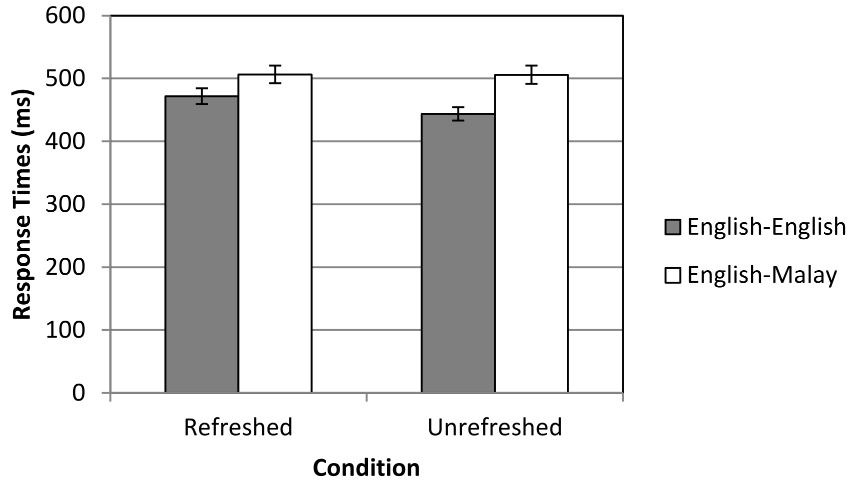

Figure 4. 10. Experiment 6 response times – comparing English → English and English → Malay. Significant switch effects if English → Malay for both refreshed and unrefreshed conditions. Error bars represent standard error of means.

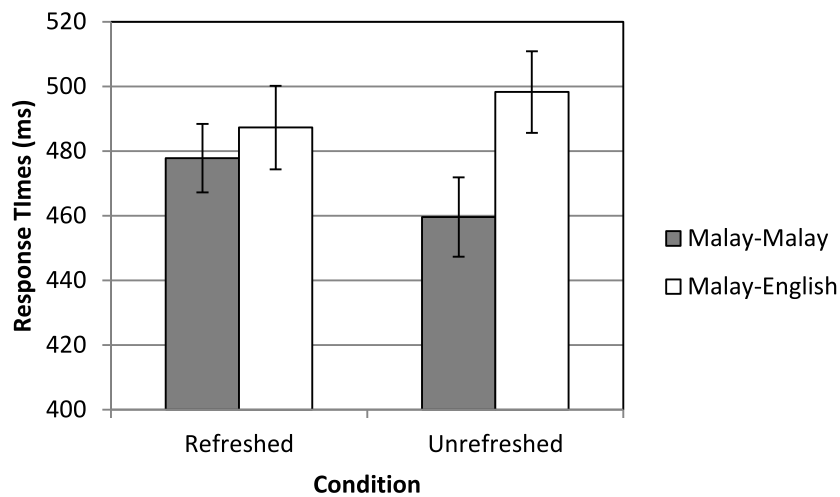

Figure 4. 11. Experiment 6 response times - comparing Malay → Malay and Malay → English. For Malay → English, the switch effect was significant for unrerefreshed condition but not for refreshed condition. Error bars represent standard error of means.

Further analysis examining the main effects of input and output languages by performing a 2 (input: English, Malay) × 2 (condition: refreshed, unrefreshed) × 2 (output: English, Malay) repeated measures ANOVA on RTs was conducted (see Appendix A.13) to give the overall pattern for completeness.

Two points emerged from the refresh data which support the initial hypothesis. The first tested to see whether a robust rIOR effect will emerge, as measured by the short term inaccessibility to recently active mental representations. The data confirmed this pattern as unrefreshed RTs were significantly shorter than refreshed RTs for both English and Malay words during non-switch trials. The second point observed was that when switching from English (weaker language) to Malay (stronger language), there was a significant switching cost for both refreshed and unrefreshed words. On the other hand, switching from Malay to English did not demonstrate a strong switch cost and that refreshing a word in Malay produced almost similar RTs if the probe target word was presented in either Malay or English. This behavioural pattern implicated that refreshing may have priming effect on the weaker language to stronger language link.

4.5 General Discussion

Refresh task

The successful rIOR effect demonstrated in Experiment 4 using English words replicated previous findings (e.g. M.K. Johnson, Reeder, Raye, & Mitchell, 2002; M.R. Johnson et al., 2013) gave rise to further investigation on refreshing and access to two active language representations. In that M. K. Johnson et al. (2002) study, participants saw a word, followed by the same word, a new word, or a dot (cue to refresh) which they had to respond to by saying the word out loud. Response Times (RTs) to refreshed items were longer in comparison to the new or same word. The authors suggested that additional time was needed to refresh an item that was no longer present perceptually. Evidence in Experiment 4 was parallel to their findings although I compared unrefreshed and refreshed word items. Additionally, M. K. Johnson et al. (2002) found that refreshed words were more memorable on later word recognition test in comparison to the read or new word. Experiment 5 also replicated this finding that will be discussed in the section below (Memory test – Experiment 5).

To examine the inhibition effect in the current study, unrefreshed RTs subtracted from the refreshed RTs should produce a positive value. This implicates a short inaccessibility to just refreshed representations (M. K. Johnson et al., 2002; M. R. Johnson et al., 2013). Evidence in Experiment 4 and 6 demonstrated a strong rIOR effect. However, results in Experiment 5 showed this trend in the non-switch trials that was not significant. The reverse to the IOR pattern was found instead in the switch trials the refreshed condition produced shorter RTs than the unrefreshed condition, which suggests attending to the general mental representation that working memory is currently focusing on leads to easier access.

The analyses in Experiment 5 and 6 provided insights to how language switching might mediate the rIOR mechanism. In the condition effect analysis, the significant trial effect indicated that non-switch trials produced shorter RTs compared to switch trials, as overall shorter RTs were observed. This also indicates a switch cost during switch trial when input and output language were incongruent, therefore slowing down the process of accessing from another language domain. This was in line with previous studies on language switching and selection whereby bilinguals showed slower responses to switch trials compared to non-switch trials (Meuter & Allport, 1999). Language switching even in preceding trials resulted in an involuntary processing of the following trial even if participants had anticipated a shift was coming up.

Allport, Styles, & Hsieh (1994, p. 441) termed this as “active disengagement from initial task” can only occur until triggered by the next trial. Therefore, as a result, switch trials showed an increased interference or response conflict between the two trials, and a slower reaction during this conflict.

The switch cost was shown by the significant delay in RTs if participants had to switch between languages compared to the non-switch trials. The current results reflected that the cost of switching to Malay significantly delayed RTs for both refreshed and unrefreshed conditions, whereas the switch to English was not significant. Although there was no significant difference between English and Malay proficiencies among participants, English had a higher global mean proficiency score suggesting participants had a stronger grasp in English compared to Malay. According to Meuter and Allport (1999), asymmetrical cost is measured when switching between the dominant language (L1) and weaker language (L2), the cost of switching to L1 is larger than to L2. According to this logic, switching to English (stronger language) should produce a significant cost such as a larger delay in RTs compared to switching to Malay (weaker language). However, the analysis did not reflect this pattern, and there was a significant cost when switching to Malay. The refresh act may have offset the switch cost effect even though a significant refresh effect was not obtained in the current analysis. Henceforth, this was further explored in the following experiment (Experiment 6).

Another reason for slower response could be due the fact that bilinguals are slower in naming tasks because two active languages and lexical access are non-selective according to BIA+ model (see review Kroll, Sumutka, & Schwartz, 2005; Dijkstra & Van Heuven, 2002). The refresh interval that determines how long the mental representation would stay active and the magnitude would have an impact on subsequent suppression or enhancement effect which will be further investigate in the next experimental chapter. Meuter and Allport (1999) found in a naming task, responses are faster and more accurate in L1 than in L2. And the reason for this was suppressing a weaker language (L2) is relatively easier therefore the switch to dominant language (L1) would also be an easy transition (MacNamara, 1967). The current data in Experiment 6 showed that refreshing primed the word representation at an activated state, facilitating a switch to the weaker language, therefore it is worth examining whether refresh duration would impact the overall switch cost.

The data showed a trend for an IOR effect, although no significant effect was reported in the non-switch language context which was initially hypothesized in Experiment 5. However, once the trials were arranged into blocks based on language and trial type. As a result, this organization produced two language modes such as monolingual mode (non-switch) and bilingual mode (switch) in which participants would operate. The reason for this result could be because trials were not blocked based on language, so both lexicons were equally active during the experiment. According to Wu and Thierry (2013), mixed language contexts can shift executive function to an enhanced functional level thus improving the effectiveness in resolving nonlinguistic conflict resolution. The enhanced functional level primed by mixed language context in the Experiment 5 could explain the absence of rIOR effect in the results. However, trials in Experiment 6 were separated trials into non-switch and switch language contexts. As a result, a significant rIOR was observed in non-switch trial while priming and switch cost were observed in switch trial.

Memory test (Experiment 5)

Experiment 5 recall memory analysis showed, as it was initially hypothesized, that refresh effect enhanced memory retrieval. The novelty of this design was in examining the influence of languages in refresh experimental paradigm which previous related study did not investigate (M. R. Johnson et al., 2013; M. K. Johnson et al., 2002). Word items that were used during the refresh task were tested in the later memory task to examine if the participants could correctly identify between real from the former task to foil words and secondly, if refresh or probe effects enhanced memory retrieval. Despite word items derived from non-switch or switch trials, participants were able to correctly identify original words from the foils. Investigating words from non-switch trials allowed for comparison between original words and equivalent words. In addition, the effects refreshing or probing were examined whether the memory retrieval on both types of words would be enhanced or suppressed. The results showed that refreshing did enhance later memory retrieval for that item and this benefit was present in both languages (i.e., English and Malay). However, the probe effect differed from the refresh effect because the word reappeared on screen again allowing participants to potentially re-learn the word instead of a cue directing attention to a word. This effect was present for both languages. This was in line with previous literature that a brief refresh can lead to long term memory benefits (M. K. Johnson et al., 2002; M. R. Johnson et al., 2013). In addition, this benefit also extended to switch trials which suggest both lexicons were activated.

M. K. Johnson and colleagues (2002) found that foregrounding a mental representation by refreshing can increase long-term memory for refreshed item relative to unrefreshed words in which was repeated in the current experiment. However, when tested if this effect will persist across languages, for example if a word was refreshed in one language (real word) but asked in another language (equivalent) in later memory task, would the refresh effect enhance memory retrieval for the original word despite the confusion in which participants may mistakenly identified equivalents as the real word item. In such cases, this would indicate that refreshing may contribute to incidences of false memory. This was evident within Malay words in which participants indicated that they had a weaker grasp on compared to English. They were more likely to mistakenly think that they have seen the equivalent instead of the original words from the refresh trials. According to previous related experimental evidence, false memories are memories for events that did not occur the way we remember them (M. K. Johnson & Raye, 1981; Loftus, 1979) and they occurred because imaginations were wrongly judged to be memories for perceived events, also known as reality-monitoring failures (e.g., M. K. Johnson & Raye, 1981, 2000). Similarities between perceived and refreshed items may also be a contributing factor towards the increase of false memories. Based on the source monitoring framework, Henkel and colleagues (Henkel & Franklin, 1998; Henkel, M. K. Johnson, & De Leonardis, 1998) suggested features from perceived object can be activated upon testing of imagined objects then misattributed as an imagined object. The more intense the similarities between perceived and imagined objects, the more likely false memories are likely to occur.

In addition, L1 and L2 language proficiency may influence lexical encoding of words (Sampaio & Konopka, 2013). The authors tested the memory retention of surface form in monolinguals and bilinguals with using a set of sentence pairs with different surface forms but share the same meaning (e.g., “The bullet *hit/struck* the bull’s eye”). The memory for these sentence pair was tested with a cued recall procedure and the results showed that non-native speakers outperformed native speakers in retention of surface. In other words, if the word “struck” was used, non-native speakers were less likely to reconstruct the context with a preferred word item like “hit”. This behavioural pattern suggested that L2 processing involved more intensive encoding of lexical information compared to L1. The current finding was in line with logic such that refreshing in weaker language improved memory performance. Additionally, according to Revised Hierarchical Model (RHM) from Kroll and Stewart (1990, 1994), the L2-L1 link is much stronger compared to L1-L2 link because learners rely heavily on L2-L1 link for L2 lexical and semantic processing. As a result, it is possible when refreshing in the weaker (Malay) language, the same word in the stronger (English) language becomes activated; therefore, participants made a mistake in thinking the equivalent word appeared during the refresh task when it did not.

CHAPTER 5

Temporal course and language switching on reflective attention

5.1 Preamble

The results from Chapter 4 (Experiments 5 and 6) suggested that inhibition and facilitation effects can occur in different language contexts within the reflective attention. In the non-switch trials for both languages, an inhibition effect is apparent if words were refreshed compared unrefreshed words (longer RTs). However, in switch trials where participants had to switch between languages, a priming-like effect was observed instead. Refreshing a word would facilitate RTs to the subsequent target word. The current chapter explored the time course at which these effects take place in further detail by testing refreshing at 1400ms, 1700ms and 2000ms. Due to the absence of IOR effect in switch trials as exhibited in Experiments 5 and 6, it is worth exploring a set of refresh durations to identify the onset of a delayed rIOR which may be caused by word retrieval problems in bilingual speakers; for example, more tip-of-the-tongue (TOT) experiences among bilingual speakers than in monolingual speakers. (Gollan & Acenas, 2004; Gollan & Silverberg, 2001; Gollan, Bonanni, & Montoya, 2005; Gollan, Ferreira, Cera & Flett, 2014; Pyers et al., 2009).

Klein (2000) identified that the onset of IOR begins at cue-to-target SOA of 22ms. The onset of IOR is related to attentional demands of performing a task like a discrimination task where the onset of IOR occurs later compared to when using a detection task (Lupianez, Milan, & Tornay, 1997). The concept of attentional control setting (ACS) proposed the onset of IOR can vary with the difficulty of task. Changing ACS requires time similarly to the task switching. The higher the intensity of a task, the more intensely attention is applied on the cue, thus the longer attention will dwell on it as a consequence. As a result, facilitation towards the cued location would last longer and more target processing is required for successful performance. A stronger attentional engagement could lead to longer dwell times, hence resulting in late onset of IOR. Sufficient time for attention to dwell on the cue should lead to successful target processing, which may lead to higher motivation to remove attention from the cue.

As discussed in Chapter 2, Bilingual speakers tend to experience more tip-of-the-tongue (TOT) states, characterized by incapability of retrieving a familiar word, than monolingual speakers (Gollan & Acenas, 2004; Gollan & Silverberg, 2001; Gollan et al., 2005; Gollan et al., 2013; Pyers et al., 2009). According to frequency-lag hypothesis, bilingual speaker use each of their languages less frequently than monolingual speakers, so the inter-level connections between phonological and semantic levels of the lexical nodes in will be weaker thus, slowing speech production of the intended word (Gollan & Acenas, 2004; Gollan, Slattery, Goldenberg, Van Assche, Duyck, & Rayner, 2011). Altogether, these factors could contribute to the current finding of a delayed rIOR effect. Similar to Experiment 6 (Chapter 4), I predicted a distinct IOR effect in non-switch trials would emerge but at a later duration (i.e., 2000ms).

Additionally, the Asymmetrical Switch Costs could also contribute to the lack of rIOR in switch trials. The rationale of Asymmetrical Switch Cost is based on the assumption that the cost of switching between a dominant language (L1) and non-dominant language (L2) is larger than the cost of switching to L2 (Meuter & Allport, 1999). Similar to the research question of this experiment, in order to engage in weaker language, an active inhibition is needed for the competing and stronger language. The momentum of this inhibition persists to the following trial. First, there would be a delay in RTs, with prolonged attention due to task difficulty and suppression of languages further enhanced as demanded by the rapid switch. These mechanisms would obscure the onset of IOR for switch trials.

5.2 EXPERIMENT 7

Introduction

This final experiment in this thesis consisted of three aims. The first was to determine the time course of IOR in reflective attention. IOR has been studied extensively as an external attention in the peripheral domain but not in internal attention. I expect to repeat previous findings, in which the onset IOR effect is observed if RTs in refreshed (cued) representation becomes slower than unrefreshed (uncued). During the non-switch trials, the onset of IOR is at later refresh duration (2000ms). However, if languages were incongruent between cue and target, IOR would be obscured due to an asymmetrical switch cost. The second aim was to test whether attentional engagement at a cue was longer, providing for sufficient time for information processing then priming towards cued target word equivalent to the cue would be observed instead of inhibition. The third aim investigated whether refreshing a word in similar language would improve later retrieval in a memory test, also if encoding a related word/concept would create a false memory effect.

Method

Participants The University of Nottingham Malaysia Campus Research Ethics Committee approved all procedures. Twenty-four participants (mean age = 21; 16 females and eight males) were recruited from the University of Nottingham Malaysia Campus. One course credit was awarded to psychology students whereas RM10 were awarded to non-psychology students.

A breakdown of participants' ages and self-rated proficiency scores, years of experience and age of acquisition (AoA) of the language are listed in the table below. Participants had to rate their proficiency of the languages (i.e., English or Malay) on a scale of 1 to 7, with 1= "Very poor" to 7 = "Native-like" (see **Table 5.1**). Two-tailed paired sample t-test comparing proficiencies namely, reading (t (23) = 1.66, p = .110), writing (t (24) = .87, p = .396), speaking (t (23) = 1.14, p = .267) and listening (t (23) = 1.56, p = .133) for both languages were not significant suggesting that participants were equally fluent in both. However, note that participants rated English as a slightly stronger language compared to Malay.

	Self-Rated Language proficiency					AoA			Years of experience
	R	W	S	L	Overall	S	R	W	
English	6.08	5.58	5.46	5.75	5.72	3.54	3.96	4.43	14.67
Malay	5.79	5.38	5.13	5.42	5.43	4.21	4.75	4.83	13.30

Table 5. 1. Experiment 7 participants' self-rated proficiency and age of acquisition (AoA). Self-rated proficiency score on a scale of 1 to 7, age of acquisition (AoA) of the language and how many years they have been using the language (R = reading; W = writing; S = speaking; L = listening). Although no significant differences between proficiencies were reported, English appears to be the stronger language and Malay as the weaker one.

Materials Stimuli such as English and Malay word items created in Experiment 5 were used in the current design.

Procedure The study included the experimental tasks similar to Experiment 6 except with one main difference. The refresh duration was varied among 1400ms, 1700ms and 2000ms whereas in Experiment 6 it was only 1500ms. In addition, the memory task was also added to this design (see **Figure 5.1**).

Screen Start of task --→ End of task					
First fixation (1000ms)	**Initial Display (1500ms)**	**Second fixation (500ms)**	**Refresh (1400ms, 1700ms or 2000ms)**	**Probe Task**	**Condition**
Non-switch trial					
+	cat + house	+	^ (say "cat")	cat	*Refreshed*
+	cat + house	+	^ (say "cat")	house	*Unrefreshed*
Switch trial					
+	cat + house	+	^ (say "cat")	kucing	*Refreshed*
+	cat + house	+	^ (say "cat")	rumah	*Unrefreshed*

Figure 5. 1. Experiment 7 refresh task design. Sequence of events in current experimental design and this differs from Experiment 6 as refresh duration varied instead of constant 1500ms.

Results and discussion

Post-check analysis

Mean confidence ratings for the post-check survey were 81.09%, in which participants had seen both English and Malay word stimuli and agreed that both words were equivalent in meaning.

Refresh task

Similar analysis as experiments in Chapter 4 was conducted, with duration as the new variable included in the analysis. Mean response times (RTs) per condition were calculated after outliers were removed at 2.5 standard deviations from each participant's data. Trials whereby participants provided incorrect responses were removed from the subsequent data set. A total of 7.47% of data were removed from the data set due to error such as incorrect responses or technical error in computer voice recording during data collection.

There were three specific questions aimed to investigate in the refresh task. The first was to identify the presence of a rIOR effect; the refreshed condition should produce slower responses whereas the unrefreshed condition should produce shorter RTs. In addition, would this be significant for both languages. The second analysis investigated rIOR within a range of refresh durations. And finally, the third analysis investigated the language switch cost across both refreshed and unrefreshed conditions.

Condition effect

A 2 (trial: non-switch or switch) × 2 (output: English or Malay) × 2 (condition: refreshed or unrefreshed) × 3 (duration: 1400ms, 1700ms or 2000ms) repeated-measures ANOVA with response times as the dependent variable. There was a significant main effect of trial (F (1, 21) = 12.91, MSE = 14807.89, p = .002, η_p^2 = .381) with shorter RTs in the non-switch trials (M = 457.27, SE = 11.92) compared to the switch trials (M = 495.32, SE = 9.96). A significant main effect of condition was also found (F (1, 21) = 6.69, MSE = 804.68, p = .017, η_p^2 = .242) indicating shorter RTs observed in the unrefreshed condition (M = 473.10, SE = 9.95) compared to the refreshed condition (M = 479.49, SE = 9.44). A significant trial × condition interaction (F

(1, 21) = 38.57, *MSE* = 1269.61, p < .001, η_p^2 = .647) was also found. Pairwise comparisons showed that in non-switch trials, unrefreshed condition (*M* = 444.45, *SE* = 13.11) produced shorter RTs compared to refreshed condition (*M* = 470.09, *SE* = 11.05).

Main effect of output (*F* (1, 21) = 3.13, *MSE* = 24267.04, p = .091, η_p^2 = .091) and main effect of duration (*F* (2, 42) = .01, *MSE* = 584.02, p = .990, η_p^2 = 0) were not significant. Two-way interactions such as trial × output (*F* (1, 21) = 3.93, *MSE* = 10441.47, p = .061, η_p^2 = .157), output × condition (*F* (1, 21) = 1.40, *MSE* = 658.33, p = .250, η_{p}^2 = .062), condition × duration (*F* (2, 42) = .59, *MSE* = 651.03, p = .557, η_p^2 = .027) plus the interactions were not significant. Other three-way interactions were not significant including trial × output × condition (*F* (1, 21) = .81, *MSE* = 558.89, p = .380, η_p^2 = .037), trial × condition × duration (*F* (2, 42) = .97, *MSE* = 526.22, p = .39, η_p^2 = .044) and output × condition × duration (*F* (2, 42) = 3.59, *MSE* = 504.00, p = .036, η_p^2 = .146). Four way interaction trial × output × condition × duration (*F* (2, 42) = 1.99, *MSE* = 417.77, p = .150, η_p^2 = .087) was not significant. A table reporting the mean RTs and standard deviation for each condition is included in Appendix A.12.

This Condition Effect analysis showed two points that shared similar findings in Chapter 4. Firstly, non-switch trials produced faster response compared to switch trials. Secondly, evidence of rIOR effect reflected by the behavioural pattern initially hypothesized that unrefreshed condition RTs was shorter than refreshed condition. In other words, this finding suggested refreshing lead to a short term inaccessibility to just activated representation and that the internal attention is biased to novel representations. Additionally, the absence of a significant main effect of duration suggested that short or long duration did not impact the rIOR mechanism.

Duration effect

The main research question was to test the timeline of the suppression effect. In order to test this, four reduced 2 (condition: refreshed or unrefreshed) × 3 (duration: 1400ms, 1700ms or 2000ms) repeated-measures ANOVAs were performed in the non-switch and switch trials across both languages, including English → English, Malay → Malay, English → Malay and Malay → English trials.

English →English trial There was a significant main effect of condition (F (1, 21) = 16.16, MSE = 913.75, p = .001, η_p^2 = .435), indicating unrefreshed words (M = 443.51, SE = 14.19) produced shorter RTs than refreshed words (M = 464.67, SE = 12.72). There was also a significant duration effect (F (1, 21) = 4.46, MSE = 635.32, p = .017, η_p^2 = .175) indicating 2000ms (M = 448.453, SE = 12.87) produced shorter RTs compared to the 1400ms duration (M = 450.54, SE = 14.84) and 1700ms (M = 463.28, SE = 12.91). The interaction between condition × duration (F (2, 42) = 1.85, MSE = 506.78, p = .169, η_p^2 = .081) was not significant.

Malay → Malay trial A main effect of condition was found that showed the unrefreshed condition was significantly shorter than refreshed condition (F (1, 21) = 33.31, MSE = 899.14, p < .001, η_p^2 = .613). The condition × duration interaction was significant (F (2, 42) = 3.55, MSE = 640.67, p =.038, η_p^2 = .145). Three post-hoc two-tailed paired sample t-test (Bonferroni corrected p = .0167) comparing the condition effect across three durations were all significant. The unrefreshed condition showed shorter RTs at 1400ms (t (21) = 6.28, p < .001), 1700ms (t (21) = 2.59, p = .017) and 2000ms (t (21) = 2.72, p = .013). The main effect of refresh duration was not significant (F (2, 42) = .84, MSE = 558.95, p = .44, η_p^2 = .038). Mean RTs are displayed in the graph below (see **Figure 5.2**).

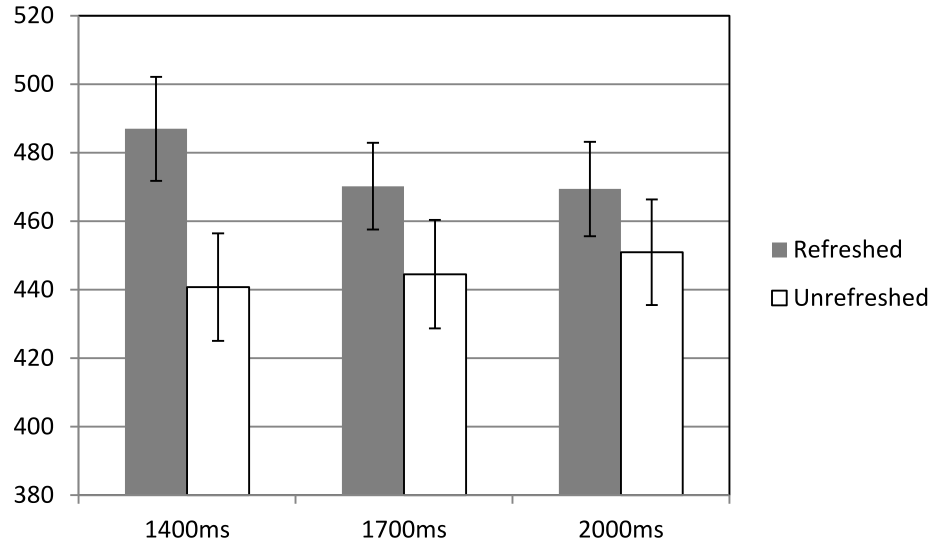

Figure 5. 2. Experiment 7 response times – refresh effect × duration for Malay words. Unrefreshed RTs was significantly shorter than refreshed ones across all durations. Inhibition effect at 1400ms was larger than the other two durations. Error bars represent standard error of means.

English → Malay trial The main effect of condition was significant (F (1, 21) = 9.73, MSE = 493.92, p = .005, η_p^2 = .317) showed that the refreshed condition (M = 510.19, SE = 15.18) produced shorter RTs than the unrefreshed condition (M = 522.16, SE = 15.09). The main effect of duration (F (1, 21) = .41, MSE = 499.09, p = .668, η_p^2 = .019) and the condition × duration interaction (F (1, 21) = .02, MSE = 446.84, p = .983, η_p^2 = .001) effects were not significant.

Malay → English trial The main effect of condition was also significant (F (1, 23) = 7.41, MSE = 936.82, p = .012, η_p^2 = .244), suggesting the refreshed (M = 472.30, SE = 12.07) condition produced shorter RTs than the unrefreshed condition (M = 486.28, SE = 12.47). The main effect of duration (F (2, 46) = 1.28, MSE = 636.70, p = .289, η_p^2 = .053) and the condition

× duration interaction (F (2, 46) = .54, MSE = 474.09, p = .59, η_p^2 = .023) effects were not significant.

The Duration Effect analysis showed that refresh duration had a significant impact on Malay words in non-switch trial. Participants showed significantly faster response to unrefreshed words compared to refreshed words at all refresh durations (i.e., 1400ms, 1700ms and 2000ms). Refresh duration did not show a strong impact on English words in non-switch trial as behavioural pattern reflected that participants responded faster if they had refreshed a word at 2000ms.

Switch cost analysis

The changes in refresh duration were too subtle to affect switch cost in this experiment therefore conditions were collapsed across duration. Similar to language effect analysis conducted in Experiment 5, four two-tailed paired sample t-test examining language direction (i.e., English → Malay or Malay → English) for both conditions (i.e., refreshed or unrefreshed) were performed. In the refreshed condition, English → English (M = 464.67, SD = 59.65) produced significantly shorter RTs than English → Malay (M = 510.09, SD = 71.21; t (21) = 2.52, p = .02). However, RTs comparison between Malay → Malay and Malay → English did not show significant difference (t (21) = .52, p = .611). In unrefreshed condition, English → English (M = 443.51, SD = 66.55) produced significantly shorter RTs than English → Malay (M = 522.16, SD = 70.77; t (21) = 4.52, p < .001). However, there was no significant difference between Malay → Malay RTs and Malay → English (t (21) = 1.83, p = .081). The significant difference between English → English and English → Malay for both refreshed and unrefreshed conditions are displayed in the graph below (see **Figure 5.3**).

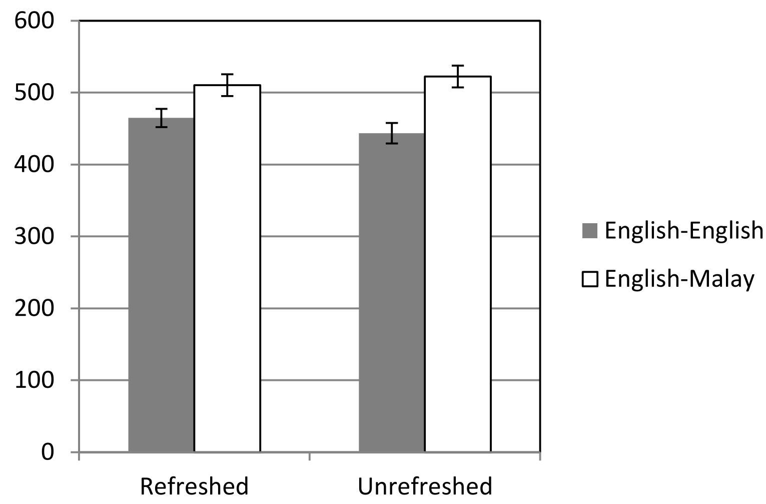

Figure 5. 3. Experiment 7 response times comparing English → English and English → Malay. Cost of switching to Malay is measured by the delayed RTs compared to conditions that did not have a switch. This cost was significant for refreshed and unrefreshed conditions. Error bars represent standard error of means.

Further analysis examining the main effects of input and output languages by performing a 2 (input: English, Malay) × 2 (condition: refreshed, unrefreshed) × 2 (output: English, Malay) repeated measures ANOVA on RTs is included (see Appendix A.15) to give the overall pattern for completeness.

Memory test

The analysis is divided into two sections: (1) non-switch and (2) switch. The main aim was to investigate if refresh treatment did enhance memory retrieval in real words or enhance false memory by increasing confidence ratings in equivalent words. A table reporting the mean RTs and standard deviation for each condition is reported in Appendix A.16.

<u>Non-switch trials</u>

The refresh and probe conditions were collapsed across to produce only one word type factor that contained all three levels including real, foil and equivalent words. A 3 (type: foil, real or equivalent) × 2 (language: English or Malay) repeated measures ANOVA with confidence ratings as the dependent variable was performed. There was a significant main effect for word type (F (2, 44) = 85.31, MSE = .092, p < .001, η_p^2 = .795), real words (M = 2.57, SE = .104) correctly identified compared to foils (M = 1.74, SE = .110) and equivalents (M = 2.16, SE = .089). There was also a significant main effect of language (F (1, 22) = 16.16, MSE = .035, p = .001, η_p^2 = .424) which showed that English words (M = 2.22, SE = .095) produced higher confidence ratings compared to Malay words (M = 2.10, SE = .097). A significant type × language interaction was also present (F (2, 44) = 3.75, MSE = .044, p = .031, η_p^2 = .146).

Three post-hoc two-tailed paired sample t-tests (Bonferroni adjusted p = .017) compared languages for all word types showed that English real words (M = 2.70, SD = .541) produced higher confidence ratings than Malay real words (M = 2.44, SD = .523; t (22) = 3.31, p = .003). Languages did not differ significantly in terms of foil (t (22) = 2.29, p = .032) or equivalent words (t (22) = .71, p = .487). Confidence ratings are presented in the graph below (see **Figure 5.4**). The overall results support the fact that participants could correctly identify real words in the refresh trial from the foil and equivalent words.

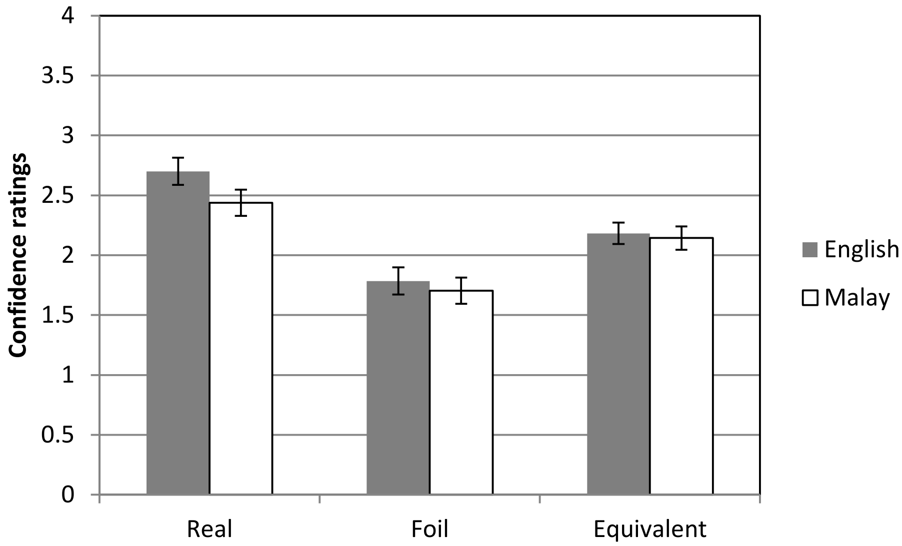

Figure 5. 4. Experiment 7 memory test – confident ratings for all word types. Word types (i.e. real, foil and equivalent) across both English and Malay, real words were correctly identified compared to foil and equivalent words. English words also produced significantly higher confidence ratings than Malay words. Error bars represent standard error of means.

The following analyses investigated the presence of refresh benefit and probe effects on memory performance for both real and equivalent word items across both languages (English and Malay). A 2 (refresh: refreshed or unrefreshed) × 2 (probe: probed or unprobed) repeated measures ANOVA with confidence rating as the dependent variable was performed for each language (i.e., English or Malay) and word type (i.e., real or equivalent).

i. <u>Non-switch English trials</u>

Real words The ANOVA revealed significant main effect of probe (F (1, 22) = 80.88, MSE = .177, p < .001, η_p^2 = .786) showed that words that were probed yielded higher ratings (M = 3.09, SE = .122) than unprobed (M = 2.31, SE = .120). The main effect of refresh (F (1, 22) = .028, MSE = .132, p = .869, η_p^2 = .001) and refresh × probe interaction (F (1, 22) = .001, MSE = .098, p = .978, η_p^2 = 0) were not significant.

Equivalent words The ANOVA revealed significant main effect of probe (F (1, 22) = 74.48, MSE = .128, p < .001, η_p^2 = .772), probed words (M = 2.47, SE = .094) had higher confidence ratings than unprobed words (M = 1.82, SE = .115). A significant main effect for refresh (F (1, 22) =109.58, MSE = .071, p < .001, η_p^2 = .833), showed refreshed words (M = 1.85, SE = .110) had lower confidence ratings than unrefreshed words (M = 2.43, SE = .093). The probe × refresh interaction was also significant (F (1, 22) = 103.64, MSE = .074, p < .001, η_p^2 = .825).

Two post-hoc two-tailed paired sample t-tests (Bonferroni adjusted p = .025) were conducted to compare between the refresh effect on both probed and unprobed words. For probed words, refreshing (M = 1.89, SD = .525) led to lower confidence ratings compared to unrefreshed ones (M = 3.04, SD = .481; t (22) = 12.12, p < .001). For unprobed words, refreshing was not significant (t (22) = .062, p = .951). Confidence ratings are presented in the graph below (see **Figure 5.5**).

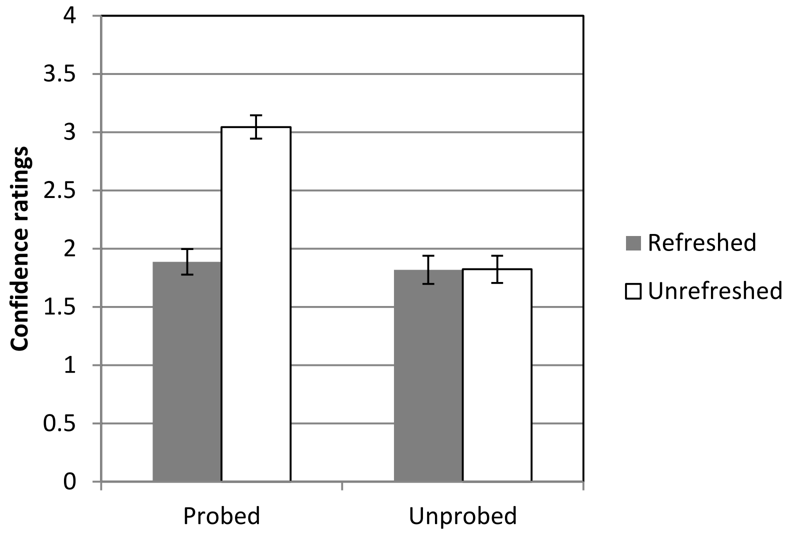

Figure 5. 5. Experiment 7 memory test - refresh effect on equivalent English words. For probed words, refreshed had significantly higher confidence ratings than refreshed one. Error bars represent standard error of means.

ii. Non-switch Malay trials

Real words The ANOVA revealed a significant main effect of probe (F (1, 22) =27.46, p < .001, η_p^2 = .555) which showed that probed words (M = 2.69, SE = .114) had higher confidence ratings than unprobed words (M = 2.18, SE = .125). Both the main effect of refresh (F (1, 22) = 3.12, MSE = .214, p = .091, η_p^2 = .124) and refresh × probe interaction effect (F (1, 22) = 2.71, MSE = .081, p = .114, η_p^2 = .110) were not significant.

Equivalent words The ANOVA revealed a significant main effect of probe (F (1, 22) = 47.53, MSE = .187, p < .001, η_p^2 = .684) which showed that probed words (M = 2.49, SE = .099) produced higher confidence ratings than unprobed words (M = 1.87, SE = .10). Main effect of refresh (F (1, 22) = 27.46, MSE = .335, p < .001, η_p^2 = .555) was significant; refreshed words (M = 2.50, SE = .101) produced higher confidence ratings than unrefreshed words (M = 1.87, SE

= .11). There was also a significant probe × refresh interaction (F (1, 22) = 37.00, MSE = .202, p < .001, η_p^2 = .627).

Two post-hoc two-tailed paired sample t-tests (Bonferroni adjusted p = .025) were performed to compare the refresh effect on both probed and unprobed words. For probed words, refreshing (M = 3.09, SD = .785) produced higher confidence ratings compared to unrefreshing (M = 1.89, SD =.496; t (22) = 6.32, p < .001). Refreshing did not have a significant effect on unprobed words (t (22) = .602, p = .553). Confidence ratings for this analysis were presented in the following graph (see **Figure 5.6**).

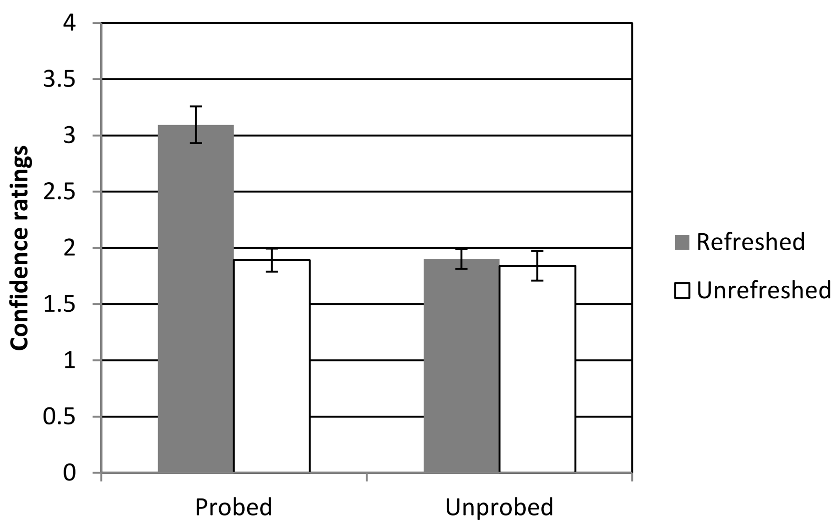

Figure 5. 6. Experiment 7 memory test - refresh effect on equivalent Malay words. Refreshed produced significantly higher confidence ratings for probed words. No significant effect was present for unprobed words. Error bars represent standard error of means.

<u>Switch trials</u>

A one-way ANOVA was conducted comparing foil, real and equivalent word items and showed that real words produced higher confidence ratings compared to foil and equivalent words (*F* (2, 44) = 105.84, *MSE* = .027, p < .001, η_p^2 = .828). Participants correctly identified real words (*M* = 2.44, *SD* = .498) from foil (*M* = 1.74, *SD* = .528) and equivalent (*M* = 2.09, *SD* = .487) words that did not appear during the refresh task. In order to examine the hypothesis whether refreshing leads to an enhancement effect on memory retrieval, conditions were collapsed across languages for further analysis.

Real and equivalent words from switch trials A 2 (probe: probe or unprobe) × 2 (refresh: refreshed or unrefreshed) × 2 (type: real or equivalent) repeated measures ANOVA with confidence ratings as dependent variable was performed. A significant main effect of probe (*F* (1, 22) = 31.45, *MSE* = .104, p < .001, η_p^2 = .588) showed if words were probed, the confidence rating (*M* = 2.31, *SE* = .102) reduced compared to unprobed words (*M* = 2.58, *SE* = .104). There was also a significant main effect of refresh (*F* (1, 22) = 5.11, *MSE* = .122, p = .034, η_p^2 = .189) suggesting that refreshed words (*M* = 2.50, *SE* = .105) produced higher confidence ratings than unrefreshed words (*M* = 2.39, *SE* = .102). There was a significant main effect of type (*F* (1, 22) = 74.47, p < .001, η_p^2 = .772) showed that real words (*M* = 2.72, *SE* = .114) produced higher confidence ratings than equivalent words (*M* = 2.17, *SE* = .095). There was also a significant probe × type interaction (*F* (1, 22) = 36.97, *MSE* = .190, p < .001, η_p^2 = .627).

In order to compare refresh effects across probed real words and probed equivalent words, four post-hoc two-tailed paired sample t-tests (Bonferroni adjusted p = .0125) were performed. For equivalent words that were probed, refreshing (*M* = 1.96, *SD* = .494) produced higher confidence ratings than unrefreshing (*M* = 1.82, *SD* = .556; *t* (22) = 2.93, p = .008). Unprobed equivalent words showed no refreshing effect (*t* (22) = .7, p = .491). Confidence ratings for this comparison across these conditions are shown in the graph below (see **Figure**

5.7). For real words, no significant refresh effects were found for probed (*t* (22) = 2.37, *p* = .027) and unprobed words (*t* (22) = .536, *p* = .597).

Other two-way interactions were not significant were probe × refresh (*F* (1, 22) = 2.59, *MSE* = .083, *p* = .122, η_p^2 = .105), refresh × type (*F* (1, 22) = .384, *MSE* = .050, *p* = .542, η_p^2 = .017) and three way interaction probe × refresh × type (*F* (1, 22) = .715, *MSE* = .024, *p* = .407, η_p^2 = .031) were not significant. A table reporting the mean RTs and standard deviation for each condition is reported in Appendix A.17.

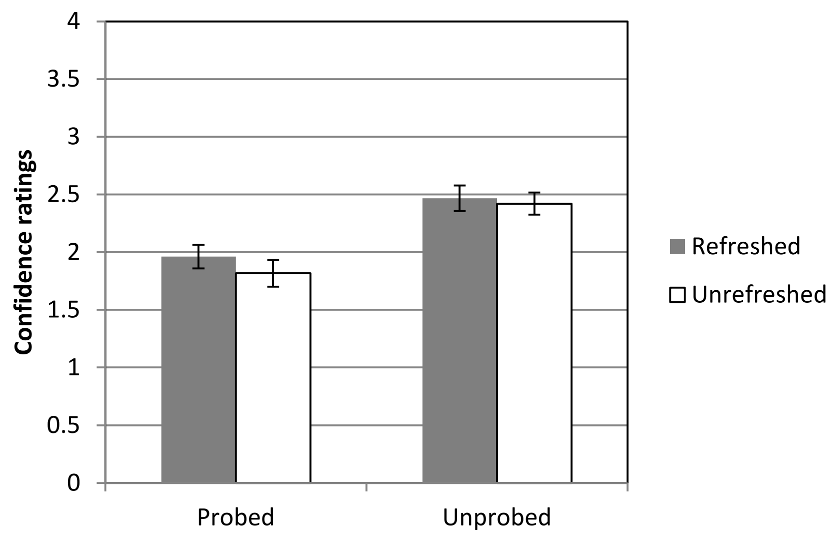

Figure 5. 7. Experiment 7 memory test – refresh effect on equivalent words during switch trial. Refreshed probed words produced significantly higher confidence ratings than unrefreshed. However, this refresh effect was not significant for unprobed words. Error bars represent standard error of means.

5.3 General Discussion

Refresh task

Three main aims were investigated in this analysis in providing insights on time course of rIOR (i.e., unrefreshed RTs faster than refreshed RTs) and how the rIOR effect might be modulated depending on language context. I acknowledged the fact whether bilinguals have shared or separate lexicons are under debate (see Chapter 2) but I do not favour a specific view in interpreting the data. However, certain language models are used in order to help explain how language can influence reflective attention. Firstly, non-switch trials produced shorter RTs compared to switch trials. The explanation for this finding is because as two languages were activated, bilinguals search longer before making a response (Soares & Grosjean, 1984). The authors also compared bilinguals' response to word targets in both monolingual and bilingual speech modes; their response to monolingual speech mode was identical but significantly slower in the bilingual speech mode. Bilinguals also took a longer time to identify non-words in both monolingual and bilingual speech modes. These results suggested that it is impossible for bilinguals to completely deactivate one language mode during a monolingual speech mode. Although the current design is different from Soares and Grosjean (1984) study, the current results showed similar findings when confronted with words under switch trials and in addition, refresh duration did not show a significant interaction under such a context. The second finding showed a significant rIOR effect. The unrefreshed words produced shorter RTs resulting in short term inaccessibility compared to the refreshed representations.

The next analysis was performed to determine at which time point inhibition occurs before being replaced by priming effect. Refreshed representations that were previously activated produced a faster response than the unrefreshed ones. I investigated this in both languages and switch or non-switch contexts. As mentioned, inhibition was primarily observed in non-switch trials and priming in switch trials. In the non-switch English context, a significant inhibition effect observed specifically at 2000ms. This finding was consistent with the initial hypothesis that inhibition occurs after 2000ms of refresh duration. However, this was not consistent as an inhibition effect was observed at all refresh durations (i.e., 1400ms, 1700ms and 2000ms) in Malay language. This asymmetrical bias may be link to participants stronger grasp or preference to English compared to Malay, although no significant differences were found between the two and they did not covariate with refresh RTs. Meuter and Allport (1999) indicated "negative priming" arises from actively inhibiting two mutually competitive lexicons, L1 (the dominant language) which then persisted involuntarily into L2 (the weaker language). The strong inhibition effect is observed consistently at all time points was due to a "carryover" effect of suppressing L1. In sum, these results revealed asymmetrical rIOR is modulated due to different language proficiencies among the bilingual speakers.

The results in the non-switch trials were the opposite of the initial asymmetrical switch costs prediction that a larger cost would occur when switching from L1 to L2 (Meuter & Allport, 1999). According to this prediction, a significant and larger delay when switching to English (L1) and a relatively small cost when switching to Malay (L2) would be observed. However, the current results showed that switching from English → Malay (relatively weaker language, L2) resulted in a significant delay in RTs but switching from Malay → English (stronger language, L1) was not significant. The explanation for this could be that the act of refreshing and the variety of refresh durations that was introduced offset the switch cost and was replaced by "asymmetrical priming" instead. The term was coined by Jiang and Foster (2001) which indicated priming effects in L1-L2 direction are stronger than the L2-L1 direction.

Memory test

Although there was a short-term inaccessibility of the recently refreshed representations, there was a presence of long-term memory benefit for refreshed words as higher confidence ratings were reported. There is a more long term memory recognition benefit when tested on real words that were refreshed. Whatever mechanisms underlie the impairment in responding to refreshed items in the short-term (1s) time scale do not persist after a delay, but crossed over into a long-term memory benefit (by 20min later, in this study).

In sum, real and equivalent words produced different results. For real words, there was a probe effect in which the act of probing produced higher confidence ratings but refreshing did not produce any significant effects as initially expected. This was consistent for both English and Malay words. The interpretation on equivalent words is based on the assumption that equivalent words should show confidence ratings that are similar or at “0” across all conditions because they did not appear during refresh. However, the equivalents are close translations (presented in another language) to real words and refresh and probe effects to the real words may have produced different patterns other than “0”. For English real words, the results indicated equivalent words that were both refreshed and probed produced significantly lower confidence ratings. If a real English word was refreshed and probed in the refresh task, participants were more confident in correctly identifying equivalent words as items that did not appear, hence confidence ratings were lower. However, the unrefreshed probed words produced significantly higher confidence ratings. This suggested only seeing the real without refreshing could lead to false memory as participants made more errors by falsely identifying equivalent words as real words. Refreshing and probing had a reverse effect on Malay real words whereby refreshed and probed effects on real words produced significantly higher confidence ratings for equivalent words, indicating some form of false memory.

The analysis on switch trials showed that refreshing, or thinking back to a presented word produced overall higher confidence ratings. Similarly, presenting the word in another language during the probe task also enhanced confidence ratings. Even though words were presented in both languages during switch trials and participants were likely to see a word in two languages, as the real word during initial presentation and later at the probe task, they were much better at remembering real words. Further analysis also showed if a word was refreshed and shown again in another language in the probe task, this would also enhance confidence ratings for the equivalent words.

CHAPTER 6
General Discussion and Conclusion

6.1 Overview

The primary objective of this thesis was to investigate the time course of reflective attention, whether language switching modulates reflective attention and whether these factors might lead to robust reflective inhibition of return like effect (rIOR). I first examined the time course on primed mental representations using picture stimuli; previous research by M. R. Johnson and colleagues (2013) obtained rIOR by using the detection probe method. The participants pressed a stop button as soon as they detect the probe picture then identified which category it belonged to (i.e., face, chair or house). The studies in this thesis employed an adaptation of this visual stimulus-response paradigm and participants had to name the picture (or word) instead. The first three experiments used picture stimuli (consisting of chairs, faces & houses) while the remaining experiments were presented with word stimuli in either English or Malay. There is no existing research that addresses refreshing in two languages. There are other refresh studies testing factors such as age-related deficits in reflective attention (M. K. Johnson, Reeder, Raye & Mitchell, 2002), implicit semantic interference on reflective access (Higgins & M. K. Johnson, 2013) and neural characteristic of refreshing (Lepsien & Nobre, 2007, M. R. Johnson & M. K. Johnson, 2009; M. R. Johnson, Mitchell, Raye, D'Esposito, & M. K. Johnson, 2007; Roth, M. K. Johnson, Raye, & Constable, 2009).

6.2 Summary of experimental results

The first section (6.2.1) will focus on discussing the results of the rIOR experiments which used the picture stimuli; while the second section (6.2.2) will discuss the results of the experiments that used word stimuli and the effects of language on rIOR. The third section (6.2.3) will focus on the long-term benefits of refreshing on memory.

6.2.1 Temporal dynamics of refreshing picture stimuli

The experiments in Chapter 3 explored a variety of refresh durations in which a mental representation was kept active using a controlled set of categories of pictures consisting of either houses, chairs or faces; the durations were manipulated into short, medium or long (e.g., 1400ms, 1700ms and 2000ms) refresh durations. There were three different conditions: the first was the refreshed probe condition. Participants saw a picture at the beginning of the trial and kept the representation active for either a short, medium or long duration. The second was the unrefreshed probe condition; participants actively suppressed the other representation that was also seen at the beginning of the trial. Finally, the baseline comparison was a novel-probe condition in which a new representation was used as a control; it was a new category of picture never presented during the initial trial.

Overall, participants responded faster to novel conditions. However, during the shorter refresh durations participants responded faster to the refreshed rather than unrefreshed items. When participants had to refresh an item by keeping the mental representation active for a longer duration, this resulted in a slower response towards the target probe. There was an interaction between these two factors, refresh duration and condition, which showed that the participants produced faster response in novel conditions compared to the refreshed condition (at both 1400ms and 1700ms). The pattern result suggests a bias towards moving to new visual representations instead of turning attention towards mental representations that was seen before.

An interpretation to this result is a defence mechanism or survival skill of the brain to look for new information to process and not process stale information (Klein, 2000).

An inhibition effect is observed by the response times to the unrefreshed condition gradually became faster (reduced RTs) than the refreshed condition, when participants had to refresh an item for a longer duration interval (2000ms). This is in line with Dukewich's (2009) finding that orienting response at shorter durations (i.e., 1400ms and 1700ms). Refreshed representations that were just activated stayed in a primed state and had yet to dissipate, so responding to that representation is faster. However, at 2000ms, this changed as participants responded faster to unrefreshed mental representations, similar to the rIOR result found in M. R. Johnson's and colleagues' (2013) study. This finding is consistent with Lupianez and colleagues' (1997) findings on perceptual IOR that found IOR effects with a longer stimulus onset asynchrony (SOA) using a discrimination task. The authors also concluded IOR can be obtained in both detection and discrimination tasks, although the time course differs between tasks. These findings provided the basis for Experiment 2 to investigate whether longer refresh durations would produce a more robust rIOR effect.

Experiment 2 employed a similar design as Experiment 1 but manipulated the arrow duration by adding 200ms to each existing duration. This resulted in the refreshed condition yielding a faster response, indicating a significant priming effect in contrast to the earlier predictions of a slower response. No other significant results (i.e., IOR) were obtained from this experiment. Although Lupianez and colleagues (1997) successfully obtained IOR effect with colour, shape, direction discrimination and strict time course, other experimental designs and procedures failed to replicate this effect (i.e., Tanaka & Shimojo, 1996; Terry, Valdes, & Neill, 1994). Although Experiment 2 failed to show any rIOR effect, it suggests that this effect might only occur under specific refresh durations or SOAs. Time course seems to play a critical role in efforts to find an IOR-like effect. Klein (2000) claims IOR is a rapid effect, appearing approximately 250ms following the presentation of a cue and dissipate within 3200ms (Samuel & Kat, 2003).

Posner and Cohen (1984) suggested the removal of attention from a cued location is needed in order to observe an IOR effect. This is further supported by Klein's (2000) proposal that IOR depends on factors that affect efficiency of attentional removal from cued locations. For example, exogenous attention can be controlled by a peripheral cue or a central fixation that will automatically pull attention away from the previously cued location. However, if a central fixation is absent, then the decision to remove attention from peripheral cued locations becomes optional reorientation is endogenously controlled and slowed. As a result, the appearance of IOR will be delayed and the effect is smaller or simply absent.

To test if this also applies to rIOR, a short fixation was introduced into the Experiment 3 design, by inserting a short fixation point (i.e., interval of 50 – 650ms) between the refresh and probe trials. The aim of this was to give a break between refreshing a mental representation and subsequent probe response (i.e., naming trial). The break should facilitate reflective attention to refocus and assist in producing an IOR effect. However, this hypothesis was not supported as a priming effect was observed instead; refreshed representations produced faster responses than unrefreshed representations. This finding may lent support to the notion that rIOR effect occurs under specific conditions.

The initial refresh experiments (Experiments 1, 2, and 3) employed a specific set of picture stimuli from three categories. Despite the efforts in adjusting and manipulating variables in order to identify the nature and development of rIOR, there was not any significant IOR result or trend. It was suspected that the rIOR was overshadowed by other underlying mechanisms such that refreshing further enhanced or primed later speech production of the target picture. Further investigation was carried out to examine whether slower attentional disengagement could be a factor in lack of IOR by manipulating the refresh duration and providing a break between refresh cue and target probe. The purpose of this central fixation was to reset orienting response. Previous research (MacPherson, Klein, & Moore, 2003; Prime, Visser, & Ward, 2006) has suggested that all participants' IOR onset varies thus cuing attention to a fixation would terminate participants' orienting response and ensure that everyone has an equal start point to response. However, the data stands in contrast to these findings. The speculation is because bilingual speakers are often reported to be slower at picture naming tasks (Gollan, Montoya, Fennema-Notestine, & Morris, 2005; Kaushanskaya & Marian, 2007; Roberts, Garcia, Desrochers, & Hernandez, 2002), and experience more tip-of-tongue retrieval problems (Gollan & Acenas, 2004; Gollan, Bonanni, Montoya, 2005). Bilingual speakers have to process both language lexicons thus causing difficulties in producing words and could be responsible for abolishing any potential IOR effect. Nevertheless, the results are comparable with other related picture-word priming effect studies. Zwisterlood, Bolte and Dohmes (2000) found shorter naming latencies to pictures with monomorphemic names (a word existing in only one form e.g., "dog") if they were primed with visually with a picture name (e.g., "doghouse"). The current experiments used a set of picture stimuli from specific categories (e.g., chair, face and house) and refreshing maintained activation at a higher level thus leading to faster speech production.

Another explanation is some form of training effect, such as frequently reading a word would make it easier to produce the similar word over time (Monsell, 1991; Wheeldon & Monsell, 1992).

6.2.2 Refresh word stimuli experiments

Refreshing is thought to operate across different modalities, whether it is speaking a word aloud or visualizing a just presented image (M. R. Johnson, 2011). Experiment 4 used a similar design to the authors' study but instead of using picture stimuli, word stimuli were used (see M. R. Johnson and colleagues' (2013), Experiment 1a). Again, the refresh durations (e.g., 900ms, 1200ms and 1500ms) were varied in order to investigate the time course of rIOR. The results indicated that there was a significant rIOR effect across all refresh durations; when the mental representation was refreshed participants would respond to that representation, slower but faster towards the unattended information. The novel condition was consistently slower at all time points relative to refreshed and unrefreshed conditions.

Because robust rIOR using word stimuli was observed, I wanted to further investigate the role of language and how it would interact with reflective attention. The next experiment included a comparison between switching (refreshing in the initial language but then probed in a different language) and non-switch trials (both languages remain the same). The design of Experiment 5 was very similar to Experiment 4, with the addition of the language manipulation in which I examined what would happen when participants had to voice an equivalent word which they had not initially been presented with.

The sequence of events consisted of an initial word presentation followed by a cue then target-probe word. During non-switch trials, language used was consistent throughout the trial and was presented in either English or Malay. In contrast, both languages are involved in switch trials. The switch between English and Malay occurs at the onset of the target-probe word. The target-probe word is an equivalent word to the initial word presented at the beginning of the trial and refreshed (input language). If input language (i.e., initial words and refresh word) was in English, then output language (target-probe word) would be in Malay. Vice versa, if input language was Malay then the output language would be in English. Due to the manipulation of the two independent variables including languages (Malay and English) and type of trial (switch and non-switch), four types of condition were produced from this manipulation including English non-switch trials, Malay non-switch trials, English → Malay switch trial and Malay → English switch trials.

These four types of trials were randomly assigned into four blocks and the results showed that non-switch trials produced shorter RTs compared to switch trials. In terms of rIOR, the data revealed hints of rIOR during non-switch trials in which unrefreshed words produced shorter RTs than refreshed words, although this was not significant. Because of the overall mixed context, there were no significant main effects found in this experiment that led to Experiment 5 where trials were blocked accordingly. The speculation is that due to nature of trials presented in a mixed language context that may have diluted the rIOR effect. A mixed language context, compared to mono-linguistic language context, can facilitate non-linguistic conflict resolution (Wu & Thierry, 2013). Wu & Thierry (2013) suggested that the incidental processing of words triggered by mixed-language context may not have competed for more cognitive resources but shifted executive system to an enhanced functional level. This explanation is in line with theories such as conflict resolution in human cognitive control, suggesting that effectiveness of processing conflict is enhanced when the brain was primed to a state of higher cognitive control (Botvinick, Nystrom, Fissel, Carter & Cohen, 1999; Gratton, Coles & Donchin 1992; Kerns, 2006; Kerns et al., 2004). The primed effectiveness contributed to the lack of a significant rIOR in the present finding, thus Experiment 6 aimed to investigate this issue further by blocking the trials.

In non-switch trials, overall, participants responded to English (i.e., participants' stronger language) faster compared to their weaker language (Malay). In switch trials, switching to weaker language (Malay) was found to be significantly slower but not when switching to the stronger language (English). These results are in line with previous literature (Allport, Styles, & Hsieh, 1994; Meuter & Allport, 1999) that found the asymmetrical switch costs going from the dominant language to the non-dominant language is larger. Meuter and Allport (1999) conducted a language switching experiment in which bilingual speakers were instructed to name aloud a list of digits. The background colour on screen was used as a cue to signal the language participants had to name the digit in (i.e., if blue, name in L1 or if red, name in L2). Their data showed naming latencies in switch conditions were slower than non-switch ones, implicating a switching cost. In addition, the magnitude of this switching cost was asymmetrical and the cost of switching from L2 to L1 was larger compared to L1 to L2. This implies that stronger inhibition is applied on L1 in order for successful L2 lexical selection while speaking in L2. This explanation is borrowed from the assumption of the Inhibition Control (IC) Model (Green, 1998). Stronger inhibition to the dominant language is needed when non-dominant language is used, that must also be overcome in order to return to the dominant language (Meuter & Allport, 1999; see review Declerk & Philipp, 2015). According to Gollan and Goldrick (2016), these effects are also attributed to inhibitory control mechanisms that might support non-linguistic task switching (Bobb & Wodniecka, 2013; Green, 1998; Meuter & Allport, 1999, see also Philipp et al., 2007; Philipp & Koch, 2009).

The main difference between Experiment 5 and 6 was blocking trials based on language and either a non-switch or switch context; I deliberately focused on examining rIOR effect in Experiment 6. These two experiments showed consistent results; non-switch trials produced shorter RTs compared to switch trials across both experiments. In addition, a clear rIOR surfaced and the data showed that participants were slower to responses to refreshed word items but faster to respond to unrefreshed ones, which replicates previous findings by M. R. Johnson and colleagues (2013). Overall, switching seemed to lead to a between-language repetition priming effect. This is in line with a simulated effect in BIA+ model, seeing a word (although in another language) would temporarily increase its activation state which seemed to result in the overall faster naming of the target word compared to the non-repeated (unrefreshed) word (Lam & Djikstra, 2010). According to this principle, recognizing a word raises the activation levels and concurrently suppresses other words, therefore generating a minor competition effect when the target word is presented again later (Grainger & Jacobs, 1999). Therefore, it is no surprise that in switch-trials, the equivalent word showed faster responses (decrease in RTs) compared to the unrelated more novel word.

The lack of rIOR in switch trials could be due to bilingual speakers' generally slower response in naming tasks as mentioned earlier. Time course could play an important role in determining when does rIOR effect occurs before transitioning to a repetition priming effect. In order to eliminate this possibility, I wanted to examine if manipulating the refresh duration would it play a role in affecting the rIOR result in both English and Malay words. Experiment 7 examined three factors including type of trial: switch or non-switch trials; languages: English or Malay; and refresh duration: 1400ms, 1700ms and 2000ms. Results from this experimental design replicated findings from Experiments 5 and 6. This first consistent finding was that non-switch trials produced shorted RTs compared to switch trials; and the second finding showed rIOR effect (unrefreshed condition produced faster responses than refreshed condition) present in non-switch trials while a repetition priming effect was present in switch trials. There was an absence of rIOR effect in switch trials. It is possible that refreshing could facilitate repetition-priming effect which is consistent with the general word recognition mechanisms proposed by BIA/BIA+ model. According to this model, in switch trials, when cueing participants to say one of the words would increase the activation level of the refreshed word while inhibiting unrefreshed words. Therefore, the stronger activation in refreshed words leads to faster naming of the equivalent word.

6.2.3 Longer-term Memory benefit for refreshed words

Since the memory recall task was administered under similar circumstance in both Experiments 5 and 7, (it was excluded from Experiment 6 as the aim was focused on investigating rIOR effect only) this invites a comparison between both data sets. First, overall real words were better remembered than both equivalent and foil words. Second, English real words were better remembered than Malay real words in non-switch trials. Although participants did not show significant differences between language proficiencies, English appears to be a stronger language in both Experiment 5 and 7. The data showed refreshing produced a long-term memory benefit for both languages. I replicated previous findings that refreshing produced short term inaccessibility of word representations but had long-term memory benefits (M. K. Johnson et al., 2002; M. R. Johnson et al., 2013). There are underlying mechanisms that impairs response to refreshed items at short term (1s) timescales that does not persist over a long time but show a long-term (~20 minutes) memory benefit (M. R. Johnson et al., 2013).

Alternating between languages has shown to interact with this refreshing benefit in other ways which are new key findings in the current study that have never been investigated in the previous literature. For example, in examining equivalent words (in Experiment 5), refreshing in Malay (the weaker language) word led to participants falsely remembering that they had seen the English word but in fact was not present in the refresh trials. Conversely, refreshing in English (the stronger language) demonstrated lesser incidences of false memories. This meant that for English words that were refreshed, its equivalent word showed lower confidence ratings as participants were able to correctly identify them as words that did not appear during the refresh task. The results also showed an interesting contrast of refreshing for English equivalent words. If participants had to refresh the original Malay word, then the confidence rating was lower. However, if the original word was not refreshed then this lead to higher confidence ratings. The interpretation is refreshing a word in dominant language would strengthen the confidence in distinguishing between the original word and equivalent word as a foil. This adds to the previous study (M. R. Johnson et al., 2013) that refreshing not only enhanced later memory retrieval, but also resulted in participants correctly identifying the equivalent word that did not appear in the current study. However, this was not the case for Malay equivalent words. For example, refreshing Malay words lead to higher false memories as participants thought they had seen its equivalent in English when it never did appear during the refresh task.

Apart from other false memory and source monitoring errors as discussed elsewhere (see Discussion section in Chapter 5), the data also suggests the roles of lexical access and language proficiency may interact with refreshing that results in examples of false memory. Although the distinction between dominant and non-dominant language (or L1 and L2) is not clear among participants in the current studies, there is a trend which showed higher English proficiency/dominancy compared to Malay. In this case, in order to explain the empirical data, it is assumed that English is the participants' stronger language while Malay is the weaker one. In addition, how this discrepancies between the levels of language proficiency can impact on refreshing and later long-term memory benefit.

Refreshing in stronger or weaker language (similar to L1 or L2) kept the concept of the lexical item activated in either in its shallow form in language or in meaning. The Revised hierarchical model (RHM) by Kroll and Stewart (1994) suggests that the L1 lexicon and the smaller non-native L2 lexicon are directly interconnected (L2-L1 links). Each lexicon also has independent links to a shared conceptual store (CS, L1-CS, L2-CS). In this case, semantic access for L2 words can be attained via an indirect route through inter-lexicon links (L2-L1 links), or a direct route such as L2-CS links (Chen & Leung, 1989; Dufour & Kroll, 1995; Kroll & Stewart, 1994; McElree, Jia, & Litvak, 2000; also see Potter, So, von Eckardt, & Feldman, 1984). According to the RHM, inter-lexicon links are asymmetrical, depending on the dominance of L1 and L2. L2-CS link is also assumed to be weaker than L1-CS link while L2-L1 directional link is stronger than L1 to L2 links. According to this logic, results from the current study indicated refreshing in the weaker language may have temporarily strengthened these links (e.g., L2-CS or

L2-L1) therefore when later shown in stronger language, participants would indicate that they have seen it.

In the early stages of non-native language acquisition, learners first rely heavily on L2-L1 lexical link for semantic processing (Kroll & Stewart, 1994). For example, in order to access meaning of a L2 word, the speaker requires to first access its L1 translation equivalent, followed by retrieval of conceptual representation. As L2 proficiency becomes stronger, the L2-CS link becomes stronger and speakers would rely on L2-CS link in addition to the indirect L2-L1 link for semantic processing. The inter-lexicon links mediate non-native language processing even in fluent L2 speaker (Kroll & Stewart, 1994). As Malay is the weaker language in these experiments, participants may have relied on these links when presented with the words earlier in the trial. By refreshing, one focus reflective attention to word in L2 and inadvertently kept word in L1 active through L2-L1 link. The BIA/BIA+ (e.g., Dijkstra & van Heuven, 1998, 2002; van Heuvan, Dijkstra, & Grainger, 1998) models offer a similar explanation in terms of a masked translation priming effect. For balanced and simultaneous bilinguals, a brief presentation of L2 word can facilitate word recognition in the following L1 translation equivalent and this priming also works in the opposite direction (e.g., L2 to L1; see Duñabeitia, Perea, & Carreiras, 2010). For unbalanced bilinguals, more activation or acquisition is demanded for L2 until its activation threshold surpasses L1, then efficient recognition in L1 can be obtained.

Somewhat similar findings from a study by Sampaio and Konopka (2013) found that memory for non-native language (L2) sentences contained more surface form information compared to native language (L1) sentences. They used complex linguistic structures and showed memory for L2 sentences contained more surface information than L1 sentences. They suggested that L2-L1 route leads non-native speakers to devote more resources to individual L2 lexical items that benefits verbatim memory (i.e., retention of L2 surface form). If processing L2 via direct and indirect links predicted by RHM, memory for lexical items in L2 as opposed to meaning associated with these items should be more superior to L1. Their finding showed L2 processing involves more intensive encoding of lexical information relative to L1 processing. Although my experiments differed from theirs in terms of testing strategy (they used sentences while I focused on word stimuli), essentially my results have shown the influence of language proficiency can boost memory performance on the weaker language (similar to L2).

6.3 Limitation and further studies

McPherson, Klein and Moore (2003) suggested that much research has been dedicated to studying the development and nature of IOR but little research has been devoted to the notion that IOR may vary with individual differences. The most obvious way to compare one of these differences is by exploring refreshing in bilinguals and how managing two languages would inevitably impact the overall rIOR. I examined the interactions between two components of reflective attention and language processing and how the result of this interaction may have an effect on thought processes. I did so by examining time scale, if spending a longer time on a specific thought would affect attention to move to new mental representations, such as pictures or words. I also examined the role of language in reflective attention in bilingual individuals.

6.3.1 Monolinguals vs bilinguals

Evidence from Chapter 3, refreshing experiments with the picture stimuli showed strong facilitation in response instead of rIOR that was initially hypothesized and was found in the previous study by M. R. Johnson's and colleagues (2013). The major manipulation I made to the task design was by introducing probed-speech production as a way to measure response times as opposed to a detection task. As a result, facilitation to refreshed items (decreased in RTs) was observed instead of inhibition effect to refreshed items as previously obtained. Although one possible explanation could be due to a training effect, repeating a similar word improves performances over time (Monsell, 1991; Wheeldon & Monsell, 1992) resulting in the overall priming of refreshed items. This was not observed when word stimuli were used in Experiment 4 and beyond (Experiments 5, 6 and 7). Therefore, it was speculated that refreshing may be an efficient way of overcoming any difficulties in naming tasks, for instance, bilingual speakers tend to experience tip-of-the-tongue (TOT) states compared to monolingual speakers (see Chapter 2 for review).

Future studies could do a comparison between monolingual and bilingual speakers' data using the refresh experimental paradigm with picture stimuli. As previous bilingual versus monolingual studies have shown that bilingual speakers tend to show deficits in performances involving lexical access, refreshing could enhance speech production but this effect may only appear in the bilingual group. On the other hand, there might not be any differences between monolingual and bilingual speakers – both groups might be equally fast in the refresh conditions. This prediction is based on the connectionist models like the BIA/BIA+ models that the associative networks between words and concepts are distributed across two or more languages in bilingual speakers which is why priming instead of inhibition-like effects was observed (Dijkstra, 2005). By refreshing the picture stimuli (i.e., concept) may have concurrently connected the concept with the word, thus a speeded naming response was produced. This might result into comparable RTs in both monolingual and bilingual groups and priming effect in both groups.

Additionally, eye-tracking methods could also be incorporated in the refreshing studies to ensure that the eye movements shift between both items and that the items were given sufficient attention within the 1500ms timeframe. If sufficient attention was distributed evenly during the initial presentation before the refresh event, then that specific trial could be qualified as a valid trial. Conversely, if both items were not given sufficient attention during the presentation, then the trial should be removed as it is an invalid one. It is possible that participants did not have a chance to see one of the (unrefreshed) items during the presentation and responded to it in a similar way to a new item. This method would also ensure that unrefreshed items participants had to respond to were items that they had seen but ignored during the cue. Distinguishing valid and invalid trials based on eye-movements would strengthen the robustness of rIOR effect as well as addressing any possible Type II error.

6.3.2 Language proficiency and refreshing

Another aspect to further investigate is the role of participants' language proficiencies in modulating the concept-word connection during the refresh task using word or non-word stimuli. The main difference here is manipulating levels of language proficiency as opposed to controlling for it in other experiments (Experiment 5, 6 and 7). As Meuter and Allport (1999) proposed there is a basic cost when bilinguals are required to inhibit the more dominant L1 language during non-dominant L2 production (see also Jackson, Swainson, Cunnington, & Jackson, 2001; Philipp, Gade, & Koch, 2007; Schwieter & Sunderman, 2008; Verhoef, Roclofs, & Chwilla, 2009). The basic idea is that larger inhibition in L1 is need for L2 production exclusively in unbalanced bilinguals, and they demonstrated asymmetric switch cost in language switching. On the other hand, previous studies have reported that this inhibition effect is not present in highly proficient balanced bilinguals and they had symmetric switching (Calabria, Hernandez, Branzi & Costa, 2012; Costa, Santesteban & Ivanova, 2006; Hernandez & Kohnert, 1999). Further investigation could explore the role this inhibition effect plays in unbalanced bilinguals speakers. I would expect facilitation for refreshed items (lack of rIOR) and slower responses for unrefreshed items. By contrast, if they had to perform using L1 (note that L1 lexical access is not interfered by their L2), their response may be further inhibited due to the rIOR mechanism. There should be an enhanced rIOR effect as seen in Experiment 4 and replicate previous findings (M. R. Johnson et al., 2013). In addition, further investigation on whether refreshing could potentially reverse the switching cost depending on bilinguals' grasp on L2 language (highly proficiency vs. low proficiency).

6.3.3 Refreshing with emotional words

The current data showed a significant rIOR pattern using neutral word stimuli; it would be interesting to investigate whether the valence of a word can affect rIOR by investigating emotional English words (e.g., positive and negative words). Recent findings showed positive words produced faster recognition in Lexical Decision Tasks (LDT) compared to neutral (Briesemeister, Kuchinke & Jacobs, 2011; Hofmann, Kuchinke, Tamm, Vo & Jacobs, 2009; Kanske & Kotz, 2007; Kousta, Vinson & Vigliocco, 2009; Kuchinke, Jacobs, Grubick, Vo, Conrad & Hermann, 2005; Scott et al., 2009, 2012, 2014) and negative words (Briesemeister et al., 2011; Kanske & Kotz, 2007; Kuchincke et al., 2005; Knickerbocker, Johnson, & Altarriba, 2015). Further evidence also implicated that positive words are processed faster than negative and neutral words and that lexical access (i.e., time needed until a word is recognized) is fastest in positive words (Kissler & Herbert, 2013). Using the same time course method used in Experiment 7, I could determine if the onset for rIOR in lexical access for positive words is much earlier compared to negative words.

On the other hand, it is possible to observe a lack of rIOR in negative words. According to Bertels, Kolinsky, Bernaerts and Morais (2011) who found evidence to show that the IOR effect was present with neutral (e.g., “bulb”), positive (e.g., “love”) and taboo (e.g., “bitch”) word cues but eliminated by negative (e.g., “death”) word cues. In other words, attention stays on the location where negative stimuli were previously presented. However, attention can be disengaged and becomes inhibited to return to the location if the information present was not threatening. This supports the idea of an evolutionary advantage according to the authors, because it is not an adaptive strategy for subjects if attention is prevented from returning to the location where threatening stimulus appeared in order to fully assess it. This study focused on interaction between emotional content and location in IOR development. Furthermore, Bertels and colleagues (2011) findings are at odds with other claims that IOR is a “blind phenomenon” (Taylor & Therrien, 2005) and that visual studies are unaffected by emotional stimuli processing (Lange, Heuer, Reinecke, Becker, & Rinck, 2008; Stoyanova, Pratt, & Anderson, 2007). This is because IOR is associated with occurrence of exogenous attentional shifts which is a reflexive mechanism that is not modulated by emotional content (Rutherford & Raymond, 2010). The results from previous literature are ambiguous as to whether IOR is affected by emotional content processing or not. So, the aim of further investigation can focus on whether this pattern (i.e., lack of IOR) will be present within reflective attention in emotional content namely, positive, negative or neutral. Negative content (negative words) should demand more cognitive effort in assessing whether the presented stimuli is threatening. Hence, reflective attention would take longer to be disengaged from or later onset of rIOR would be observed.

6.3.4 Language switching on later memory for refreshed items

Although the current results replicated an overall advantage in long-term memory for refreshed items (M. R. Johnson et al., 2013; M. K. Johnson et al., 2002), there is evidence of false memories that is most apparent in equivalent words during non-switch trials. However, as a by-product of language-switching, equivalent words were present during refresh switch trials. The issue here is equivalent words did not appear in all events during non-switch refresh task whereas the former may have appeared during switch trials at the probe event (see below, **Figure 6.1**). However, I would like to expand upon this finding by exclusively focusing on the direction of language switching (e.g., L1 to L2 or L2 to L1) in the refresh task and subsequent impact on later memory test. Additionally, data on participants' language background to distinguish between their actual first and additional languages might lead to stronger results. There is a need for a technique to tease apart false memory in refreshed equivalent words induced by switch trials. The question is to test whether the presentation of two languages in switch trials and language switching direction would also affect this refresh benefit. In line with the BIA/BIA+ models (e.g., Dijkstra & van Heuven, 1998, 2002; van Heuven, Dijkstra, & Grainger, 1998) priming in L2 should facilitate word recognition in the L1 equivalent words. In this case, refreshing in either language (i.e., L1 or L2) would result in later long-term memory benefits. On the other hand, in unbalanced bilinguals, brief priming in L2 would have no effect on the L1 equivalent words unless the resting level of activation for L2 is as high as L1. So, it would be interesting to test whether by refreshing in L2, its activation level would temporarily increase and it is possible to observe a facilitation effect on L1 equivalent word recognition. In other words, if refreshing in L2 was absent then L1 equivalent presented during the probe event may be easily forgotten. In short, the criteria of observing a false memory during switch trial can be further controlled and further studies test whether language switching while refreshing can reverse this long-term memory benefit.

	Initial presentation		Cue	Probe	Condition
+	cat + house	+	^ (say "cat")	kucing	Refreshed
+	cat + house	+	^ (say "cat")	rumah	Unrefreshed

Figure 6. 1. Language switching during refresh trial. Words in both languages are presented during switch trial as real or equivalent. Words stimuli in initial presentation are in English and Malay in probe event. Cue indicates participants to refresh in the coherent language as initial presentation. By focusing on the direction of language switching, it allows investigation on the long-term memory benefit of refreshed items within the switch-language context.

6.4 Conclusion

The present study showed rIOR for picture stimuli, specifically at refresh durations of around 2000ms. Any less or more than this produced a priming-like effect. Other manipulations such as including additional duration times and manipulating the central fixation did not produce a robust rIOR effect. However, when stimuli were changed to words, a robust rIOR effect at all time points were observed. It is clear that rIOR is unaffected by language presentation and strong inhibition effects were observed in both English and Malay words. However, language switching interferes with the rIOR mechanism. The inhibition effect was absent while a stronger priming effect was present even when a set of longer refresh durations were tested. The presence of rIOR showed refreshing produced temporary inaccessibility to active mental representations but better long-term memory recall. Participants' ability to tease apart real words from words they had not seen were enhanced, however, when it came to judging equivalent words – this led to false memories.

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APPENDIX

A.1 Chapter 3 – Experiment 1, 2 and 3: A sample of stimulus set from three categories

Chair	Face	House
		
		
		
		

		
		
		
		

A.2 Chapter 3 – Experiment 1: Mean RTs and SD for refreshed, unrefreshed and novel conditions for each time interval

Duration	**Condition**		
	Refreshed	Unrefreshed	Novel
1400ms	560.53 (79.55)	571.08 (92.27)	573.29 (101.62)
1700ms	600.87 (94.40)	591.50 (98.59)	575.23 (91.52)
2000ms	602.66 (89.90)	582.29 (94.41)	577.20 (95.20)

A.3 Chapter 3 – Experiment 2: Mean RTs and SD for refreshed, unrefreshed and novel conditions for each time interval

Duration	**Condition**		
	Refreshed	Unrefreshed	Novel
1600ms	514.41 (77.08)	542.64 (66.01)	542.57 (63.91)
1900ms	508.66 (72.41)	537.83 (66.58)	546.60 (64.45)
2200ms	496.35 (70.89)	539.21 (67.37)	533.24 (68.53)

A.4 Chapter 3 – Experiment 3: Mean RTs and SD for refreshed, unrefreshed and novel conditions for each delay interval

Duration	**Condition**		
	Refreshed	Unrefreshed	Novel
50ms	553.55 (89.42)	570.52 (77.13)	561.51 (70.70)
350ms	529.68 (85.69)	544.01 (83.40)	556.22 (72.79)
650ms	527.57 (89.40)	543.03 (84.86)	548.11 (76.76)

A.5 Chapter 4 – Experiment 4: Mean RTs and SD for refreshed, unrefreshed and novel conditions for each time interval

Duration	Condition		
	Refreshed	Unrefreshed	Novel
900ms	566.50 (96.81)	528.13 (95.01)	579.69 (95.38)
1200ms	536.65 (81.07)	512.85 (82.23)	569.18 (74.60)
1500ms	527.02 (79.22)	507.39 (90.58)	569.67 (85.21)

A.6 Chapter 4 – Experiment 5: Participants' language background and self-rated proficiency were collected using a language history questionnaire

Language Background Questionnaire

1. Date of birth (DD/MM/YYYY) : ______________
2. Gender : Male / Female
3. Ethnicity :__________________
4. Country you were born in : __________________
5. Current Residence Country :___________________
6. Region/State/City do you originate from : ___________________________________

   (e.g., Kuala Lumpur)
7. Student ID :___________________________________
8. Course : ___________________________________

   :Pre-sessional / Undergraduate / Postgraduate
9. Year of study : Not Applicable / 1st / 2nd / 3rd / 4th
10. First/Native Language (Language that you speak most at home, could be dialects e.g., Hokkien, Hakka, telugu)

    :___________________________________
11. What language(s) does your Mother speak :___________________________________
    (List all the languages down)
12. What language(s) does your Father speak? :___________________________________
    (List all the languages down)
13. List **ALL** the languages you know (even if your listening comprehension/speaking ability is poor, including dialects e.g., Hokkien, Hakka, telugu) in the order of most proficient. Rate your ability on the following aspects in each language. Please rate according to the following scale (write down the number in the table):

    1- Very poor
    2- Poor
    3- Fair
    4- Functional
    5- Good
    6- Very good
    7- Native-like

Language	Reading Proficiency	Writing Proficiency	Speaking Fluency	Listening Ability/Comprehension

14. Provide the age at which you were first exposed to EACH language (including dialects e.g., Hokkien, Hakka, telugu) in terms of speaking, reading and writing, where you have learnt them from and the number of years you have spent on learning each language.

Language	**Age first exposed to the language**			**Where/ how was the language learnt?** (e.g., Home, School, friends)	**Number of years learning (Academically/ from formal education)**
	Speaking	Reading	Writing		

15. Please could you provide us with your Education Background:

Education Background			
School Level	Name of School	Languages taught	Main medium (Language) used for instructions

Kindergarden			
Primary School			
Secondary School			
College			
University			

16. Estimate how often you use your native language (first language) and other language per day for **DAILY ACTIVITIES** (eg. Going to classes, writing papers, talking to parents, classmates, or peers).

Language	**WHEN/WHERE do you use this language?** **(can be more than one)**	**How Often? (Answer with NUMBERS, where 1 = Never, 2 = Rarely, 3 = Sometimes, 4 = Often, 5 = All the time)**

17. Please could you provide us with your information about your English Proficiency qualifications (e.g., GSCE / SPM / IELTS / TOEFL):

Name of Test	Testing Date (mm/yyyy)	Overall Score/ Grade	Listening Score	Speaking Score	Writing Score
e.g., IELTS	09/2009	62	75	58	61

18. In which language (CHOOSE ONE among your best two languages) do you feel you usually do better? Write the name of the language under each condition:

	At Home	**At Work/ Study**
Reading		
Writing		
Speaking		
Understanding		

19. Do you mix/switch between languages (e.g., within/between sentences) when you speak?

    YES / NO

    (If **NO**, skip question 20)

20. What languages do you mix and how often do you do that?
    Write the main language (which should compose most part of your conversation) in the first column.

Main Language	**Minor Language** (Different language words/ sentences found	**How often?** (Answer with numbers, 1 = Never, 2 =

	in the main language spoken)	Rarely, 3 = Sometimes, 4 = Often, 5 = All the time)

21. Do / did you have any **reading difficulties** in your native language or other languages (e.g., dyslexia - a disorder that involves difficulty in learning to read or interpret words, letters, and other language symbols)?

Yes / No

If Yes, Please provide details:

____

____

22. Do you have any **listening difficulties** in your native or other languages (e.g., unable to accurately perceive/process, understand and respond to sound)? Yes / No

If Yes, Please provide details:

____

____

23. Do you have **normal vision**? If you wear spectacles or contact lenses, you are not considered to have normal vision, but are corrected to normal vision. Yes / No

If No, Please provide details:

____

____

A.7 Chapter 4 – Experiment 5: English and Malay translation equivalent words

English Word	English Length Z-score	Frequency Log transformed Z-scored	English Number of Phoneme Z-score	English Number of Syllable Z-score	Malay Word	Malay Length Z-score	Frequency Log transformed Z-score	Malay Number Phoneme Z-score	Malay Number Syllable Z-score
absorbent	2.0638968	-2.374561	3.0929412	2.0501994	penyerap	1.5570201	-1.837796	1.8055016	1.2881038
accent	0.2394796	-0.346206	1.0369528	0.5529177	loghat	0.1055406	-0.423389	-0.5077579	-0.7436476
accept	0.2394796	1.037981	1.0369528	0.5529177	terima	0.1055406	1.05004	0.2633286	1.2881038
accurate	1.4557578	0.525463	1.7222822	2.0501994	tepat	-0.6201992	1.135298	-0.5077579	-0.7436476
achieve	0.8476187	0.326084	-0.3337062	0.5529177	mencapai	1.5570201	1.312713	1.0344151	1.2881038
actor	-0.3686595	0.082977	-0.3337062	0.5529177	pelakon	0.8312803	1.659977	1.0344151	1.2881038
addict	0.2394796	-0.971513	0.3516233	0.5529177	penagih	0.8312803	-0.800053	1.0344151	1.2881038
advice	0.2394796	0.97316	0.3516233	0.5529177	nasihat	0.8312803	0.620945	1.0344151	1.2881038
age	-1.5849376	1.223615	-1.7043651	-0.9443639	umur	-1.3459389	0.638907	-1.2788444	-0.7436476
almond	0.2394796	-1.632095	0.3516233	0.5529177	badam	-0.6201992	-1.837796	-0.5077579	-0.7436476
angel	-0.3686595	0.422613	0.3516233	0.5529177	malaikat	1.5570201	-0.597186	1.0344151	1.2881038
angle	-0.3686595	0.089175	-0.3337062	0.5529177	sudut	-0.6201992	1.126072	-0.5077579	-0.7436476
angry	-0.3686595	0.236632	0.3516233	0.5529177	marah	-0.6201992	0.305934	-0.5077579	-0.7436476
animal	0.2394796	0.612194	0.3516233	2.0501994	haiwan	0.1055406	-0.047812	-0.5077579	-0.7436476
answer	0.2394796	1.525987	-0.3337062	0.5529177	menjawab	1.5570201	0.468443	1.8055016	1.2881038
ant	-1.5849376	-0.734636	-1.0190357	-0.9443639	semut	-0.6201992	-1.291686	-0.5077579	-0.7436476
applause	1.4557578	-0.625149	0.3516233	0.5529177	tepukan	0.8312803	-0.061686	1.0344151	1.2881038
archer	0.2394796	-0.385063	-0.3337062	0.5529177	pemanah	0.8312803	0.126492	1.0344151	1.2881038
argument	1.4557578	1.037021	3.0929412	2.0501994	hujah	-0.6201992	-0.047812	-0.5077579	-0.7436476
ark	-1.5849376	-0.709205	-1.0190357	-0.9443639	bahtera	0.8312803	-0.640964	1.0344151	1.2881038
arm	-1.5849376	0.494189	-1.0190357	-0.9443639	lengan	0.1055406	-0.597186	-0.5077579	-0.7436476
army	-0.9767986	0.80815	-0.3337062	0.5529177	tentera	0.8312803	1.046948	1.0344151	1.2881038
arrive	0.2394796	0.026194	-0.3337062	0.5529177	tiba	-1.3459389	1.243009	-1.2788444	-0.7436476
arrogant	1.4557578	-0.519116	1.7222822	2.0501994	sombong	0.8312803	-0.453249	0.2633286	-0.7436476
art	-1.5849376	1.182477	-1.0190357	-0.9443639	seni	-1.3459389	2.023433	-1.2788444	-0.7436476
assignment	2.6720359	-0.080431	2.4076117	2.0501994	tugasan	0.8312803	0.437733	1.0344151	1.2881038
auction	0.8476187	1.258332	-0.3337062	0.5529177	lelongan	1.5570201	-0.688943	1.0344151	1.2881038
author	0.2394796	1.085311	-1.0190357	0.5529177	pengarang	2.2827598	0.232267	1.0344151	1.2881038
badge	-0.3686595	-0.92384	-1.0190357	-0.9443639	lambang	0.8312803	0.029484	0.2633286	-0.7436476
banana	0.2394796	-0.711552	1.0369528	2.0501994	pisang	0.1055406	-0.341603	-0.5077579	-0.7436476
barn	-0.9767986	-0.780222	-0.3337062	-0.9443639	kandang	0.8312803	-0.557756	0.2633286	-0.7436476
basil	-0.3686595	-0.972818	-0.3337062	0.5529177	selasih	0.8312803	-0.423389	1.0344151	1.2881038
basin	-0.3686595	-0.89409	-0.3337062	0.5529177	lembangan	2.2827598	-1.496343	1.8055016	1.2881038
bath	-0.9767986	-0.299837	-1.0190357	-0.9443639	mandi	-0.6201992	-0.367408	-0.5077579	-0.7436476
beach	-0.3686595	0.658201	-1.0190357	-0.9443639	pantai	0.1055406	0.541952	-0.5077579	-0.7436476

bead	-0.9767986	-0.992408	-1.0190357	-0.9443639
beautiful	2.0638968	0.757625	1.7222822	2.0501994
bed	-1.5849376	0.757683	-1.0190357	-0.9443639
bee	-1.5849376	-0.62981	-1.7043651	-0.9443639
beetle	0.2394796	-1.346463	-0.3337062	0.5529177
beginner	1.4557578	-0.534151	1.0369528	2.0501994
bell	-0.9767986	0.613932	-1.0190357	-0.9443639
best	-0.9767986	2.082109	-0.3337062	-0.9443639
bitter	0.2394796	-0.268985	-0.3337062	0.5529177
black	-0.3686595	1.76369	-0.3337062	-0.9443639
blanket	0.8476187	-0.538491	1.7222822	0.5529177
blood	-0.3686595	1.066811	-0.3337062	-0.9443639
bone	-0.9767986	0.346294	-1.0190357	-0.9443639
borrow	0.2394796	-0.473044	-0.3337062	0.5529177
box	-1.5849376	1.803609	-0.3337062	-0.9443639
boxing	0.2394796	-0.72648	1.0369528	0.5529177
bracelet	1.4557578	-1.863273	1.7222822	0.5529177
brain	-0.3686595	1.093681	-0.3337062	-0.9443639
bread	-0.3686595	-0.005886	-0.3337062	-0.9443639
breakfast	2.0638968	-0.112281	2.4076117	0.5529177
breath	0.2394796	0.280408	-0.3337062	-0.9443639
bridge	0.2394796	0.461049	-0.3337062	-0.9443639
bright	0.2394796	0.249544	-0.3337062	-0.9443639
bronze	0.2394796	-0.337882	0.3516233	-0.9443639
bruise	0.2394796	-1.845475	-0.3337062	-0.9443639
builder	0.8476187	-0.524139	0.3516233	0.5529177
building	1.4557578	1.024641	1.0369528	0.5529177
bulldozer	2.0638968	-2.088938	1.7222822	2.0501994
bullet	0.2394796	-0.057193	0.3516233	0.5529177
burner	0.2394796	-1.277861	-0.3337062	0.5529177
busy	-0.9767986	0.469197	-0.3337062	0.5529177
butter	0.2394796	-0.178336	-0.3337062	0.5529177
buyer	-0.3686595	0.412996	-1.0190357	-0.9443639
cage	-0.9767986	-0.045496	-1.0190357	-0.9443639
caller	0.2394796	-0.40163	-0.3337062	0.5529177
camel	-0.3686595	-0.613739	-0.3337062	0.5529177
candle	0.2394796	-0.746737	0.3516233	0.5529177
cane	-0.9767986	-0.323949	-1.0190357	-0.9443639
cash	-0.9767986	0.900107	-1.0190357	-0.9443639

manik	-0.6201992	-1.034676	-0.5077579	-0.7436476
cantik	0.1055406	0.76576	0.2633286	-0.7436476
katil	-0.6201992	-0.740825	-0.5077579	-0.7436476
lebah	-0.6201992	-0.423389	-0.5077579	-0.7436476
kumbang	0.8312803	-0.688943	0.2633286	-0.7436476
pemula	0.1055406	-1.837796	0.2633286	1.2881038
loceng	0.1055406	-0.867246	-0.5077579	-0.7436476
terbaik	0.8312803	2.1475	1.8055016	1.2881038
pahit	-0.6201992	0.096199	-0.5077579	-0.7436476
hitam	-0.6201992	0.620945	-0.5077579	-0.7436476
selimut	0.8312803	-1.146857	1.0344151	1.2881038
darah	-0.6201992	0.16429	-0.5077579	-0.7436476
tulang	0.1055406	0.16429	-0.5077579	-0.7436476
meminjam	1.5570201	-0.29416	1.8055016	1.2881038
kotak	-0.6201992	0.506497	-0.5077579	-0.7436476
tinju	-0.6201992	0.240191	-0.5077579	-0.7436476
gelang	0.1055406	-0.740825	-0.5077579	-0.7436476
otak	-1.3459389	-0.800053	-1.2788444	-0.7436476
roti	-1.3459389	-0.367408	-1.2788444	-0.7436476
sarapan	0.8312803	-1.034676	1.0344151	1.2881038
nafas	-0.6201992	0.520161	-0.5077579	-0.7436476
jambatan	1.5570201	-0.453249	1.8055016	1.2881038
terang	0.1055406	0.155055	-0.5077579	-0.7436476
gangsa	0.1055406	1.17425	-0.5077579	-0.7436476
lebam	-0.6201992	-1.291686	-0.5077579	-0.7436476
pembina	0.8312803	-1.837796	1.0344151	1.2881038
wisma	-0.6201992	0.263079	-0.5077579	-0.7436476
jentolak	1.5570201	-1.034676	1.8055016	1.2881038
peluru	0.1055406	-0.29416	0.2633286	1.2881038
pembakar	1.5570201	-0.557756	1.8055016	1.2881038
sibuk	-0.6201992	0.886647	-0.5077579	-0.7436476
mentega	0.8312803	-1.837796	1.0344151	1.2881038
pembeli	0.8312803	0.679441	1.0344151	1.2881038
sangkar	0.8312803	-1.146857	0.2633286	-0.7436476
pemanggil	2.2827598	-0.367408	1.8055016	1.2881038
unta	-1.3459389	-1.146857	-1.2788444	-0.7436476
lilin	-0.6201992	-0.520442	-0.5077579	-0.7436476
rotan	-0.6201992	-1.496343	-0.5077579	-0.7436476
tunai	-0.6201992	1.029502	-1.2788444	-0.7436476

cashew	0.2394796	-2.371381	-0.3337062	0.5529177	gajus	-0.6201992	-1.837796	-0.5077579	-0.7436476
cave	-0.9767986	-0.121797	-1.0190357	-0.9443639	gua	-2.0716786	-0.138915	-1.2788444	-0.7436476
century	0.8476187	0.770102	1.7222822	2.0501994	abad	-1.3459389	-0.07627	-1.2788444	-0.7436476
chain	-0.3686595	0.575564	-1.0190357	-0.9443639	rantaian	1.5570201	-0.520442	1.8055016	1.2881038
charcoal	1.4557578	-1.460097	1.0369528	0.5529177	arang	-0.6201992	-0.367408	-1.2788444	-0.7436476
charity	0.8476187	-0.175915	1.0369528	2.0501994	amal	-1.3459389	0.520161	-1.2788444	-0.7436476
chase	-0.3686595	-0.005682	-1.0190357	-0.9443639	mengejar	1.5570201	0.877979	1.0344151	1.2881038
cheap	-0.3686595	0.813588	-1.0190357	-0.9443639	murah	-0.6201992	0.817679	-0.5077579	-0.7436476
cheek	-0.3686595	-0.581765	-1.0190357	-0.9443639	pipi	-1.3459389	-1.146857	-1.2788444	-0.7436476
chew	-0.9767986	-0.715411	-1.7043651	-0.9443639	mengunyah	2.2827598	-1.496343	1.8055016	1.2881038
chicken	0.8476187	0.139481	0.3516233	0.5529177	ayam	-1.3459389	0.511094	-1.2788444	-0.7436476
chisel	0.2394796	-0.751737	-0.3337062	0.5529177	pahat	-0.6201992	-0.21054	-0.5077579	-0.7436476
choice	0.2394796	1.2115	-1.0190357	-0.9443639	pilihan	0.8312803	1.740555	1.0344151	1.2881038
cigarette	2.0638968	-0.711125	1.7222822	2.0501994	rokok	-0.6201992	-0.367408	-0.5077579	-0.7436476
circuit	0.8476187	0.400951	0.3516233	0.5529177	litar	-0.6201992	1.176649	-0.5077579	-0.7436476
clever	0.2394796	-0.11414	0.3516233	0.5529177	pandai	0.1055406	0.106574	-0.5077579	-0.7436476
climb	-0.3686595	-0.24509	-0.3337062	-0.9443639	mendaki	0.8312803	0.483068	1.0344151	1.2881038
cloud	-0.3686595	-0.229563	-0.3337062	-0.9443639	awan	-1.3459389	-0.944882	-1.2788444	-0.7436476
cloudy	0.2394796	-1.334583	0.3516233	0.5529177	mendung	0.8312803	-0.453249	0.2633286	-0.7436476
clove	-0.3686595	-1.7754	-0.3337062	-0.9443639	ulas	-1.3459389	-1.146857	-1.2788444	-0.7436476
clown	-0.3686595	-0.737305	-0.3337062	-0.9443639	badut	-0.6201992	-1.034676	-0.5077579	-0.7436476
cockroach	2.0638968	-2.145587	1.0369528	0.5529177	lipas	-0.6201992	-1.496343	-0.5077579	-0.7436476
cold	-0.9767986	0.822981	-0.3337062	-0.9443639	sejuk	-0.6201992	0.126492	-0.5077579	-0.7436476
column	0.2394796	0.334771	0.3516233	0.5529177	ruangan	0.8312803	-0.020604	1.0344151	1.2881038
comedian	1.4557578	-1.290326	2.4076117	2.0501994	pelawak	0.8312803	0.199432	1.0344151	1.2881038
commerce	1.4557578	0.043604	0.3516233	0.5529177	dagang	0.1055406	-0.061686	-0.5077579	-0.7436476
company	0.8476187	1.746243	1.7222822	2.0501994	syarikat	1.5570201	2.285397	1.0344151	1.2881038
compete	0.8476187	-0.040951	1.0369528	0.5529177	bersaing	1.5570201	1.215962	1.8055016	1.2881038
confident	2.0638968	-0.317719	2.4076117	2.0501994	yakin	-0.6201992	1.582924	-0.5077579	-0.7436476
continent	2.0638968	-0.563517	2.4076117	2.0501994	benua	-0.6201992	0.57907	0.2633286	1.2881038
cork	-0.9767986	-1.15785	-0.3337062	-0.9443639	gabus	-0.6201992	-1.837796	-0.5077579	-0.7436476
corn	-0.9767986	-0.373356	-0.3337062	-0.9443639	jagung	0.1055406	-0.800053	-0.5077579	-0.7436476
cough	-0.3686595	-0.872893	-1.0190357	-0.9443639	batuk	-0.6201992	-0.341603	-0.5077579	-0.7436476
coward	0.2394796	-1.050754	-0.3337062	-0.9443639	pengecut	1.5570201	-1.291686	1.0344151	1.2881038
crab	-0.9767986	-1.374689	-0.3337062	-0.9443639	ketam	-0.6201992	-1.291686	-0.5077579	-0.7436476
crater	0.2394796	-1.466624	0.3516233	0.5529177	kawah	-0.6201992	-1.146857	-0.5077579	-0.7436476
crawl	-0.3686595	-0.659918	-0.3337062	-0.9443639	merangkak	2.2827598	-0.557756	1.8055016	1.2881038
creator	0.8476187	-0.081351	1.0369528	2.0501994	pencipta	1.5570201	0.004933	1.8055016	1.2881038
crime	-0.3686595	0.798526	-0.3337062	-0.9443639	jenayah	0.8312803	-0.034023	1.0344151	1.2881038

crocodile	2.0638968	-1.763474	2.4076117	2.0501994
crowded	0.8476187	-0.519429	1.0369528	0.5529177
crown	-0.3686595	-0.012782	-0.3337062	-0.9443639
crunchy	0.8476187	-1.664412	1.0369528	0.5529177
crutch	0.2394796	-1.684858	-0.3337062	-0.9443639
cucumber	1.4557578	-1.590594	2.4076117	2.0501994
culture	0.8476187	0.88156	0.3516233	0.5529177
curtain	0.8476187	-0.950358	-0.3337062	0.5529177
customer	1.4557578	0.78845	1.7222822	2.0501994
dance	-0.3686595	0.645589	-0.3337062	-0.9443639
dancer	0.2394796	-0.687656	0.3516233	0.5529177
dark	-0.9767986	1.26297	-0.3337062	-0.9443639
day	-1.5849376	2.008012	-1.7043651	-0.9443639
deaf	-0.9767986	-0.247599	-1.0190357	-0.9443639
debt	-0.9767986	0.270089	-1.0190357	-0.9443639
deep	-0.9767986	0.947846	-1.0190357	-0.9443639
deer	-0.9767986	-0.38293	-1.0190357	-0.9443639
delicious	2.0638968	-0.803106	1.7222822	2.0501994
desk	-0.9767986	0.244954	-0.3337062	-0.9443639
desperate	2.0638968	-0.128722	2.4076117	2.0501994
dew	-1.5849376	-1.186308	-1.7043651	-0.9443639
diamond	0.8476187	0.426224	1.0369528	0.5529177
difficult	2.0638968	1.075704	1.7222822	2.0501994
dig	-1.5849376	-0.015052	-1.0190357	-0.9443639
dignity	0.8476187	-0.65639	1.7222822	2.0501994
dim	-1.5849376	-0.466264	-1.0190357	-0.9443639
director	1.4557578	0.853178	1.7222822	2.0501994
dirt	-0.9767986	-0.11083	-1.0190357	-0.9443639
dirty	-0.3686595	0.265825	-0.3337062	0.5529177
disease	0.8476187	0.571671	0.3516233	0.5529177
dish	-0.9767986	-0.144337	-1.0190357	-0.9443639
distance	1.4557578	0.726621	1.0369528	0.5529177
dive	-0.9767986	-0.069191	-1.0190357	-0.9443639
diver	-0.3686595	-1.023546	-0.3337062	0.5529177
dog	-1.5849376	1.13969	-1.0190357	-0.9443639
donkey	0.2394796	-0.767451	0.3516233	0.5529177
donor	-0.3686595	-1.036456	-0.3337062	0.5529177
door	-0.9767986	1.09026	-1.0190357	-0.9443639
doorknob	1.4557578	-2.403947	1.0369528	0.5529177

buaya	-0.6201992	-0.640964	0.2633286	1.2881038
sesak	-0.6201992	-0.091293	-0.5077579	-0.7436476
mahkota	0.8312803	0.642363	1.0344151	1.2881038
rangup	0.1055406	-1.837796	0.2633286	-0.7436476
tongkat	0.8312803	-0.155975	0.2633286	-0.7436476
timun	-0.6201992	-1.837796	-0.5077579	-0.7436476
budaya	0.1055406	1.540022	0.2633286	1.2881038
tirai	-0.6201992	1.002976	-1.2788444	-0.7436476
pelanggan	2.2827598	1.084465	1.8055016	1.2881038
menari	0.1055406	0.116525	0.2633286	1.2881038
penari	0.1055406	0.326059	0.2633286	1.2881038
gelap	-0.6201992	-0.020604	-0.5077579	-0.7436476
hari	-1.3459389	2.221111	-1.2788444	-0.7436476
pekak	-0.6201992	-1.146857	-0.5077579	-0.7436476
hutang	0.1055406	0.722964	-0.5077579	-0.7436476
mendalam	1.5570201	0.520161	1.8055016	1.2881038
rusa	-1.3459389	-1.496343	-1.2788444	-0.7436476
lazat	-0.6201992	-1.034676	-0.5077579	-0.7436476
meja	-1.3459389	0.017359	-1.2788444	-0.7436476
terdesak	1.5570201	-0.00781	1.8055016	1.2881038
embun	-0.6201992	1.034315	-0.5077579	-0.7436476
berlian	0.8312803	-0.688943	1.8055016	1.2881038
sukar	-0.6201992	1.628325	-0.5077579	-0.7436476
menggali	1.5570201	-0.944882	1.0344151	1.2881038
maruah	0.1055406	0.754697	1.0344151	1.2881038
malap	-0.6201992	-0.485718	-0.5077579	-0.7436476
pengarah	1.5570201	1.791634	1.0344151	1.2881038
habuk	-0.6201992	-1.496343	-0.5077579	-0.7436476
kotor	-0.6201992	-0.341603	-0.5077579	-0.7436476
penyakit	1.5570201	0.497277	1.8055016	1.2881038
hidangan	1.5570201	-0.00781	1.0344151	1.2881038
jarak	-0.6201992	1.002976	-0.5077579	-0.7436476
menyelam	1.5570201	-0.800053	1.8055016	1.2881038
penyelam	1.5570201	-1.837796	1.8055016	1.2881038
anjing	0.1055406	-0.688943	-0.5077579	-0.7436476
keldai	0.1055406	-0.867246	-0.5077579	-0.7436476
penderma	1.5570201	-1.034676	1.8055016	1.2881038
pintu	-0.6201992	0.743445	-0.5077579	-0.7436476
tombol	0.1055406	-1.837796	0.2633286	-0.7436476

dragon	0.2394796	0.716587	1.0369528	0.5529177
dream	-0.3686595	0.778491	-0.3337062	-0.9443639
drink	-0.3686595	0.477238	0.3516233	-0.9443639
driving	0.8476187	0.55046	1.0369528	0.5529177
drought	0.8476187	-1.321199	-0.3337062	-0.9443639
drunk	-0.3686595	-0.141961	0.3516233	-0.9443639
dry	-1.5849376	0.461875	-1.0190357	-0.9443639
duck	-0.9767986	-0.180046	-1.0190357	-0.9443639
eagle	-0.3686595	-0.178606	-1.0190357	0.5529177
ear	-1.5849376	0.130517	-1.7043651	-0.9443639
early	-0.3686595	1.300738	-1.0190357	0.5529177
earring	0.8476187	-1.900492	0.3516233	0.5529177
east	-0.9767986	1.033834	-1.0190357	-0.9443639
easy	-0.9767986	1.432019	-1.0190357	0.5529177
eat	-1.5849376	0.835148	-1.7043651	-0.9443639
eclipse	0.8476187	-0.7607	1.0369528	0.5529177
effort	0.2394796	0.870481	-0.3337062	0.5529177
egg	-1.5849376	0.302807	-1.7043651	-0.9443639
elbow	-0.3686595	-0.609017	-0.3337062	0.5529177
elephant	1.4557578	-0.163948	1.7222822	2.0501994
energy	0.2394796	1.142658	0.3516233	2.0501994
errand	0.2394796	-2.094981	0.3516233	0.5529177
evidence	1.4557578	1.180712	1.7222822	2.0501994
evil	-0.9767986	0.962669	-1.0190357	0.5529177
exit	-0.9767986	0.633793	0.3516233	0.5529177
expensive	2.0638968	0.849637	3.0929412	2.0501994
expert	0.2394796	0.474849	1.0369528	0.5529177
eye	-1.5849376	0.923698	-2.3896946	-0.9443639
eyebrow	0.8476187	-1.519107	-0.3337062	0.5529177
face	-0.9767986	1.316353	-1.0190357	-0.9443639
factory	0.8476187	0.46289	1.7222822	2.0501994
fall	-0.9767986	0.994515	-1.0190357	-0.9443639
famous	0.2394796	0.398492	0.3516233	0.5529177
farmer	0.2394796	-0.368686	0.3516233	0.5529177
fast	-0.9767986	1.310761	-0.3337062	-0.9443639
fate	-0.9767986	-0.045713	-1.0190357	-0.9443639
fence	-0.3686595	-0.338698	-0.3337062	-0.9443639
fever	-0.3686595	-0.483431	-0.3337062	0.5529177
fig	-1.5849376	-0.971513	-1.0190357	-0.9443639

naga	-1.3459389	-0.520442	-1.2788444	-0.7436476
impian	0.1055406	1.21262	1.0344151	1.2881038
minum	-0.6201992	0.136264	-0.5077579	-0.7436476
memandu	0.8312803	0.57506	1.0344151	1.2881038
kemarau	0.8312803	0.298992	0.2633286	1.2881038
mabuk	-0.6201992	-0.394616	-0.5077579	-0.7436476
kering	0.1055406	0.096199	-0.5077579	-0.7436476
itik	-1.3459389	-0.867246	-1.2788444	-0.7436476
helang	0.1055406	-0.944882	-0.5077579	-0.7436476
telinga	0.8312803	-0.07627	0.2633286	1.2881038
awal	-1.3459389	1.883616	-1.2788444	-0.7436476
subang	0.1055406	0.56703	-0.5077579	-0.7436476
timur	-0.6201992	0.939578	-0.5077579	-0.7436476
mudah	-0.6201992	1.652128	-0.5077579	-0.7436476
makan	-0.6201992	0.704792	-0.5077579	-0.7436476
gerhana	0.8312803	-1.146857	1.0344151	1.2881038
usaha	-0.6201992	1.700836	-0.5077579	1.2881038
telur	-0.6201992	-0.453249	-0.5077579	-0.7436476
siku	-1.3459389	-0.423389	-1.2788444	-0.7436476
gajah	-0.6201992	0.136264	-0.5077579	-0.7436476
tenaga	0.1055406	1.410609	0.2633286	1.2881038
suruhan	0.8312803	-1.034676	1.0344151	1.2881038
bukti	-0.6201992	0.427139	-0.5077579	-0.7436476
jahat	-0.6201992	-0.230279	-0.5077579	-0.7436476
keluar	0.1055406	1.190884	1.0344151	1.2881038
mahal	-0.6201992	0.515648	-0.5077579	-0.7436476
pakar	-0.6201992	1.019737	-0.5077579	-0.7436476
mata	-1.3459389	2.303429	-1.2788444	-0.7436476
kening	0.1055406	-1.837796	-0.5077579	-0.7436476
muka	-1.3459389	0.952917	-1.2788444	-0.7436476
kilang	0.1055406	0.862452	-0.5077579	-0.7436476
jatuh	-0.6201992	1.278591	-0.5077579	-0.7436476
terkenal	1.5570201	1.177858	1.8055016	1.2881038
petani	0.1055406	0.126492	0.2633286	1.2881038
pantas	0.1055406	1.267682	0.2633286	-0.7436476
nasib	-0.6201992	1.200154	-0.5077579	-0.7436476
pagar	-0.6201992	-0.317574	-0.5077579	-0.7436476
demam	-0.6201992	0.364163	-0.5077579	-0.7436476
ara	-2.0716786	-1.837796	-2.049931	-0.7436476

fin	-1.5849376	-0.561002	-1.0190357	-0.9443639
finger	0.2394796	0.869091	0.3516233	0.5529177
fire	-0.9767986	1.184384	-1.0190357	-0.9443639
fireman	0.8476187	-2.099043	1.0369528	0.5529177
fish	-0.9767986	0.743163	-1.0190357	-0.9443639
fisherman	2.0638968	-1.391236	1.7222822	2.0501994
flag	-0.9767986	0.31679	-0.3337062	-0.9443639
flat	-0.9767986	0.648667	-0.3337062	-0.9443639
float	-0.3686595	-0.3017	-0.3337062	-0.9443639
flood	-0.3686595	0.028317	-0.3337062	-0.9443639
floor	-0.3686595	0.836618	-0.3337062	-0.9443639
flour	-0.3686595	-0.419852	-0.3337062	-0.9443639
flower	0.2394796	-0.230834	-0.3337062	-0.9443639
flute	-0.3686595	-0.592945	-0.3337062	-0.9443639
fog	-1.5849376	-0.398667	-1.0190357	-0.9443639
fold	-0.9767986	-0.383556	-0.3337062	-0.9443639
foot	-0.9767986	0.598794	-1.0190357	-0.9443639
forecast	1.4557578	-0.672225	1.7222822	0.5529177
forehead	1.4557578	-0.823275	1.0369528	0.5529177
foreign	0.8476187	0.940509	0.3516233	0.5529177
forget	0.2394796	0.959481	0.3516233	0.5529177
fort	-0.9767986	-0.05117	-0.3337062	-0.9443639
founder	0.8476187	-0.307437	0.3516233	0.5529177
fragile	0.8476187	-0.839374	1.0369528	0.5529177
fragrant	1.4557578	-1.768217	2.4076117	0.5529177
fresh	-0.3686595	0.328178	-0.3337062	-0.9443639
friction	1.4557578	-0.73842	1.0369528	0.5529177
fried	-0.3686595	-0.652883	-0.3337062	-0.9443639
full	-0.9767986	1.74365	-1.0190357	-0.9443639
funnel	0.2394796	-1.506533	-0.3337062	0.5529177
funny	-0.3686595	0.854974	-0.3337062	0.5529177
furniture	2.0638968	-0.409822	1.0369528	2.0501994
gamble	0.2394796	-0.945649	0.3516233	0.5529177
gap	-1.5849376	-0.189855	-1.0190357	-0.9443639
garbage	0.8476187	0.196775	1.0369528	0.5529177
germ	-0.9767986	-1.632095	-1.0190357	-0.9443639
gift	-0.9767986	0.152425	-0.3337062	-0.9443639
glass	-0.3686595	0.504377	-0.3337062	-0.9443639
goal	-0.9767986	0.643347	-1.0190357	-0.9443639

sirip	-0.6201992	-0.557756	-0.5077579	-0.7436476
jari	-1.3459389	0.405134	-1.2788444	-0.7436476
api	-2.0716786	0.483068	-2.049931	-0.7436476
bomba	-0.6201992	-0.688943	-0.5077579	-0.7436476
ikan	-1.3459389	0.339131	-1.2788444	-0.7436476
nelayan	0.8312803	-0.394616	1.0344151	1.2881038
bendera	0.8312803	0.326059	1.0344151	1.2881038
rata	-1.3459389	0.743445	-1.2788444	-0.7436476
terapung	1.5570201	-1.146857	1.0344151	1.2881038
banjir	0.1055406	-0.944882	0.2633286	-0.7436476
lantai	0.1055406	-0.07627	-0.5077579	-0.7436476
tepung	0.1055406	-1.291686	-0.5077579	-0.7436476
bunga	-0.6201992	0.571018	-1.2788444	-0.7436476
seruling	1.5570201	-0.29416	1.0344151	1.2881038
kabus	-0.6201992	-0.740825	-0.5077579	-0.7436476
melipat	0.8312803	-1.496343	1.0344151	1.2881038
kaki	-1.3459389	1.263653	-1.2788444	-0.7436476
ramalan	0.8312803	0.497277	1.0344151	1.2881038
dahi	-1.3459389	-1.146857	-1.2788444	-0.7436476
asing	-0.6201992	1.319994	-1.2788444	-0.7436476
lupa	-1.3459389	0.524539	-1.2788444	-0.7436476
kubu	-1.3459389	0.432521	-1.2788444	-0.7436476
pengasas	1.5570201	-0.138915	1.0344151	1.2881038
rapuh	-0.6201992	-0.155975	-0.5077579	-0.7436476
wangi	-0.6201992	-0.800053	-1.2788444	-0.7436476
segar	-0.6201992	0.590828	-0.5077579	-0.7436476
geseran	0.8312803	-1.496343	1.0344151	1.2881038
goreng	0.1055406	-0.557756	-0.5077579	-0.7436476
penuh	-0.6201992	1.47155	-0.5077579	-0.7436476
corong	0.1055406	-1.034676	-0.5077579	-0.7436476
lucu	-1.3459389	0.052644	-1.2788444	-0.7436476
perabot	0.8312803	0.427139	1.0344151	1.2881038
berjudi	0.8312803	-1.146857	1.0344151	1.2881038
jurang	0.1055406	0.669611	-0.5077579	-0.7436476
sampah	0.1055406	-0.688943	0.2633286	-0.7436476
kuman	-0.6201992	-0.688943	-0.5077579	-0.7436476
hadiah	0.1055406	1.358231	1.0344151	1.2881038
kaca	-1.3459389	0.312781	-1.2788444	-0.7436476
matlamat	1.5570201	0.964062	1.8055016	1.2881038

goat	-0.9767986	-0.783336	-1.0190357	-0.9443639
goddess	0.8476187	-0.314796	0.3516233	0.5529177
gold	-0.9767986	1.08167	-0.3337062	-0.9443639
graceful	1.4557578	-1.427776	1.0369528	0.5529177
grape	-0.3686595	-1.058969	-0.3337062	-0.9443639
grass	-0.3686595	-0.134469	-0.3337062	-0.9443639
grasshopper	3.280175	-1.926104	2.4076117	2.0501994
gravel	0.2394796	-0.823788	0.3516233	0.5529177
gravy	-0.3686595	-1.416248	0.3516233	0.5529177
greedy	0.2394796	-0.686218	0.3516233	0.5529177
green	-0.3686595	1.411998	-0.3337062	-0.9443639
grey	-0.9767986	0.20101	-1.0190357	-0.9443639
grill	-0.3686595	-1.114806	-0.3337062	-0.9443639
guard	-0.3686595	0.346448	-0.3337062	-0.9443639
guest	-0.3686595	0.296816	-0.3337062	-0.9443639
hair	-0.9767986	0.946518	-1.0190357	-0.9443639
hammer	0.2394796	-0.190497	-0.3337062	0.5529177
hand	-0.9767986	1.608134	-0.3337062	-0.9443639
handcuffs	2.0638968	-1.655429	2.4076117	0.5529177
happy	-0.3686595	1.259783	-0.3337062	0.5529177
hat	-1.5849376	0.153789	-1.0190357	-0.9443639
hawk	-0.9767986	-0.574538	-1.0190357	-0.9443639
head	-0.9767986	1.525102	-1.0190357	-0.9443639
heal	-0.9767986	-0.461975	-1.0190357	-0.9443639
healthy	0.8476187	0.232314	0.3516233	0.5529177
heart	-0.3686595	0.990817	-0.3337062	-0.9443639
heaven	0.2394796	0.353682	-0.3337062	0.5529177
heritage	1.4557578	-0.148432	1.7222822	2.0501994
hero	-0.9767986	0.343799	-0.3337062	0.5529177
hill	-0.9767986	0.757703	-1.0190357	-0.9443639
history	0.8476187	1.389709	1.7222822	2.0501994
hoarse	0.2394796	-2.316781	-0.3337062	-0.9443639
holder	0.2394796	-0.368686	0.3516233	0.5529177
hole	-0.9767986	0.637647	-1.0190357	-0.9443639
holy	-0.9767986	0.671804	-0.3337062	0.5529177
honest	0.2394796	0.541822	0.3516233	0.5529177
honey	-0.3686595	-0.003852	-0.3337062	0.5529177
horse	-0.3686595	0.589653	-0.3337062	-0.9443639
hot	-1.5849376	1.063775	-1.0190357	-0.9443639

kambing	0.8312803	-0.367408	0.2633286	-0.7436476
dewi	-1.3459389	0.029484	-1.2788444	-0.7436476
emas	-1.3459389	1.875646	-1.2788444	-0.7436476
anggun	0.1055406	0.199432	-0.5077579	-0.7436476
anggur	0.1055406	-1.496343	-0.5077579	-0.7436476
rumput	0.1055406	0.063953	0.2633286	-0.7436476
belalang	1.5570201	-1.146857	1.0344151	1.2881038
batu	-1.3459389	0.731871	-1.2788444	-0.7436476
kuah	-1.3459389	-0.800053	-0.5077579	-0.7436476
tamak	-0.6201992	-0.173638	-0.5077579	-0.7436476
hijau	-0.6201992	0.659584	-1.2788444	-0.7436476
kelabu	0.1055406	-1.291686	0.2633286	1.2881038
panggang	1.5570201	-1.146857	0.2633286	-0.7436476
pengawal	1.5570201	-0.155975	1.0344151	1.2881038
tetamu	0.1055406	0.707889	0.2633286	1.2881038
rambut	0.1055406	0.106574	0.2633286	-0.7436476
tukul	-0.6201992	-0.557756	-0.5077579	-0.7436476
tangan	0.1055406	1.275643	-0.5077579	-0.7436476
gari	-1.3459389	-1.496343	-1.2788444	-0.7436476
gembira	0.8312803	1.301589	1.0344151	1.2881038
topi	-1.3459389	-0.640964	-1.2788444	-0.7436476
menjaja	0.8312803	-0.867246	1.0344151	1.2881038
kepala	0.1055406	0.550482	0.2633286	1.2881038
sembuh	0.1055406	0.207889	0.2633286	-0.7436476
sihat	-0.6201992	0.57907	-0.5077579	-0.7436476
jantung	0.8312803	-0.173638	0.2633286	-0.7436476
syurga	0.1055406	-0.191551	-0.5077579	-0.7436476
warisan	0.8312803	0.298992	1.0344151	1.2881038
wira	-1.3459389	0.757501	-1.2788444	-0.7436476
bukit	-0.6201992	1.339477	-0.5077579	-0.7436476
sejarah	0.8312803	1.384307	1.0344151	1.2881038
serak	-0.6201992	-0.485718	-0.5077579	-0.7436476
pemegang	1.5570201	1.084465	1.0344151	1.2881038
lubang	0.1055406	1.275643	-0.5077579	-0.7436476
suci	-1.3459389	0.096199	-1.2788444	-0.7436476
jujur	-0.6201992	0.270533	-0.5077579	-0.7436476
madu	-1.3459389	0.096199	-1.2788444	-0.7436476
kuda	-1.3459389	0.487883	-1.2788444	-0.7436476
panas	-0.6201992	0.869159	-0.5077579	-0.7436476

hungry	0.2394796	-0.229661	1.0369528	0.5529177
husband	0.8476187	0.455171	1.7222822	0.5529177
important	2.0638968	1.507298	2.4076117	2.0501994
infection	2.0638968	-0.008881	1.7222822	2.0501994
inject	0.2394796	-1.328145	1.0369528	0.5529177
ink	-1.5849376	-0.30258	-1.0190357	-0.9443639
insect	0.2394796	-0.788886	1.0369528	0.5529177
install	0.8476187	1.040924	1.0369528	0.5529177
insult	0.2394796	-0.155925	1.0369528	0.5529177
intact	0.2394796	-0.218914	1.0369528	0.5529177
interpret	2.0638968	-0.236636	2.4076117	2.0501994
investor	1.4557578	-0.621445	1.7222822	2.0501994
iron	-0.9767986	0.455652	-1.0190357	-0.9443639
island	0.2394796	0.978449	0.3516233	0.5529177
itch	-0.9767986	-1.532756	-1.7043651	-0.9443639
ivory	-0.3686595	0.100874	0.3516233	2.0501994
jasmine	0.8476187	-0.843862	1.0369528	0.5529177
jealous	0.8476187	-0.61997	0.3516233	0.5529177
jump	-0.9767986	0.662547	-0.3337062	-0.9443639
kick	-0.9767986	0.477393	-1.0190357	-0.9443639
kidnap	0.2394796	-1.650494	1.0369528	0.5529177
king	-0.9767986	1.076031	-1.0190357	-0.9443639
knee	-0.9767986	-0.149546	-1.7043651	-0.9443639
kneel	-0.3686595	-1.553394	-1.0190357	-0.9443639
knife	-0.3686595	-0.154367	-1.0190357	-0.9443639
knock	-0.3686595	-0.172612	-1.0190357	-0.9443639
knot	-0.9767986	-0.935416	-1.0190357	-0.9443639
lab	-1.5849376	0.61274	-1.0190357	-0.9443639
lace	-0.9767986	-0.630372	-1.0190357	-0.9443639
lake	-0.9767986	0.528947	-1.0190357	-0.9443639
land	-0.9767986	1.295157	-0.3337062	-0.9443639
language	1.4557578	1.458346	1.7222822	0.5529177
large	-0.3686595	1.653289	-0.3337062	-0.9443639
latest	0.2394796	1.084342	1.0369528	0.5529177
laughter	1.4557578	-0.359933	0.3516233	0.5529177
laundry	0.8476187	-0.834656	1.0369528	0.5529177
lawyer	0.2394796	0.17221	-0.3337062	0.5529177
lazy	-0.9767986	-0.227127	-0.3337062	0.5529177
leader	0.2394796	0.784816	-0.3337062	0.5529177

lapar	-0.6201992	-0.29416	-0.5077579	-0.7436476
suami	-0.6201992	0.586911	0.2633286	1.2881038
penting	0.8312803	1.713327	0.2633286	-0.7436476
jangkitan	2.2827598	-0.740825	1.8055016	1.2881038
menyuntik	2.2827598	0.410756	2.5765881	1.2881038
dakwat	0.1055406	-1.837796	0.2633286	-0.7436476
serangga	1.5570201	-1.034676	1.0344151	1.2881038
memasang	1.5570201	0.247827	1.0344151	1.2881038
menghina	1.5570201	-1.291686	1.0344151	1.2881038
utuh	-1.3459389	-1.146857	-1.2788444	-0.7436476
mentafsir	2.2827598	-1.291686	2.5765881	1.2881038
pelabur	0.8312803	1.488601	1.0344151	1.2881038
besi	-1.3459389	0.319535	-1.2788444	-0.7436476
pulau	-0.6201992	1.521648	-1.2788444	-0.7436476
gatal	-0.6201992	-1.837796	-0.5077579	-0.7436476
gading	0.1055406	-0.688943	-0.5077579	-0.7436476
melati	0.1055406	-1.496343	0.2633286	1.2881038
cemburu	0.8312803	0.029484	1.0344151	1.2881038
lompat	0.1055406	0.298992	0.2633286	-0.7436476
menendang	2.2827598	-0.250828	1.8055016	1.2881038
menculik	1.5570201	-0.944882	1.8055016	1.2881038
raja	-1.3459389	1.33072	-1.2788444	-0.7436476
lutut	-0.6201992	0.463436	-0.5077579	-0.7436476
melutut	0.8312803	-1.496343	1.0344151	1.2881038
pisau	-0.6201992	-1.146857	-1.2788444	-0.7436476
mengetuk	1.5570201	-0.944882	1.0344151	1.2881038
simpulan	1.5570201	-1.291686	1.8055016	1.2881038
makmal	0.1055406	-0.122417	0.2633286	-0.7436476
renda	-0.6201992	-1.837796	-0.5077579	-0.7436476
tasik	-0.6201992	0.173357	-0.5077579	-0.7436476
tanah	-0.6201992	1.37791	-0.5077579	-0.7436476
bahasa	0.1055406	1.168161	0.2633286	1.2881038
besar	-0.6201992	2.022105	-0.5077579	-0.7436476
terkini	0.8312803	0.800127	1.0344151	1.2881038
ketawa	0.1055406	0.255511	0.2633286	1.2881038
dobi	-1.3459389	-1.837796	-1.2788444	-0.7436476
peguam	0.1055406	-0.155975	1.0344151	1.2881038
malas	-0.6201992	-0.740825	-0.5077579	-0.7436476
pemimpin	1.5570201	0.907659	1.8055016	1.2881038

leaf	-0.9767986	-0.16036	-1.0190357	-0.9443639
leak	-0.9767986	-0.354525	-1.0190357	-0.9443639
lecturer	1.4557578	-1.058218	1.0369528	2.0501994
lice	-0.9767986	-1.932289	-1.0190357	-0.9443639
lick	-0.9767986	-0.448029	-1.0190357	-0.9443639
lightning	2.0638968	0.217664	1.0369528	0.5529177
lion	-0.9767986	-0.108499	-0.3337062	-0.9443639
lip	-1.5849376	-0.623294	-1.0190357	-0.9443639
list	-0.9767986	2.181713	-0.3337062	-0.9443639
listen	0.2394796	0.806175	-0.3337062	0.5529177
lotus	-0.3686595	0.483707	0.3516233	0.5529177
lung	-0.9767986	0.239328	-1.0190357	-0.9443639
main	-0.9767986	1.287063	-1.0190357	-0.9443639
maker	-0.3686595	-0.076534	-0.3337062	0.5529177
map	-1.5849376	0.639743	-1.0190357	-0.9443639
marker	0.2394796	-0.548085	0.3516233	0.5529177
market	0.2394796	1.464452	1.0369528	0.5529177
massage	0.8476187	-0.503525	0.3516233	0.5529177
mattress	1.4557578	-1.22053	1.0369528	0.5529177
measles	0.8476187	-1.304167	0.3516233	0.5529177
meat	-0.9767986	0.298433	-1.0190357	-0.9443639
medal	-0.3686595	-0.624777	-0.3337062	0.5529177
melon	-0.3686595	-1.531945	0.3516233	0.5529177
metal	-0.3686595	0.690784	-0.3337062	0.5529177
method	0.2394796	1.042915	0.3516233	0.5529177
midwife	0.8476187	-1.730141	1.0369528	0.5529177
milk	-0.9767986	0.31211	-0.3337062	-0.9443639
millionaire	3.280175	-1.308099	2.4076117	2.0501994
mirror	0.2394796	0.668295	-1.0190357	-0.9443639
mobile	0.2394796	0.006615	-0.3337062	0.5529177
money	-0.3686595	1.926918	-0.3337062	0.5529177
monk	-0.9767986	-0.544816	-0.3337062	-0.9443639
monster	0.8476187	0.328573	1.0369528	0.5529177
month	-0.3686595	1.305117	-0.3337062	-0.9443639
monument	1.4557578	-1.117694	3.0929412	2.0501994
morning	0.8476187	0.847351	1.0369528	0.5529177
mosquito	1.4557578	-1.490409	1.7222822	2.0501994
moth	-0.9767986	-1.770602	-1.0190357	-0.9443639
mountain	1.4557578	0.820735	0.3516233	0.5529177

daun	-1.3459389	-0.250828	-0.5077579	-0.7436476
bocor	-0.6201992	-0.173638	-0.5077579	-0.7436476
pensyarah	2.2827598	-0.00781	1.8055016	1.2881038
kutu	-1.3459389	-1.837796	-1.2788444	-0.7436476
menjilat	1.5570201	-1.837796	1.8055016	1.2881038
kilat	-0.6201992	-0.250828	-0.5077579	-0.7436476
singa	-0.6201992	0.199432	-1.2788444	-0.7436476
bibir	-0.6201992	-0.271792	-0.5077579	-0.7436476
senarai	0.8312803	1.484069	0.2633286	1.2881038
mendengar	2.2827598	0.76576	1.8055016	1.2881038
teratai	0.8312803	-0.944882	0.2633286	1.2881038
paru	-1.3459389	-0.688943	-1.2788444	-0.7436476
utama	-0.6201992	2.026305	-0.5077579	1.2881038
pembuat	0.8312803	-0.367408	1.8055016	1.2881038
peta	-1.3459389	-0.640964	-1.2788444	-0.7436476
penanda	0.8312803	-0.138915	1.0344151	1.2881038
pasar	-0.6201992	0.620945	-0.5077579	-0.7436476
urut	-1.3459389	-1.034676	-1.2788444	-0.7436476
tilam	-0.6201992	-1.837796	-0.5077579	-0.7436476
campak	0.1055406	-1.034676	0.2633286	-0.7436476
daging	0.1055406	-0.00781	-0.5077579	-0.7436476
pingat	0.1055406	1.696593	-0.5077579	-0.7436476
tembikai	1.5570201	-1.837796	1.0344151	1.2881038
logam	-0.6201992	-1.291686	-0.5077579	-0.7436476
kaedah	0.1055406	0.773943	0.2633286	1.2881038
bidan	-0.6201992	-0.597186	-0.5077579	-0.7436476
susu	-1.3459389	-0.271792	-1.2788444	-0.7436476
jutawan	0.8312803	-0.367408	1.0344151	1.2881038
cermin	0.1055406	-0.07627	0.2633286	-0.7436476
bimbit	0.1055406	0.017359	0.2633286	-0.7436476
wang	-1.3459389	1.582924	-2.049931	-2.775399
sami	-1.3459389	-0.250828	-1.2788444	-0.7436476
raksasa	0.8312803	-1.496343	1.0344151	1.2881038
bulan	-0.6201992	1.782754	-0.5077579	-0.7436476
tugu	-1.3459389	-1.291686	-1.2788444	-0.7436476
pagi	-1.3459389	1.23237	-1.2788444	-0.7436476
nyamuk	0.1055406	-0.485718	0.2633286	-0.7436476
kupu	-1.3459389	-0.367408	-1.2788444	-0.7436476
gunung	0.1055406	0.364163	-0.5077579	-0.7436476

mud	-1.5849376	0.137709	-1.0190357	-0.9443639
muscle	0.2394796	0.011057	-0.3337062	0.5529177
mushroom	1.4557578	-0.976095	1.0369528	0.5529177
narrow	0.2394796	0.057664	-0.3337062	0.5529177
neck	-0.9767986	0.297604	-1.0190357	-0.9443639
necklace	1.4557578	-1.276789	1.0369528	0.5529177
needle	0.2394796	-0.36612	-0.3337062	0.5529177
neighbor	1.4557578	-0.413235	-0.3337062	0.5529177
nerve	-0.3686595	-0.479754	-1.0190357	-0.9443639
new	-1.5849376	2.676934	-1.7043651	-0.9443639
news	-0.9767986	1.717141	-1.0190357	-0.9443639
night	-0.3686595	1.456141	-1.0190357	-0.9443639
north	-0.3686595	1.312492	-0.3337062	-0.9443639
nose	-0.9767986	0.258136	-1.0190357	-0.9443639
numb	-0.9767986	-1.214692	-1.0190357	-0.9443639
oath	-0.9767986	-0.57488	-1.7043651	-0.9443639
ocean	-0.3686595	0.116097	-1.0190357	0.5529177
office	0.2394796	1.395704	-0.3337062	0.5529177
oil	-1.5849376	0.821762	-1.7043651	-0.9443639
old	-1.5849376	2.005976	-1.0190357	-0.9443639
opium	-0.3686595	-0.92113	0.3516233	0.5529177
origin	0.2394796	0.388451	1.0369528	2.0501994
owner	-0.3686595	0.668817	-1.0190357	0.5529177
oyster	0.2394796	-1.289232	-0.3337062	0.5529177
palace	0.2394796	-0.457149	0.3516233	0.5529177
paper	-0.3686595	1.196991	-0.3337062	0.5529177
park	-0.9767986	0.999849	-0.3337062	-0.9443639
parrot	0.2394796	-1.010553	0.3516233	0.5529177
pay	-1.5849376	1.650756	-1.7043651	-0.9443639
peacock	0.8476187	-1.381636	0.3516233	0.5529177
pepper	0.2394796	-0.333241	-0.3337062	0.5529177
perfect	0.8476187	0.934956	1.0369528	0.5529177
person	0.2394796	1.788755	-0.3337062	0.5529177
piece	-0.3686595	0.99545	-1.0190357	-0.9443639
pigeon	0.2394796	-1.427092	0.3516233	0.5529177
pillow	0.2394796	-0.902777	-0.3337062	0.5529177
pineapple	2.0638968	-1.639775	1.0369528	2.0501994
pirate	0.2394796	-0.230443	0.3516233	0.5529177
place	-0.3686595	1.883151	-0.3337062	-0.9443639

lumpur	0.1055406	2.052044	0.2633286	-0.7436476
otot	-1.3459389	0.096199	-1.2788444	-0.7436476
cendawan	1.5570201	-1.034676	1.8055016	1.2881038
sempit	0.1055406	0.075011	0.2633286	-0.7436476
leher	-0.6201992	-0.341603	-0.5077579	-0.7436476
kalung	0.1055406	-0.061686	-0.5077579	-0.7436476
jarum	-0.6201992	0.562922	-0.5077579	-0.7436476
jiran	-0.6201992	0.483068	-0.5077579	-0.7436476
saraf	-0.6201992	-0.867246	-0.5077579	-0.7436476
baru	-1.3459389	2.396124	-1.2788444	-0.7436476
berita	0.1055406	1.513129	0.2633286	1.2881038
malam	-0.6201992	1.856545	-0.5077579	-0.7436476
utara	-0.6201992	0.899351	-0.5077579	1.2881038
hidung	0.1055406	-0.520442	-0.5077579	-0.7436476
kebas	-0.6201992	-1.146857	-0.5077579	-0.7436476
sumpah	0.1055406	-0.453249	0.2633286	-0.7436476
lautan	0.1055406	-0.250828	1.0344151	1.2881038
pejabat	0.8312803	1.014746	1.0344151	1.2881038
minyak	0.1055406	1.066796	0.2633286	-0.7436476
lama	-1.3459389	1.707953	-1.2788444	-0.7436476
candu	-0.6201992	-1.837796	-0.5077579	-0.7436476
asal	-1.3459389	0.760289	-1.2788444	-0.7436476
pemilik	0.8312803	0.515648	1.0344151	1.2881038
tiram	-0.6201992	-1.291686	-0.5077579	-0.7436476
istana	0.1055406	0.880172	0.2633286	1.2881038
kertas	0.1055406	0.731871	0.2633286	-0.7436476
taman	-0.6201992	0.794966	-0.5077579	-0.7436476
nuri	-1.3459389	-1.146857	-1.2788444	-0.7436476
membayar	1.5570201	0.844081	1.8055016	1.2881038
merak	-0.6201992	-1.291686	-0.5077579	-0.7436476
lada	-1.3459389	-1.034676	-1.2788444	-0.7436476
sempurna	1.5570201	0.586911	1.8055016	1.2881038
orang	-0.6201992	1.898613	-1.2788444	-0.7436476
keping	0.1055406	-0.688943	-0.5077579	-0.7436476
merpati	0.8312803	-0.944882	1.0344151	1.2881038
bantal	0.1055406	-1.291686	0.2633286	-0.7436476
nanas	-0.6201992	-1.496343	-0.5077579	-0.7436476
lanun	-0.6201992	0.145849	-0.5077579	-0.7436476
tempat	0.1055406	2.054339	0.2633286	-0.7436476

plant	-0.3686595	0.624016	0.3516233	-0.9443639
pliers	0.2394796	-1.555917	0.3516233	-0.9443639
plow	-0.9767986	-1.52871	-1.0190357	-0.9443639
poisonous	2.0638968	-1.174857	1.0369528	2.0501994
pole	-0.9767986	-0.288018	-1.0190357	-0.9443639
polite	0.2394796	-0.261636	0.3516233	0.5529177
potato	0.2394796	-0.650749	1.0369528	2.0501994
pour	-0.9767986	0.132472	-1.0190357	-0.9443639
powder	0.2394796	-0.080737	-0.3337062	0.5529177
practice	1.4557578	0.970471	1.7222822	0.5529177
prayer	0.2394796	0.06907	-0.3337062	-0.9443639
price	-0.3686595	1.736134	-0.3337062	-0.9443639
priest	0.2394796	0.279768	0.3516233	-0.9443639
prisoner	1.4557578	-0.438767	1.0369528	2.0501994
private	0.8476187	1.140881	1.0369528	0.5529177
promise	0.8476187	0.278187	1.0369528	0.5529177
prophet	0.8476187	-0.288555	1.0369528	0.5529177
protest	0.8476187	0.003146	1.7222822	0.5529177
proud	-0.3686595	0.368307	-0.3337062	-0.9443639
public	0.2394796	1.735417	1.0369528	0.5529177
pumpkin	0.8476187	-1.4023	1.7222822	0.5529177
puppet	0.2394796	-0.507808	0.3516233	0.5529177
pure	-0.9767986	0.516232	-0.3337062	-0.9443639
purple	0.2394796	0.017038	-0.3337062	0.5529177
queasy	0.2394796	-2.349568	0.3516233	0.5529177
question	1.4557578	1.847636	1.7222822	0.5529177
rabbit	0.2394796	-0.285767	0.3516233	0.5529177
racing	0.2394796	0.307272	0.3516233	0.5529177
rain	-0.9767986	0.409514	-1.0190357	-0.9443639
rainbow	0.8476187	-0.187297	0.3516233	0.5529177
ranch	-0.3686595	-0.565032	-0.3337062	-0.9443639
ransom	0.2394796	-1.480635	0.3516233	0.5529177
read	-0.9767986	2.12586	-1.0190357	-0.9443639
reader	0.2394796	0.569116	-0.3337062	0.5529177
red	-1.5849376	1.494632	-1.0190357	-0.9443639
relax	-0.3686595	-0.269506	1.0369528	0.5529177
reluctant	2.0638968	-0.676652	3.0929412	2.0501994
remember	1.4557578	1.69006	1.7222822	2.0501994
reporter	1.4557578	-0.308546	1.7222822	2.0501994

tumbuhan	1.5570201	-0.800053	1.8055016	1.2881038
tang	-1.3459389	-0.453249	-2.049931	-2.775399
membajak	1.5570201	-1.837796	1.8055016	1.2881038
beracun	0.8312803	-1.837796	1.0344151	1.2881038
tiang	-0.6201992	0.085603	-0.5077579	-0.7436476
sopan	-0.6201992	-0.122417	-0.5077579	-0.7436476
kentang	0.8312803	-1.291686	0.2633286	-0.7436476
mencurah	1.5570201	-0.640964	1.8055016	1.2881038
serbuk	0.1055406	-1.146857	0.2633286	-0.7436476
amalan	0.1055406	0.537725	0.2633286	1.2881038
doa	-2.0716786	-0.020604	-2.049931	-0.7436476
harga	-0.6201992	1.738215	-0.5077579	-0.7436476
imam	-1.3459389	-0.394616	-1.2788444	-0.7436476
banduan	0.8312803	-0.597186	1.8055016	1.2881038
swasta	0.1055406	0.734743	0.2633286	-0.7436476
janji	-0.6201992	0.620945	-0.5077579	-0.7436476
nabi	-1.3459389	-0.061686	-1.2788444	-0.7436476
bantahan	1.5570201	0.255511	1.8055016	1.2881038
bangga	0.1055406	0.725951	-0.5077579	-0.7436476
awam	-1.3459389	0.97137	-1.2788444	-0.7436476
labu	-1.3459389	0.190829	-1.2788444	-0.7436476
boneka	0.1055406	-1.496343	0.2633286	1.2881038
tulen	-0.6201992	0.393696	-0.5077579	-0.7436476
ungu	-1.3459389	-1.034676	-2.049931	-0.7436476
muak	-1.3459389	-1.034676	-0.5077579	-0.7436476
soalan	0.1055406	0.56703	0.2633286	1.2881038
arnab	-0.6201992	-1.291686	-0.5077579	-0.7436476
lumba	-0.6201992	0.672933	-0.5077579	-0.7436476
hujan	-0.6201992	0.692277	-0.5077579	-0.7436476
pelangi	0.8312803	-0.485718	0.2633286	1.2881038
ladang	0.1055406	0.405134	-0.5077579	-0.7436476
tebusan	0.8312803	-0.640964	1.0344151	1.2881038
membaca	0.8312803	0.432521	1.0344151	1.2881038
pembaca	0.8312803	0.79242	1.0344151	1.2881038
merah	-0.6201992	1.243009	-0.5077579	-0.7436476
santai	0.1055406	-0.155975	-0.5077579	-0.7436476
enggan	0.1055406	0.927825	-0.5077579	-0.7436476
ingat	-0.6201992	0.468443	-1.2788444	-0.7436476
wartawan	1.5570201	0.947249	1.8055016	1.2881038

retired	0.8476187	-0.270444	1.0369528	0.5529177
reward	0.2394796	-0.330588	1.0369528	0.5529177
rhino	-0.3686595	-0.96826	-0.3337062	0.5529177
rhythm	0.2394796	-0.390114	0.3516233	0.5529177
ring	-0.9767986	0.968704	-1.0190357	-0.9443639
ripe	-0.9767986	-1.207473	-1.0190357	-0.9443639
rival	-0.3686595	-0.83701	-0.3337062	0.5529177
river	-0.3686595	0.672074	-0.3337062	0.5529177
roof	-0.9767986	-0.299289	-1.0190357	-0.9443639
room	-0.9767986	1.37256	-1.0190357	-0.9443639
root	-0.9767986	0.674551	-1.0190357	-0.9443639
rope	-0.9767986	-0.224022	-1.0190357	-0.9443639
rubber	0.2394796	0.060718	-0.3337062	0.5529177
rust	-0.9767986	-0.480928	-0.3337062	-0.9443639
saddle	0.2394796	-0.707292	-0.3337062	0.5529177
sailor	0.2394796	-0.23555	-0.3337062	0.5529177
sales	-0.3686595	1.116978	-0.3337062	-0.9443639
salt	-0.9767986	0.314656	-0.3337062	-0.9443639
sand	-0.9767986	0.059742	-0.3337062	-0.9443639
scar	-0.9767986	-1.022128	-0.3337062	-0.9443639
schedule	1.4557578	0.411447	1.0369528	0.5529177
scissors	1.4557578	-1.168986	0.3516233	0.5529177
scratch	0.8476187	-0.077525	0.3516233	-0.9443639
sea	-1.5849376	0.855342	-1.7043651	-0.9443639
seagull	0.8476187	-1.741432	0.3516233	0.5529177
search	0.2394796	1.322789	-1.0190357	-0.9443639
secret	0.2394796	0.831276	1.0369528	0.5529177
sell	-0.9767986	1.312914	-1.0190357	-0.9443639
seller	0.2394796	-0.414289	-0.3337062	0.5529177
send	-0.9767986	2.195279	-0.3337062	-0.9443639
sewing	0.2394796	-0.681315	-0.3337062	0.5529177
shake	-0.3686595	-0.336951	-1.0190357	-0.9443639
shallow	0.8476187	-0.547103	-0.3337062	0.5529177
shark	-0.3686595	-0.636017	-0.3337062	-0.9443639
sharp	-0.3686595	0.208819	-0.3337062	-0.9443639
shave	-0.3686595	-0.986365	-1.0190357	-0.9443639
shellfish	2.0638968	-2.177151	1.0369528	0.5529177
shepherd	1.4557578	-0.572659	0.3516233	0.5529177
shine	-0.3686595	-0.645351	-1.0190357	-0.9443639

bersara	0.8312803	0.628161	1.0344151	1.2881038
ganjaran	1.5570201	0.427139	1.0344151	-0.7436476
badak	-0.6201992	-0.047812	-0.5077579	-0.7436476
irama	-0.6201992	0.882309	-0.5077579	1.2881038
cincin	0.1055406	-0.688943	0.2633286	-0.7436476
masak	-0.6201992	-0.061686	-0.5077579	-0.7436476
saingan	0.8312803	1.802766	1.0344151	1.2881038
sungai	0.1055406	0.669611	-1.2788444	-0.7436476
bumbung	0.8312803	-0.091293	0.2633286	-0.7436476
bilik	-0.6201992	0.620945	-0.5077579	-0.7436476
akar	-1.3459389	0.004933	-1.2788444	-0.7436476
tali	-1.3459389	-0.29416	-1.2788444	-0.7436476
getah	-0.6201992	0.370262	-0.5077579	-0.7436476
karat	-0.6201992	-1.034676	-0.5077579	-0.7436476
pelana	0.1055406	-0.800053	0.2633286	1.2881038
pelayar	0.8312803	-0.944882	1.0344151	1.2881038
jualan	0.1055406	1.373066	1.0344151	1.2881038
garam	-0.6201992	-0.485718	-0.5077579	-0.7436476
pasir	-0.6201992	0.326059	-0.5077579	-0.7436476
parut	-0.6201992	-1.837796	-0.5077579	-0.7436476
jadual	0.1055406	0.893039	1.0344151	1.2881038
gunting	0.8312803	-0.867246	0.2633286	-0.7436476
tercalar	1.5570201	-0.394616	1.8055016	1.2881038
laut	-1.3459389	0.56703	-0.5077579	-0.7436476
camar	-0.6201992	-1.837796	-0.5077579	-0.7436476
mencari	0.8312803	1.593496	1.0344151	1.2881038
rahsia	0.1055406	0.537725	1.0344151	1.2881038
menjual	0.8312803	0.862452	1.8055016	1.2881038
penjual	0.8312803	-0.020604	1.8055016	1.2881038
menghantar	3.0084995	1.137919	2.5765881	1.2881038
jahit	-0.6201992	-0.740825	-0.5077579	-0.7436476
goncang	0.8312803	-1.837796	0.2633286	-0.7436476
cetek	-0.6201992	-0.800053	-0.5077579	-0.7436476
yu	-2.7974184	0.692277	-2.8210175	-2.775399
tajam	-0.6201992	0.085603	-0.5077579	-0.7436476
mencukur	1.5570201	-1.496343	1.8055016	1.2881038
kerang	0.1055406	-1.837796	-0.5077579	-0.7436476
gembala	0.8312803	-1.291686	1.0344151	1.2881038
bersinar	1.5570201	-0.597186	1.8055016	1.2881038

ship	-0.9767986	1.060819	-1.0190357	-0.9443639
shoe	-0.9767986	-0.346679	-1.7043651	-0.9443639
shoulder	1.4557578	0.137441	0.3516233	0.5529177
shrink	0.2394796	-0.496251	0.3516233	-0.9443639
signal	0.2394796	0.693601	0.3516233	0.5529177
silver	0.2394796	0.603882	0.3516233	0.5529177
sing	-0.9767986	0.108645	-1.0190357	-0.9443639
singer	0.2394796	0.017038	-0.3337062	0.5529177
sit	-1.5849376	0.634489	-1.0190357	-0.9443639
skillful	1.4557578	-1.79622	1.0369528	0.5529177
skin	-0.9767986	0.617838	-0.3337062	-0.9443639
sky	-1.5849376	0.474849	-1.0190357	-0.9443639
sleep	-0.3686595	0.633241	-0.3337062	-0.9443639
small	-0.3686595	1.755932	-0.3337062	-0.9443639
smelly	0.2394796	-1.361028	0.3516233	0.5529177
smile	-0.3686595	0.180842	-0.3337062	-0.9443639
snake	-0.3686595	-0.345734	-0.3337062	-0.9443639
solid	-0.3686595	0.600114	0.3516233	0.5529177
song	-0.9767986	1.155185	-1.0190357	-0.9443639
soul	-0.9767986	0.777142	-1.0190357	-0.9443639
sour	-0.9767986	-0.839111	-1.0190357	-0.9443639
spelling	1.4557578	0.212591	1.0369528	0.5529177
spicy	-0.3686595	-1.464441	0.3516233	0.5529177
spider	0.2394796	-0.168972	0.3516233	0.5529177
spinach	0.8476187	-1.43052	1.0369528	0.5529177
sponsor	0.8476187	-0.067087	1.0369528	0.5529177
spy	-1.5849376	-0.341737	-1.0190357	-0.9443639
square	0.2394796	0.449755	0.3516233	-0.9443639
squeeze	0.8476187	-0.522565	0.3516233	-0.9443639
stale	-0.3686595	-1.155646	-0.3337062	-0.9443639
stampede	1.4557578	-1.392527	1.7222822	0.5529177
star	-0.9767986	1.346691	-0.3337062	-0.9443639
statement	2.0638968	1.110783	2.4076117	0.5529177
steal	-0.3686595	0.128118	-0.3337062	-0.9443639
steel	-0.3686595	0.430348	-0.3337062	-0.9443639
steep	-0.3686595	-0.635828	-0.3337062	-0.9443639
sticker	0.8476187	-0.42399	0.3516233	0.5529177
stingray	1.4557578	-1.360414	1.0369528	0.5529177
stomach	0.8476187	-0.106097	1.0369528	0.5529177

kapal	-0.6201992	0.453269	-0.5077579	-0.7436476
kasut	-0.6201992	0.319535	-0.5077579	-0.7436476
bahu	-1.3459389	0.332638	-1.2788444	-0.7436476
mengecut	1.5570201	-1.496343	1.0344151	1.2881038
isyarat	0.8312803	0.232267	0.2633286	1.2881038
perak	-0.6201992	1.775909	-0.5077579	-0.7436476
menyanyi	1.5570201	0.802688	1.8055016	1.2881038
penyanyi	1.5570201	1.751729	1.8055016	1.2881038
duduk	-0.6201992	0.751938	-0.5077579	-0.7436476
mahir	-0.6201992	-0.091293	-0.5077579	-0.7436476
kulit	-0.6201992	0.458378	-0.5077579	-0.7436476
langit	0.1055406	-0.00781	-0.5077579	-0.7436476
tidur	-0.6201992	0.357988	-0.5077579	-0.7436476
kecil	-0.6201992	1.353192	-0.5077579	-0.7436476
berbau	0.1055406	-0.597186	1.0344151	1.2881038
tersenyum	2.2827598	0.410756	2.5765881	1.2881038
ular	-1.3459389	-0.640964	-1.2788444	-0.7436476
pepejal	0.8312803	-1.496343	1.0344151	1.2881038
lagu	-1.3459389	2.152829	-1.2788444	-0.7436476
jiwa	-1.3459389	0.79242	-1.2788444	-0.7436476
masam	-0.6201992	-0.341603	-0.5077579	-0.7436476
ejaan	-0.6201992	-1.291686	-0.5077579	1.2881038
pedas	-0.6201992	-0.520442	-0.5077579	-0.7436476
labah	-0.6201992	-1.837796	-0.5077579	-0.7436476
bayam	-0.6201992	-1.496343	-0.5077579	-0.7436476
menaja	0.1055406	0.052644	0.2633286	1.2881038
perisik	0.8312803	-1.034676	1.0344151	1.2881038
persegi	0.8312803	0.029484	1.0344151	1.2881038
memerah	0.8312803	-0.520442	1.0344151	1.2881038
basi	-1.3459389	-1.291686	-1.2788444	-0.7436476
rempuhan	1.5570201	-0.688943	1.8055016	1.2881038
bintang	0.8312803	1.703779	0.2633286	-0.7436476
penyata	0.8312803	-0.047812	1.0344151	1.2881038
mencuri	0.8312803	0.717002	1.0344151	1.2881038
keluli	0.1055406	-0.597186	0.2633286	1.2881038
curam	-0.6201992	-0.688943	-0.5077579	-0.7436476
pelekat	0.8312803	-0.485718	1.0344151	1.2881038
pari	-1.3459389	-0.21054	-1.2788444	-0.7436476
perut	-0.6201992	-0.034023	-0.5077579	-0.7436476

storm	-0.3686595	0.476433	0.3516233	-0.9443639
story	-0.3686595	1.452528	0.3516233	0.5529177
straight	1.4557578	0.944536	0.3516233	-0.9443639
string	0.2394796	0.793138	0.3516233	-0.9443639
stripe	0.2394796	-1.014387	0.3516233	-0.9443639
strong	0.2394796	1.245316	0.3516233	-0.9443639
student	0.8476187	1.119819	1.0369528	0.5529177
stump	-0.3686595	-1.4515	0.3516233	-0.9443639
stupid	0.2394796	0.985837	1.0369528	0.5529177
style	-0.3686595	0.95558	-0.3337062	-0.9443639
stylish	0.8476187	-1.763474	1.0369528	0.5529177
successful	2.6720359	0.773804	2.4076117	2.0501994
sugar	-0.3686595	0.274409	-0.3337062	0.5529177
summary	0.8476187	0.521038	1.0369528	2.0501994
supporter	2.0638968	-0.831012	1.7222822	2.0501994
sure	-0.9767986	2.060676	-1.0190357	-0.9443639
sweet	-0.3686595	0.324101	-0.3337062	-0.9443639
swim	-0.9767986	-0.357764	-0.3337062	-0.9443639
swimmer	0.8476187	-1.637846	0.3516233	0.5529177
sword	-0.3686595	0.372139	-0.3337062	-0.9443639
symptom	0.8476187	-0.832051	1.7222822	0.5529177
tail	-0.9767986	0.128064	-1.0190357	-0.9443639
talent	0.2394796	0.08133	1.0369528	0.5529177
talk	-0.9767986	1.417222	-1.0190357	-0.9443639
target	0.2394796	0.722456	1.0369528	0.5529177
tax	-1.5849376	1.179922	-0.3337062	-0.9443639
teach	-0.3686595	0.553449	-1.0190357	-0.9443639
temperature	3.280175	0.2729	2.4076117	2.0501994
temple	0.2394796	0.234569	0.3516233	0.5529177
tenant	0.2394796	-1.544228	1.0369528	0.5529177
tent	-0.9767986	-0.649009	-0.3337062	-0.9443639
tentacle	1.4557578	-1.88447	1.7222822	2.0501994
termite	0.8476187	-2.2328	0.3516233	0.5529177
tester	0.2394796	-0.760237	0.3516233	0.5529177
thigh	-0.3686595	-0.792044	-1.7043651	-0.9443639
think	-0.3686595	2.626178	-0.3337062	-0.9443639
thinker	0.8476187	-1.357965	0.3516233	0.5529177
thirst	0.2394796	-1.346463	-0.3337062	-0.9443639
thorn	-0.3686595	-0.552856	-0.3337062	-0.9443639

ribut	-0.6201992	-0.800053	-0.5077579	-0.7436476
cerita	0.1055406	1.193206	0.2633286	1.2881038
lurus	-0.6201992	-0.020604	-0.5077579	-0.7436476
rentetan	1.5570201	0.004933	1.8055016	1.2881038
jalur	-0.6201992	0.216031	-0.5077579	-0.7436476
kuat	-1.3459389	1.087365	-0.5077579	-0.7436476
pelajar	0.8312803	0.962248	1.0344151	1.2881038
tunggul	0.8312803	-1.034676	0.2633286	-0.7436476
bodoh	-0.6201992	-0.191551	-0.5077579	-0.7436476
gaya	-1.3459389	1.116672	-1.2788444	-0.7436476
bergaya	0.8312803	0.57506	1.0344151	1.2881038
berjaya	0.8312803	1.935302	1.0344151	1.2881038
gula	-1.3459389	0.207889	-1.2788444	-0.7436476
ringkasan	2.2827598	-1.837796	1.8055016	1.2881038
penyokong	2.2827598	1.060797	1.8055016	1.2881038
pasti	-0.6201992	1.770794	-0.5077579	-0.7436476
manis	-0.6201992	1.081578	-0.5077579	-0.7436476
berenang	1.5570201	-0.21054	1.0344151	1.2881038
perenang	1.5570201	0.458378	1.0344151	1.2881038
pedang	0.1055406	-0.091293	-0.5077579	-0.7436476
gejala	0.1055406	0.173357	0.2633286	1.2881038
ekor	-1.3459389	-0.800053	-1.2788444	-0.7436476
bakat	-0.6201992	1.424727	-0.5077579	-0.7436476
bercakap	1.5570201	0.731871	1.8055016	1.2881038
sasaran	0.8312803	1.326274	1.0344151	1.2881038
cukai	-0.6201992	1.051596	-1.2788444	-0.7436476
mengajar	1.5570201	0.106574	1.0344151	1.2881038
suhu	-1.3459389	-0.138915	-1.2788444	-0.7436476
kuil	-1.3459389	-0.944882	-0.5077579	-0.7436476
penyewa	0.8312803	-0.640964	1.0344151	1.2881038
khemah	0.1055406	-0.485718	-0.5077579	-0.7436476
rungut	0.1055406	-1.496343	-0.5077579	-0.7436476
anai	-1.3459389	-1.146857	-2.049931	-0.7436476
penguji	0.8312803	-1.837796	0.2633286	1.2881038
paha	-1.3459389	0.16429	-1.2788444	-0.7436476
berfikir	1.5570201	0.312781	1.8055016	1.2881038
pemikir	0.8312803	-0.800053	1.0344151	1.2881038
dahaga	0.1055406	-1.034676	0.2633286	1.2881038
duri	-1.3459389	-0.597186	-1.2788444	-0.7436476

throw	-0.3686595	0.694559	-1.0190357	-0.9443639
ticklish	1.4557578	-2.22525	1.0369528	2.0501994
time	-0.9767986	2.742512	-1.0190357	-0.9443639
tired	-0.3686595	0.451663	-0.3337062	-0.9443639
tomorrow	1.4557578	0.285672	1.0369528	2.0501994
tongue	0.2394796	0.302642	-1.0190357	-0.9443639
tooth	-0.3686595	-0.660311	-1.0190357	-0.9443639
torn	-0.9767986	-0.485056	-0.3337062	-0.9443639
total	-0.3686595	1.255916	-0.3337062	0.5529177
tourist	0.8476187	-0.419985	1.0369528	0.5529177
tower	-0.3686595	0.589318	-1.0190357	-0.9443639
toy	-1.5849376	0.623039	-1.7043651	-0.9443639
training	1.4557578	1.143372	1.0369528	0.5529177
treatment	2.0638968	0.637695	2.4076117	0.5529177
tree	-0.9767986	0.67081	-1.0190357	-0.9443639
trick	-0.3686595	0.33058	-0.3337062	-0.9443639
turtle	0.2394796	-0.439041	-0.3337062	0.5529177
tweezer	0.8476187	-2.299607	0.3516233	0.5529177
umbrella	1.4557578	-0.957648	1.7222822	2.0501994
unlucky	0.8476187	-1.291971	1.0369528	2.0501994
useful	0.2394796	1.106287	0.3516233	0.5529177
valley	0.2394796	0.617911	-0.3337062	0.5529177
valve	-0.3686595	-0.41932	-0.3337062	-0.9443639
vase	-0.9767986	-1.741432	-1.0190357	-0.9443639
vein	-0.9767986	-0.885807	-1.0190357	-0.9443639
victim	0.2394796	0.148	1.0369528	0.5529177
village	0.8476187	0.2275	0.3516233	0.5529177
villain	0.8476187	-0.786225	0.3516233	0.5529177
visitor	0.8476187	-0.765814	1.0369528	2.0501994
voice	-0.3686595	1.348151	-1.0190357	-0.9443639
vote	-0.9767986	1.137459	-1.0190357	-0.9443639
waist	-0.3686595	-0.338814	-0.3337062	-0.9443639
wait	-0.9767986	1.17501	-1.0190357	-0.9443639
waiter	0.2394796	-1.238382	-0.3337062	0.5529177
wall	-0.9767986	1.419383	-1.0190357	-0.9443639
war	-1.5849376	1.527067	-1.0190357	-0.9443639
warehouse	2.0638968	-0.437259	1.0369528	0.5529177
warning	0.8476187	0.541738	1.0369528	0.5529177
warranty	1.4557578	0.192363	1.7222822	2.0501994

lontar	0.1055406	-0.07627	0.2633286	-0.7436476
geli	-1.3459389	-1.291686	-1.2788444	-0.7436476
masa	-1.3459389	2.207964	-1.2788444	-0.7436476
letih	-0.6201992	-0.230279	-0.5077579	-0.7436476
esok	-1.3459389	1.306259	-1.2788444	-0.7436476
lidah	-0.6201992	-0.740825	-0.5077579	-0.7436476
gigi	-1.3459389	-0.485718	-1.2788444	-0.7436476
koyak	-0.6201992	-0.867246	-0.5077579	-0.7436476
jumlah	0.1055406	1.865128	0.2633286	-0.7436476
pelancong	2.2827598	0.537725	1.8055016	1.2881038
menara	0.1055406	0.199432	0.2633286	1.2881038
mainan	0.1055406	-0.367408	-0.5077579	-0.7436476
latihan	0.8312803	1.790926	1.0344151	1.2881038
rawatan	0.8312803	0.669611	1.0344151	1.2881038
pokok	-0.6201992	0.305934	-0.5077579	-0.7436476
helah	-0.6201992	-0.597186	-0.5077579	-0.7436476
penyu	-0.6201992	-0.317574	-0.5077579	-0.7436476
penyepit	1.5570201	-1.837796	1.8055016	1.2881038
payung	0.1055406	-0.317574	-0.5077579	-0.7436476
malang	0.1055406	0.710967	-0.5077579	-0.7436476
berguna	0.8312803	0.247827	1.0344151	1.2881038
lembah	0.1055406	0.594713	0.2633286	-0.7436476
injap	-0.6201992	-0.317574	-0.5077579	-0.7436476
pasu	-1.3459389	-0.640964	-1.2788444	-0.7436476
urat	-1.3459389	-0.740825	-1.2788444	-0.7436476
mangsa	0.1055406	0.649352	-0.5077579	-0.7436476
kampung	0.8312803	0.978572	0.2633286	-0.7436476
penjahat	1.5570201	-1.034676	1.8055016	1.2881038
pelawat	0.8312803	0.763061	1.0344151	1.2881038
suara	-0.6201992	1.048513	0.2633286	1.2881038
mengundi	1.5570201	0.052644	1.0344151	1.2881038
pinggang	1.5570201	-0.155975	0.2633286	-0.7436476
menunggu	1.5570201	1.143093	1.0344151	1.2881038
pelayan	0.8312803	-0.557756	1.0344151	1.2881038
dinding	0.8312803	-0.423389	0.2633286	-0.7436476
perang	0.1055406	0.546235	-0.5077579	-0.7436476
gudang	0.1055406	-0.21054	-0.5077579	-0.7436476
amaran	0.1055406	0.571018	0.2633286	1.2881038
jaminan	0.8312803	0.64587	1.0344151	1.2881038

wash	-0.9767986	-0.03887	-1.0190357	-0.9443639	mencuci	0.8312803	-0.800053	1.0344151	1.2881038
watery	0.2394796	-1.806267	0.3516233	2.0501994	berair	0.1055406	-1.291686	1.0344151	1.2881038
weak	-0.9767986	0.385618	-1.0190357	-0.9443639	lemah	-0.6201992	0.85335	-0.5077579	-0.7436476
weapon	0.2394796	0.473106	0.3516233	0.5529177	senjata	0.8312803	0.351737	1.0344151	1.2881038
weather	0.8476187	0.52075	-0.3337062	0.5529177	cuaca	-0.6201992	0.85335	0.2633286	1.2881038
week	-0.9767986	1.527287	-1.0190357	-0.9443639	minggu	0.1055406	1.885073	-0.5077579	-0.7436476
weight	0.2394796	0.806955	-1.0190357	-0.9443639	berat	-0.6201992	1.30347	-0.5077579	-0.7436476
west	-0.9767986	1.185668	-0.3337062	-0.9443639	barat	-0.6201992	0.939578	-0.5077579	-0.7436476
wet	-1.5849376	0.361543	-1.0190357	-0.9443639	basah	-0.6201992	0.126492	-0.5077579	-0.7436476
wheel	-0.3686595	0.46143	-0.3337062	-0.9443639	roda	-1.3459389	0.319535	-1.2788444	-0.7436476
white	-0.3686595	1.720016	-0.3337062	-0.9443639	putih	-0.6201992	0.92981	-0.5077579	-0.7436476
wide	-0.9767986	1.190146	-1.0190357	-0.9443639	luas	-1.3459389	0.784593	-0.5077579	-0.7436476
wife	-0.9767986	0.888123	-1.0190357	-0.9443639	isteri	0.1055406	0.779268	0.2633286	1.2881038
win	-1.5849376	1.204578	-1.0190357	-0.9443639	menang	0.1055406	1.788454	-0.5077579	-0.7436476
window	0.2394796	1.102857	0.3516233	0.5529177	tingkap	0.8312803	-0.867246	0.2633286	-0.7436476
windy	-0.3686595	-1.262496	0.3516233	0.5529177	berangin	1.5570201	-0.867246	1.0344151	1.2881038
wing	-0.9767986	0.314253	-1.0190357	-0.9443639	sayap	-0.6201992	0.305934	-0.5077579	-0.7436476
wood	-0.9767986	0.594279	-1.0190357	-0.9443639	kayu	-1.3459389	0.734743	-1.2788444	-0.7436476
work	-0.9767986	2.398887	-1.0190357	-0.9443639	bekerja	0.8312803	1.163242	1.0344151	1.2881038
world	-0.3686595	2.138357	-0.3337062	-0.9443639	dunia	-0.6201992	2.383996	0.2633286	1.2881038
worm	-0.9767986	-0.492497	-1.0190357	-0.9443639	cacing	0.1055406	-1.837796	-0.5077579	-0.7436476
wrestler	1.4557578	-1.281089	0.3516233	0.5529177	bergomol	1.5570201	-1.837796	1.8055016	1.2881038
wrestling	2.0638968	-0.333357	1.0369528	0.5529177	gusti	-0.6201992	0.145849	-0.5077579	-0.7436476
wrinkle	0.8476187	-1.949624	0.3516233	0.5529177	kedutan	0.8312803	-1.496343	1.0344151	1.2881038
writer	0.2394796	0.565398	-0.3337062	0.5529177	penulis	0.8312803	1.002976	1.0344151	1.2881038
yam	-1.5849376	-1.700651	-1.0190357	-0.9443639	keladi	0.1055406	-0.944882	0.2633286	1.2881038
yarn	-0.9767986	-0.659918	-0.3337062	-0.9443639	benang	0.1055406	-0.944882	-0.5077579	-0.7436476
year	-0.9767986	2.026905	-1.0190357	-0.9443639	tahun	-0.6201992	2.569848	-0.5077579	-0.7436476
yellow	0.2394796	0.459871	-0.3337062	0.5529177	kuning	0.1055406	1.229136	-0.5077579	-0.7436476
young	-0.3686595	1.223744	-1.0190357	-0.9443639	muda	-1.3459389	1.666343	-1.2788444	-0.7436476
youngest	1.4557578	-1.098157	1.7222822	0.5529177	bongsu	0.1055406	-0.394616	-0.5077579	-0.7436476

A.8 Chapter 4 – Experiment 5 (Refresh task): Mean RTs and SD for refreshed and unrefreshed conditions for each input → output language

Input → Output Language	**Condition**	
	Refreshed	Unrefreshed
English → English	501.68 (67.31)	497.40 (66.90)
Malay → Malay	509.50 (70.02)	509.20 (79.73)
English → Malay	528.89 (88.65)	539.22 (87.72)
Malay → English	512.74 (71.53)	522.12 (71.28)

A.9 Chapter 4 - Experiment 5: Additional results

Refresh results

Switch cost full analysis for refresh task

A 2 (input: English, Malay) × 2 (condition: refreshed, unrefreshed) × 2 (output: English, Malay) repeated measures ANOVA was conducted on RTs. There was a significant main effect of output (F (1, 19) = 29.15, MSE = 622.12, p < .001, η_p^2 = .605) showed English output (M = 504.45, SE = 15.45) produced shorter RTs compared to Malay (M = 525.74, SE = 17.36). There were significant input × output interaction (F (1, 19) = 5.93, MSE = 1179.75, p = .025, η_p^2 = .238) and condition × output (F (1, 19) = 6.26, MSE = 235.41, p = .022, η_p^2 = .248), indicating in both refreshed and unrefreshed conditions, English as the output language produced shorter RTs.

Other main effects that were not significant included input (F (1, 19) = 1.36, MSE = 341.56, p = .258, η_p^2 = .067) and condition (F (1, 19) = 1.06, MSE = 538.04, p = .315, η_p^2= .053).

Input × condition × output interaction (F (1, 19) = .249, MSE = 244.34, p = .624, η_p^2 = .013) was also not significant.

Memory results

Comparison between non-switch and switch trials

In non-switch trials, word items presented during the trial was consistent throughout the refresh and probe treatments and would be considered congruent. However, in switch trials, both languages are presented so even though the words have equivalent meanings, they would still be considered incongruent. In this case, the interference in encoding a word would be higher since as lexical access for both languages would be activated. Two separate analyses were performed the first examined the probe and refresh treatments separately. Each of these analyses was performed for both English and Malay separately.

Refreshing English items A 2 (refresh: refresh or unrefresh) × 2 (congruency: congruent or incongruent) repeated measures ANOVA was conducted with confidence ratings as the dependent variable. There was a significant main effect of refresh (F (1, 17) = 79.88, MSE = .037, p < .001, η_p^2 = .825) which showed that refreshing (M = 2.98, SE = .105) increased confidence ratings compared to unrefreshing (M = 2.57, SE = .101). A significant main effect of congruency (F (1, 17) = 12.48, MSE = .057, p = .003, η_p^2 = .423) showed that the congruent pair (M = 2.87, SE = .115) produced higher confidence ratings compared to incongruent pair (M = 2.67, SE = .093). There was also a significant refresh × congruency interaction (F (1, 17) = 4.52, MSE = .031, p = .049, η_p^2 = .210). Two post hoc two-tailed paired sample t-tests (Bonferroni corrected p = .025) showed that congruent refreshed words (M = 3.12, SD = .506) had higher confidence ratings compared to incongruent refreshed words (M = 2.83, SD = .422; t (17) = 4.50,

$p < .001$). There was no significant differences between the unrefreshed pair (t (17) = 1.46, p = .162).

Refreshing Malay items Similar ANOVA was performed on the Malay words revealed a significant main effect of refresh (F (1, 17) = 53.44, MSE = .047, $p < .001$, η_p^2 = .759) that showed refreshing (M = 2.81, SE = .096) produced higher confidence ratings compared to unrefreshing (M = 2.44, SE = .093). There was not a significant main effect of congruency (F (1, 17) = 1.00, p = .331, η_p^2 = .056) and refresh × congruency interaction (F (1, 17) = 2.62, p = .124, η_p^2 = .133)

Probing English items A 2 (probe: probed or unprobed) × 2 (congruency: congruent or incongruent) repeated measures ANOVA was conducted with confidence ratings as the dependent variable. A significant main effect of probe (F (1, 17) = 125.89, MSE = .063, $p <$ .001, η_p^2 = .881) showed that probed words (M = 3.11, SE = .101) produced higher confidence rating compared to unprobed words (M = 2.44, SE = .109). There was also a significant main effect of congruency (F (1, 17) = 12.48, MSE = .057, p = .003, η_p^2= .423) showed that congruent pairs (M = 2.87, SE = .115) showed higher confidence ratings compared to incongruent pairs (M = 2.67, SE = .093). There was a significant probe × congruency interaction (F (1, 17) = 14.23, MSE = .033, p = .002, η_p^2 = .456). Two post hoc two-tailed paired sample t-tests (Bonferroni corrected p = .025) comparing the congruency for both probed and unprobed words were performed. There was a significant effect for unprobed words (t (17) = 4.39, $p < .001$), congruent (M = 2.62, SD = .558) produced higher confidence rating compared to incongruent (M = 2.26, SD =.418). There was not a significant interaction for probed words (t (17) = .668, p = .513).

Probing Malay items A similar ANOVA was performed on the Malay items revealed a significant main effect of probe (F (1, 17) = 139.71, MSE = .062, p < .001, η_p^2 = .892) which indicated that probed words (M = 2.97, SE = .094) produced higher confidence ratings compared to unprobed words (M = 2.28, SE = .097). There was a significant interaction between probe and congruency (F (1, 17) = 85.15, MSE = .022, p < .001, η_p^2 = .834). Two post hoc two-tailed paired sample t-test (Bonferroni corrected p = .025) comparing the congruency for both probed and unprobed words. The analysis showed a significant effect for probed words (t (17) = 6.18, p < .001) with incongruent (M = 2.41, SD = .441) reflected a higher confidence rating compared to congruent words (M = 2.79, SD = .478). For unprobed words, congruent pairs (M = 2.41, SD = .441) produced higher confidence rating compared to incongruent (M = 2.14, SD = .411; t (17) = 4.97, p < .001). There was not a significant effect of congruency (F (1, 17) = 1.00, MSE = .038, p = .331, η_p^2 = .056)

A probe effect in the incongruent trial indicated that when both languages were present, then lexical access for both English and Malay would have been activated thus, contributing to the higher confidence rating. However, the absence of probing meant only one language was used therefore a reduction in the confidence rating was observed instead. The results suggest that probe treatment enhanced memory retrieval particularly in the incongruent Malay word items.

A.10 Chapter 4 – Experiment 5 (Memory task): Mean confidence ratings and SD for refresh and probe conditions across each language and equivalents for non-switch trials

Language	**Condition**			
	Refresh and Probe	**Refresh and Unprobe**	**Unrefresh and Probe**	**Unrefresh and unprobe**
English	3.29 (.47)	2.95 (.63)	2.96 (.51)	2.29 (.56)
Equivalent – English	1.91 (.44)	1.85 (.36)	1.81 (.42)	1.84 (.37)
Malay	3.01 (.60)	2.66 (.50)	2.56 (.48)	2.17 (.49)
Equivalent – Malay	1.94 (.41)	1.85 (.40)	1.80 (.43)	1.75 (.41)

A.11 Chapter 4 – Experiment 5 (Memory task): Mean confidence ratings and SD for refresh and probe conditions across real and equivalents for switch trials

Word Type	**Condition**			
	Refresh and Probe	**Refresh and Unprobe**	**Unrefresh and Probe**	**Unrefresh and unprobe**
Real	3.21 (.41)	2.78 (.42)	2.76 (.47)	2.28 (.47)
Equivalent	3.31 (.37)	1.94 (.47)	3.21 (.39)	1.79 (.45)

A.12 Chapter 4 – Experiment 6: Mean RTs and SD for refreshed and unrefreshed conditions for each input → output language

Input → Output Language	**Condition**	
	Refreshed	Unrefreshed
English → English	471.87 (56.37)	443.79 (49.42)
Malay → Malay	478.13 (50.84)	458.42 (58.68)
English → Malay	506.46 (63.78)	505.93 (65.62)
Malay → English	486.05 (61.68)	497.11 (60.37)

A.13 Chapter 4 - Experiment 6: Additional results

Refresh results

Language analysis

2 (input: English or Malay) × 2 (condition: refreshed or unrefreshed) × 2 (output: English or Malay) repeated-measures ANOVA with RTs as the dependent variable showed a significant main effect of condition (F (1, 20) = 15.75, MSE = 231.39, p = .001, η_p^2 = .441) such that refreshing produced slower response (M = 485.63, SE = 9.63) than unrefreshing (M = 476.31, SE = 9.33). A significant effect of output (F (1, 20) = 18.57, MSE = 2903.95, p < .001, η_p^2 = .481) showed that English words (M = 463.05, SE = 10.20) produced faster response compared Malay words (M = 498.89, SE = 10.38). A significant condition × output interaction (F (1, 20) = 39.50, MSE = 225.99, p < .001, η_p^2 = .664) was reported.

Main effects of input (F (1, 20) = .029, MSE = 263.19, p = .868, η_p^2 = .001) was not significant. Two-way interaction such as input × condition interaction (F (1, 20) = 3.98, MSE = 263.19, p = .06, η_p^2 = .166), input × output (F (1, 20) = 2.99, MSE = 6387.14, p = .099, η_p^2 = .130) as well as three way interaction input × condition × output (F (1, 20) = .071, MSE = 382.77, p = .793, η_p^2 = .004) were not significant.

A.14 Chapter 5 – Experiment 7 Mean RTs and SD for refreshed and unrefreshed conditions for each input → output language

Input → Output Language	**Duration**	**Condition**	
		Refreshed	Unrefreshed
English → English	1400ms	456.83 (68.81)	444.25 (73.85)
	1700ms	478.75 (57.25)	447.81 (69.05)
	2000ms	458.43 (63.71)	438.48 (62.88)
Malay → Malay	1400ms	486.96 (71.18)	440.76 (73.60)
	1700ms	470.18 (59.32)	444.52 (74.21)
	2000ms	469.40 (64.62)	450.89 (72.30)
English → Malay	1400ms	507.28 (77.11)	520.26 (70.49)
	1700ms	510.96 (80.01)	522.27 (69.01)
	2000ms	512.03 (64.10)	523.94 (77.09)
Malay → English	1400ms	467.96 (58.60)	487.12 (67.44)
	1700ms	462.88 (61.44)	471.34 (59.76)
	2000ms	472.23 (61.85)	485.59 (62.17)

A.15 Chapter 5 – Experiment 7: Additional results

Refresh results

Language analysis

A 2 (input: English or Malay) × 2 (condition: refreshed or unrefreshed) × 2 (output: English or Malay) repeated measures ANOVA was conducted on RTs revealed a significant main effect of condition (*F* (1, 21) = 6.69, *MSE* = 268.23, p = .017, η_p^2 = .242) was significant showing that unrefreshed word items (*M* = 473.10, *SE* = 9.95) produced faster response than refreshed words (*M* = 479.49, *SE* = 9.44). The main effect of output (*F* (1, 21) = 12.91, *MSE* = 4935.96, p = .002, η_p^2 = .381) was also significant, indicating that English words (*M* = 457.27, *SE* = 11.92) produced faster response than Malay words (*M* = 495.32, *SE* = 9.96). A significant condition × output interaction (*F* (1, 21) = 38.57, *MSE* = 422.87, p < .001, η_p^2 = .647).

The main effect of input (*F* (1, 21) = 3.93, *MSE* = 3480.49, p = .061, η_p^2 = .157) was not significant. Other two-way interaction including input × output (*F* (1, 21) = 3.13, *MSE* = 8089.01, p = .091, η_p^2 = .130), input × condition (*F* (1, 21) = .81, *MSE* = 186.30, p = .380, η_p^2 = .037) and three-way input condition output interaction (*F* (1, 21) = 1.40, *MSE* = 219.44, p = .250, η_p^2 = .062) were not significant. Post-hoc tests were not reported here as they were reported as switch cost analysis in results section of Chapter 5.

Collapsed across condition

Three-way interaction between trial × output × duration (*F* (2, 42) = 7.62, *MSE* = 448.98, p = .002, η_p^2 = .266) was significant. In order to further understand this three way interaction, data sets were collapsed across condition and performed a 2(trial: non-switch or switch) × 2(output: English or Malay) × 3(duration: 1400ms, 1700ms or 2000ms) repeated-measures ANOVA. There was a main effect of trial (*F* (1, 21) = 12.91, *MSE* = 7403.95, *p* = .002, η_p^2 = .381) whereby non-switch trial (*M* = 457.27, *SE* = 11.92) produced shorter RTs compared to switch trials (*M* = 495.32, *SE* = 9.96). Two-way output × duration interaction (*F* (2, 42) = 7.62, *MSE* = 224.29, *p* = .002, η_p^2 = .266) was significant.

Other main effects such as output (*F* (1, 21) = 3.93, *MSE* = 5220.73, *p* = .061, η_p^2 = .157) and duration (*F* (2, 42) = .01, *MSE* = 292.01, *p* = .99, η_p^2 = 0) were not significant. Other two-way interactions including trial × output (*F* (1, 21) = 3.13, *MSE* = 12133.52, *p* = .091, η_p^2 = .130), trial × duration (*F* (2, 42) = 2.69, *MSE* = 325.73, *p* = .079, η_p^2 = .114), and three-way trial × output × duration interaction (F (2, 42) = .30, MSE = 272.16, p = .743, η_p^2 = .014) were not significant.

A reduced 2 way (output: English or Malay) × (duration: 1400ms, 1700ms or 2000ms) was conducted separately for non-switch and switch trials. In non-switch trials, there was significant interaction between output and duration (*F* (2, 42) = 4.85, *MSE* = 258.21, *p* = .013, η_p^2 = .188), different refresh durations yielded speeded response depending on the output language. Pairwise comparisons (Bonferroni) indicated if output was in English, 2000ms produced the shortest RTs (M = 450.54, SE = 14.84) compared to duration intervals at1400ms (M = 450.54, SE = 14.84) and 1700ms (M = 463.28, SE = 12.91). If output was Malay, 1700ms produced the shortest RTs (M = 457.35, SE = 13.44) compared to duration intervals 1400ms (M = 463.86, SE = 14.99) and 2000ms (M = 460.14, SE = 14.22). *we did not follow this up with post-hoc test or simple main effect test because it was not relevant to our hypothesis. There was not a significant main effect of output (*F* (1, 21) = .239, *MSE* = 5590.15, *p* = .630, η_p^2 = .011) and duration (*F* (2, 42) = 1.18, *MSE* = 398.53, *p* = .318, η_p^2 = .053).

Similar analysis was performed in switch trials revealed a significant main effect of output (*F* (1, 21) = 4.86, *MSE* = 57120.29, *p* = .039, η_p^2 = .188) such that output in English

(*M* = 474.52, *SE* = 12.30) was faster compared to Malay (*M* = 516.12, *SE* = 15.01). The main effect of duration (F (2, 42) = 1.73, *MSE* = 1.73, p = .191, η_p^2 = .076) and two-way output × duration interaction (F (2, 42) = 2.26, *MSE* = 238.44, p = .117, η_p^2 = .097) were not significant.

Collapsed across trials

Another significant three way interaction between output × condition × duration was also found (F (2, 42) = 3.59, *MSE* = 504.00, p = .036, η_p^2 = .146). Data sets were collapsed across trials and a 2(output: English or Malay) × 2(condition: refreshed or unrefreshed) × 3(duration: 1400ms, 1700ms or 2000ms) repeated-measures ANOVA revealed a significant main effect of condition (F (1, 21) = 6.69, *MSE* = 402.34, p = .017, η_p^2 = .242), unrefreshed condition (*M* = 473.10, *SE* = 9.95) produced faster response compared to the refreshed condition (*M* = 479.49, *SE* = 9.44).

Other main effects including output (F (1, 21) = 3.13, *MSE* = 12133.52, p = .091, η_p^2 = .130) and duration (F (2, 42) = .10, *MSE* = 292.01, p = .990, η_p^2 = 0) were not significant. Other two-way interactions such as output × condition (F (1, 21) = 1.40, *MSE* = 329.16, p = .250, η_p^2 = .062), output × duration (F (2, 42) = .30, *MSE* = 272.16, p = .743, η_p^2 = .014), condition × duration (F (2, 42) = .593, *MSE* = 325.52, p = .557, η_p^2 = .027) and three-way output × condition × duration (F (2, 42) = 3.59, *MSE* = 252.00, p = .036, η_p^2 = .146)

A reduced 2(condition: refreshed or unrefreshed) × 3(duration: 1400ms, 1700ms or 2000ms) for both output language separately. If the output language was English, the ANOVA did not reveal any significant results. The main effect of condition (F (1, 23) = .33, *MSE* = 466.00, p = .571, η_p^2 = .014) and duration (F (2, 46) = .832, *MSE* = 386.40, p = .442, η_p^2 = .035) were not significant. The interaction between both factors condition × duration (F (2, 46) = 1.76, *MSE* = 469.91, p = .184, η_p^2 = .071) was not significant.

If the output language was Malay, the ANOVA revealed a significant main effect of condition (F (1, 21) = 8.56, MSE = 314.33, p = .008, η_p^2 = .290) where unrefreshed condition (M = 483.77, SE = 13.61) produced shorter RTs compared to refreshed condition (M = 492.80, SE = 12.59). The main effect of duration (F (2, 42) = .236, MSE = 240.18, p = .791, η_p^2 = .011) and two-way condition × duration interaction (F (2, 42) = 1.71, MSE = 301.97, p = .193, η_p^2 = .075) were not significant.

Memory results

Comparison between non-switch and switch

In order to test for enhancement and suppression effects; A comparison between congruent (non-switch trials) and incongruent (switch trials) for both refresh and probe effect separately was performed. For example, in congruent variable comprised by a pair of refresh and probe events that were presented in English whereas incongruent variable meant refresh trial was English but probe trial was switched to Malay language.

Refresh treatment on English items 2 (refresh: refresh or unrefresh) × 2 (congruency: congruent or incongruent) repeated-measures ANOVA was conducted with confidence rating as dependent variable revealed a significant main effect of congruency (F (1, 22) = 15.49, MSE = .049, p = .001, η_p^2 = .413) such that the congruent pair (M = 2.70, SE = .113) produced higher confidence ratings than the incongruent pair (M = 2.52, SE = .105). The main effect of refresh (F (1, 22) = 1.41, MSE = .086, p = .248, η_p^2 = .060) and two-way refresh × congruency interaction (F (1, 22) = 1.63, MSE = .051, p = .215, η_p^2 = .069) were not significant.

Refresh effect on Malay items Similar analysis was performed on Malay word items revealed a significant main effect of refresh (F (1, 22) = 12.38, MSE = .133, p = .002, η_p^2 = .360) such that refresh (M = 2.54, SE = .12) produced higher confidence ratings than unrefresh (*M* = 2.27, *SE* = .097). The main effect of congruency (*F* (1, 22) = 1.57, *MSE* = .065, *p* = .223, η_p^2= .067) and interaction between both factors refresh × congruence (*F* (1, 22) = 3.92, *MSE* = .056, *p* = .060, η_p^2 = .151) were not significant.

Probe effect on English items 2 (probe: probe or unprobe) × 2 (congruency: congruent or incongruent) repeated-measures ANOVA with confidence rating as the dependent revealed a significant main effect of probe (*F* (1, 22) = 39.31, *MSE* = .050, *p* < .001, η_p^2 = .641) such that the probe (*M* = 2.76, *SE* = .107) produced higher confidence ratings than unprobe (*M* = 2.46, *SE* = .111). A significant main effect of congruency (*F* (1, 22) = 15.49, *MSE* = .792, *p* = .001, η_p^2 = .413) showed that the congruent pairs (*M* = 2.70, *SE* = .113) produced higher confidence ratings compared to the incongruent pairs (*M* = 2.52, *SE* = .105).

There was also a significant probe × congruency interaction (*F* (1, 22) = 86.90, *MSE* = .065, *p* < .001, η_p^2 = .798). Two post-hoc two-tailed paired sample t-tests (Bonferroni corrections adjusted at *p* = .025) comparing the probed pairs and found a significant difference (*t* (22) = 8.46, *p* < .001) such that congruent probed word items (*M* = 3.09, *SD* = .585) showed higher confidence ratings compared to incongruent probed word items (*M* = 2.42, *SD* = .504). The unprobed pair (*t* (22) = 5.29, *p* < .001) showed incongruent unprobed word items (*M* = 2.62, *SD* = .525) produced significantly higher confidence ratings compared to the congruent unprobed word items (*M* = 2.31, *SD* = .577).

Probe effect on Malay items Similar analysis was performed on Malay items revealed a significant interaction (*F* (1, 22) = 47.34, *MSE* = .086, *p* < .001, η_p^2 = .683). Post – hoc comparing using two-tailed paired sample t-tests (Bonferroni adjusted *p* = .025) comparing the probed pair (t (22) = 6.95, p < .001) showed the congruent effect (*M* = 2.69, *SD* = .547) showing significantly higher confidence ratings than the incongruent effect (*M* = 2.20, *SD* = .491). The unprobed word items (*t* (22) = 3.91, *p* = .001) showed incongruent effect (*M* = 2.54, *SD* = .54) produced significantly higher confidence ratings than congruent (*M* = 2.18, *SD* = .599). The main effects of probe (F (1, 22) = 2.41, *MSE* = .077, p = .135, η_p^2 = .099) and congruency (F (1, 22) = 1.57, *MSE* = .065, p = .223, η_p^2 = .067) were not significant.

A.16 Chapter 5 – Experiment 7 (Memory task): Mean confidence ratings and SD for refresh and probe conditions across each language and equivalents for non-switch trials

Language	Condition			
	Refresh and Probe	**Refresh and Unprobe**	**Unrefresh and Probe**	**Unrefresh and unprobe**
English	3.09 (.69)	2.30 (.70)	3.10 (.59)	2.31 (.52)
Equivalent – English	1.89 (.53)	1.82 (.58)	3.04 (.48)	1.82 (.56)
Malay	2.82 (.75)	2.22 (6.20)	2.56 (.50)	2.14 (.64)
Equivalent – Malay	3.09 (.79)	1.90 (.42)	1.89 (.50)	1.84 (.64)

A.17 Chapter 5 – Experiment 7 (Memory task): Mean confidence ratings and SD for refresh and probe conditions across real and equivalents for switch trials

Word Type	Condition			
	Refresh and Probe	**Refresh and Unprobe**	**Unrefresh and Probe**	**Unrefresh and unprobe**
Real	2.84 (.59)	2.74 (.64)	2.62 (.64)	2.42 (.46)
Equivalent	1.96 (.49)	2.47 (.54)	1.82 (.56)	2.69 (.55)