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INVESTIGATING STOPPING WHEN STUDYING NOVEL INFORMATION

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Dedications-

This thesis is dedicated to my Nan, Vera, who passed away at the grand age of 102 within my first year of study. My nan was a very determined lady, who inspired me so much. I will forever miss her love, jokes and endless pride and encouragement. Lots of love to my Nanny.

I would also like to dedicate my thesis to my parents, Norman and Jill, whom without I would not have achieved what I have in my life so far. I will always appreciate their unconditional love, support and understanding. No amount of thank-you's will be enough!

Author’s Declaration

At no time during the registration for the degree of Doctor of Philosophy has the author been registered for any other University award. Work submitted for this research degree at the University of Plymouth has not formed part of any other degree either at University of Plymouth or at another establishment.

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Abstract

Investigating stopping when studying novel information

Abbie Ball

The current research aimed to further the knowledge as to why people often terminate studying of novel information early, which has been found to be detrimental to performance. It has been suggested that stopping is due to an incorrect belief in information overload, specifically that seeing a higher volume of information is harmful for performance. The current research explored stopping under multiple perspectives. This included whether it is a metacognitive mechanism, a motivational mechanism or whether it is purely a belief in information overload. Chapter 1 reviews the relevant literature around stopping and study time allocation. Chapters 2-4 report 9 experiments that aimed to explore stopping of word lists, repeated word lists and texts, respectively. Chapter 2 reports four experiments, which suggest that stopping of word lists is less likely a metacognitive function, and more likely to be due to motivational factors. It also poses doubt for the original suggestion that stopping is due to an information overload belief. Chapter 3 contains the reporting of two experiments that suggest stopping of repeated word lists is consistent with a motivational account. Chapter 4 also reported similar findings with three experiments showing this account is consistent with text stimuli. Chapter 5 therefore concludes that the results provide evidence that stopping is due to motivational factors, in particular that stopping could be due to a decrease in rate of acquisition as study time increases, leading to the motivation to stop the presentation of information.

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1 Chapter 1- Introduction

How somebody masters their own learning is referred to as self-regulated study (Zimmerman & Schunk, 1989) and concerns how they approach educational tasks. Usually those who are effective self-regulated learners monitor their own knowledge, develop their own goals for learning, are more proactive in their learning and actively seek out ways to improve their learning (Zimmerman, 1990; 2000). However, in circumstances where it is important for us to learn as much information as possible, regulation of learning often fails. For example, students often limit the amount of novel information they study. Average attendance at university lectures has been found to be around only 56% (Kelly, 2012; Newman-Ford, Fitzgibbon, Lloyd, & Thomas, 2008) and barely more than half of students attend classes 80-100% of the time (Mearman, Pacheco, Webber, Ivlevs, & Rahman, 2014). Lecture attendance, however, is a reliable predictor of attainment (e.g. Romer, 1993). Thus, even though being actively engaged in learning is a necessity to acquire knowledge, people often do not do this effectively and to the detriment to our learning outcomes. This thesis will aim to focus on this; specifically, it will look at a 'stopping' behaviour, whereby people often stop the acquisition of new information with this being disadvantageous to performance. It will explore why this occurs, with the aim of applying to real-life studying behaviour.

Early research into the acquisition and loss of knowledge stems from that by Ebbinghaus (1885) who showed that memory and learning processes could be studied using experimental methods. He firstly described the learning curve, which represents people's learning over time, showing that learning increases the quickest at the beginning of study, to then gradually even out and less acquisition is made after a longer period of time. As well as this, Ebbinghaus documented the forgetting curve, which describes the loss of information over time. This showed that forgetting is quickest initially, which then gradually levels out after a longer period of time. This research was important in showing how memory and time are associated and how memory for information can quickly increase or decay.

For material to be effectively learned, the learner must invest enough study time to master the items. Research into this has investigated the studying of material within a single sitting, looking at the function of time and learning, with this showing that eventually, learning plateaus the longer a person studies it (e.g. Ebbinghaus, 1885; Son & Sethi, 2006). This relates to the list length effect, (e.g. Murdoch, Lissner, & Marvin, 1962; Ward, 2002; Ward, Tan, & Grenfell-Essam, 2010) which explains that as the to-be-studied list length increases, the proportion of items recalled decreases, but the overall total number recalled increases. When comparing list lengths of 10, 20 and 30, Ward (2002) found that total word recall increased (5.22, 7.13, 8.11 respectively), however the proportion of words that were recalled decreased. This function is also applicable to the learning of lists across multiple trials (e.g. Dunlosky & Salthouse, 1996; Karpicke & Roediger, 2007; Klein, Addis & Kahana, 2005; Nelson, Dunlosky, Graf & Narens, 1994; Tulving, 1964; 1966). These studies have investigated this by giving participants lists of words, studied across multiple trials and have plotted their recall according to trial number. Their results tend to find that the gain in recall after the first couple of list exposures reduces in rate. This research highlights that even though memory improves with additional material, the rate of this negatively accelerates, where participants get the most benefit from the first exposure, or the earliest few items. Thus, studying of novel material could be influenced by this perception in decline in rate of learning, with people being likely to reduce their time on studying if they feel that there is little benefit in continuing.

1.1 Metacognition

Experimental research into the way in which people regulate and monitor their learning acquisition has found that it is partly governed by our metacognition, suggested by Flavell (1979) as the knowledge of and experiences of our own cognitive processes. Nelson and Narens (1990) proposed two components needed to have a successful metacognitive system: control and monitoring. The notion of control involves the use of our mental faculties to decide what to do to achieve our goals; for example, the way in which people decide to study a range of complex material, or the decision to terminate vs continue revising for an exam. The monitoring component involves our cognition being informed by our thoughts and judgments about our current state of cognition, for example, when people evaluate novel information and decide how difficult it would be to learn. Within their framework, Nelson and Narens (1990) described two prospective judgment types the person will make about encoding of the stimuli they are learning. These judgement types are usually made when acquiring new knowledge. The first are Ease of Learning (EOL) judgments, which pertain to information that is yet to be learned and indicate how easy the person feels the material will be to learn. For example, a person might judge that it would be harder to learn a text about neurobiology than to learn a text about popular music, even before they had seen either text. The second judgment type are Judgments of Learning (JOL), which are usually made immediately after the person has studied the items and are often predictions of future test performance for those items. These judgements can be split into two types: item-based JOLs, which are made in response to a studied item, and list-based JOLs, which are made to indicate what proportion of a list participants judge they have learned. These judgments are usually made out of 100, indicating what level of learning has taken place.

Multiple factors have been found to influence a person’s monitoring of JOL, with the cue-utilisation framework being developed by Koriat (1997) to distinguish what sorts of cues these were. These have been determined as intrinsic, extrinsic and mnemonic cues. Intrinsic cues relate to the perceived properties of the stimuli, extrinsic cues are those that concern the conditions of learning, for example the serial position of the words and any repetition, and mnemonic cues indicate how much of something has been learned. Koriat's research found that extrinsic cues such as repetition, had little influence on the accuracy of JOLs, compared to intrinsic cues and mnemonic cues.

Research has since considered how accurate JOLs are in reflecting actual performance, as well as considering what factors can influence this accuracy. JOL accuracy can be split into two concepts: resolution and calibration. Resolution is the accuracy in which a person can discriminate their JOL for recall between items (Ariel & Dunlosky, 2011). Calibration is how accurately JOL relate to overall performance of recall (Ariel & Dunlosky, 2011). One such factor that influences accuracy of JOLs is delaying the JOL made for study items. Nelson and Dunlosky, (1991) investigated this, comparing the JOLs made by participants either immediately after studying the item stimuli or after a block of item study trials (delayed JOL). It was found that delaying the JOLs led them to be more accurate in predicting recall. This effect has since been supported by multiple studies (e.g. Dunlosky & Nelson, 1992; Weaver & Keleman, 1997; see meta-analysis by Rhodes & Tauber, 2011, for further evidence). Theoretical accounts for this 'delayed-JOL effect' largely follow that delaying the judgment allows participants to assess properly what they have and have not learnt. These accounts specify that delaying JOLs reduces the influence of immediately accessible information and thus leads to participants having to rely on cues from their long-term memory (Rhodes & Tauber, 2011).

A factor that can impact immediate and delayed-JOL accuracy is encoding fluency, whereby the less fluently an item is learned, the lower the subsequent JOL for that item (Koriat & Ma'ayan, 2005). For example, Rhodes and Castel (2008) had participants study words presented either in a large font (48pt.) or smaller (18pt.) and gave JOLs for each. Participants consistently gave higher JOLs for larger fonts, but this did not accurately reflect performance.

Another factor that impacts JOL accuracy is the test format after participants have studied the items. Research has found that test type can influence whether JOLs accurately reflect performance. For example, it is notable that previous research has found that people perceive recognition tests to be easier than recall tests (e.g. Thiede, 1996), with test expectancy research also finding that participants who anticipate a recall test will use encoding strategies that benefit both recall and recognition tests (Neely & Balota, 1981). However, it seems that participants do not vary their JOL depending on the anticipated test type. For example, Mazzoni and Cornoldi (1993) found that JOLs were equivalent when participants expected each kind of test, even though more study time was allocated when the test was recall.

Research has found that JOLs for an entire list can be subject to under confidence, compared to item-based JOLs (e.g. Connor, Dunlosky & Hertzog, 1997; Koriat, Sheffer & Ma'ayan, 2002), which is also known as the "aggregation effect" (Treadwell & Nelson, 1996). Mazzoni and Nelson (1995) put forward that item-JOLs may be overconfident due to the fact the items may seem more recallable straight after they have been studied. On the other hand, aggregate JOLs may be underconfident because people may feel that after studying a long list, they are aware that recalling a large number of items is unrealistic.

Thus, it is important to consider that JOLs are often based on heuristics that are often wrong and therefore can lead to ineffective study-decisions, like stopping of word lists. These metacognitive judgments have been utilised within previous research investigating the allocation of study time using laboratory studies in which people, often students, are asked to make decisions about whether they have studied for long enough and how to do so effectively. This research can be divided into two broad themes, which will be discussed next.

1.2 Ongoing Study Time Theories

How a person decides how to allocate their time to studying new information has been investigated and split into multiple theories. The first, and more prominent, theme of research into study time allocation is the allocation of time within ongoing study. In the typical multi-list paradigm used in this research, participants study lists of items across multiple trials and usually rate their JOL for each item on each presentation through the list. Participants usually then are asked to allocate study time between items. For example, Nelson, Dunlosky, Graf and Narens, (1994) gave participants a list of 36 Swahili-English translations to then restudy. They found that JOLs seemed to govern study time allocation. For example, items judged as ‘worst-learned’ were restudied more than those judged as ‘best-learned’. This extra time allocation led to an increase in recall. In a similar study, Thiede (1999) also presented participants with 36 Swahili-English translations across six trials with JOLs for each item given after the entire list had been presented. They found that as trial number increased, so did JOLs, which led to a decline in study time allocation for items selected for restudy. As well as this, recall increased across trials, again suggesting that JOLs mediated the relationship between time allocation and recall.

Theories that follow this path of research into ongoing study time are the Discrepancy Reduction Model, STEM and the Proximal Learning Theory, as detailed below. These theoretical perspectives focus on the parameters governing optimal study-time allocation, where the learner is seeking to learn effectively.

1.2.1 Discrepancy Reduction Model

Firstly, the Discrepancy Reduction Theory (Dunlosky & Hertzog, 1997) proposes that time is allocated in proportion to the discrepancy between current and desired states of knowledge. All other things being equal, this results in more time being allocated to items that have been less well learned. This theory also predicts that the allocation of time should be determined by the value of the reward associated with recalling the items, with more valuable items allocated more time.

Much research has provided support towards this model of study time allocation (e.g. Mazzoni, Cornoldi, & Marchitelli, 1990; Son & Metcalfe, 2000); Thiede & Dunlosky, 1999) whereby when items are judged as harder to learn, they are chosen to be restudied more often when compared to items with lower JOL. For example, Mazzoni et al. (1990) gave participants 40 transitive sentences to study, followed by giving a JOL for each, to then have a period of time to restudy the items. They found that participants allocated more restudy time to items that were given lower JOLs and thus with a higher discrepancy between their current and desired knowledge states.

However, within this literature, even though studying harder items is a preferred choice, it does not necessarily lead to better recall. This is known as the 'labor in vain' effect, first coined by Nelson and Leonesio (1988), who gave participants 27 trigrams to study. First, participants provided EOL (Ease of Learning) judgments for each trigram and then recalled as many as they could. Participants were split into two groups, one where emphasis was made within the instructions on the speed of recall and the other on the accuracy of recall. Those in the accuracy condition spent longer studying compared to those in the speed condition. In both conditions, items with lower EOL were allocated more study time, in line with the Discrepancy Reduction model. However, this did not lead to a subsequent improvement in recall. While participants had allocated more than twice as much study time under the accuracy instructions compared to under the speed instructions, mean percentage of recall for those in the accuracy condition was only 6% higher than the speed condition. Because the additional study time was disproportionate to the subsequent benefit to recall, it was labelled the 'labor in vain' effect.

Other research has since cast doubt on the Discrepancy Reduction theory, suggesting that it is not truly reflective of study time allocation in that students do not necessarily always allocate their time to least well learned items. Son and Metcalfe (2000) posited that research supporting the Discrepancy Reduction theory usually use short study materials and allow participants ample study time. As well as this, Son and Metcalfe conducted a study where participants studied biographies and gave EOL judgments afterwards. It was found that participants do not necessarily solely allocate their study time to harder items. For example, their first experiment found that more study time was allocated to judged-easy items when the goal was to freely read the materials, versus those who were told they would be tested on the materials. Their second experiment found more time allocated to harder items when the materials were shorter, and their third experiment found study time was allocated more to judged-easy materials when there was higher time pressure. Therefore, it seems that studying least-well learned over most-well learned items is the case only in certain circumstances. This idea led to the Shift To Easier Materials (STEM) effect.

1.2.2 STEM

Due to evidence that people allocate time to easier items in certain circumstances, the Shift to Easier Material (STEM) effect was proposed. Thiede and Dunlosky (1999) first reported this shift. Participants studied 30 paired associates and then gave a JOL rating for each. These items were then presented simultaneously in an array, where participants had to select the items they wished to restudy. Prior to selection, participants were instructed to either focus on maximising their performance or they were told to only learn 6 out of the 30 items (low performance goal). Thiede and Dunlosky (1999) found that those instructed with the latter on average selected 8 items to learn, which were on average rated as easier, compared to those in the former group who selected most of the items to restudy. Thus, when performance goals are lowered, people are likely to select easier over harder items to learn. Dunlosky and Thiede (2004) conducted their research to further support this and found that when participants are given a low goal for performance, they have the tendency to restudy easier items over harder items. Dunlosky and Thiede also used items that were presented together (simultaneously) or one at a time (sequentially) and participants were either given instructions on how best to study the materials or were not. Participants in the instructed group were told to select 6 of the easiest items to restudy, a strategy that was previously hypothesised as being used by the people when studying independently (i.e.when not instructed). Thus, if this hypothesis is correct, those in the instructed group should simulate the non-instructed group. The participants studied 30 noun pairs and participants gave JOLs for each item once the whole list had been studied. All participants were then asked to restudy 6 items, with the instructed group specifically told to study the easiest items. Dunlosky and Thiede (2004) found that in the sequential condition, participants selected more of the difficult items to restudy, against their goal (i.e. study the easiest items), however under the simultaneous condition, participants were more likely to start with harder items and then switch to easier items (STEM). Thus, when participants had a low performance goal and selected items under the simultaneous format, instructions did not influence item selection. This suggests that under the sequential format, participants were unable to execute a plan effectively but were able to under the simultaneous format. Participants therefore were more likely to study the easier items under certain conditions.

To account for this behaviour that is opposed to the Discrepancy Reduction theory, Metcalfe and Kornell (2005) proposed the Region of Proximal Learning theory.

1.2.3 Region of Proximal Learning Theory

This theory proposes that people allocate more study time to items that are perceived to be more learnable. Metcalfe (2002) surmised that the Discrepancy Reduction model does apply to study behaviour, but only under certain conditions, leading to the Region of Proximal Learning theory (Metcalfe & Kornell, 2005). This model is based on findings from multiple studies (Kornell & Metcalfe, 2006; Metcalfe, 2002; Metcalfe & Kornell, 2003; Metcalfe & Kornell, 2005), which show that people actually allocate more time to items that are in their own region of learning ability and as time allowance increases, participants give more time to harder items. Within their first experiment, Metcalfe (2002) gave participants 144 English-Spanish word pairs divided into easy, medium and hard difficulties. They found that when participants had more time to study, they studied more of the medium and harder words which was proportionate to their recall. The easier items also had the highest proportion recalled across all word difficulties. Thus, participants allocated time to achieve the most learning. This study also incorporated participants' previous knowledge and found that participants with expert knowledge allocated more time to the harder items, which were more likely to be unfamiliar to them. Similarly, Metcalfe and Kornell (2003) gave participants 144 English-Spanish word pairs split into easy, medium and hard difficulties. They found that participants selectively allocated their study time to items of easy and medium difficulty, which was shown to be an effective strategy; initial recall gain for these items was smaller but became more sustained. Therefore, these results provide support that allocating time to items more within a person's region of proximal learning is more effective than allocating time more to harder items.

From this, Metcalfe and Kornell (2005) formulated that the Region of Proximal learning theory has two components: choice and perseverance. They proposed that a person's metacognition is involved in both stages - for choice, people decide what to study and in which order and in the perseverance stage, people decide how long an item is studied before switching to another. Metcalfe and Kornell (2005) proposed that the decision to stop studying an item within ongoing study time is based on the person's judgment of their Rate of Learning (jROL). For example, if someone believes that their rate of learning is high, they will continue, but if this rate decreases, then they are more likely to switch to the next item.

Thus far, I have summarised the research that exists into the allocation of ongoing study time between items where participants are required to optimise the time they are given. The theories outlined share core concepts in that people often have goals for performance, and their behaviour is governed by these goals through the monitoring of learning, which is often elicited using JOLs. This behaviour in turn can impact learning outcomes, for example choosing to continue studying an item versus switching to another. Overall, even though some of these behaviours may be ineffective at times, they generally are not maladaptive in the way it impacts performance, for example leading to poorer recall.

However, more recently, research has explored study time following a different path, looking at the studying of items that are completely novel to participants, where the pacing of time is not controllable by the learner, and where they have one opportunity to study the items. This research highlights that people can be maladaptive and hold false beliefs when learning word lists, which will be discussed next.

1.3 Novel Information Study Time

The second research theme examining study time allocation is more recent, and involves the decision to restrict exposure to novel information. Murayama, Blake, Kerr, and Castel (2016) initiated such research to investigate the metacognitive decision to stop the incoming of novel information. This line of research is separate to the previous ongoing study time literature in that this firstly does not include the ability to restudy items, nor does it allow participants to control the pacing of item presentation. Thus, the stimuli are completely novel to participants, and they are unable to control what information is presented to them next. The only control mechanism available to participants was the choice to continue or stop studying the list prior to the test. The goal for the participants was to maximise recall on the final test (and there was financial reward for this). Nevertheless, Murayama et al. (2016) reported a pattern of behaviour that they described as maladaptive, and reflecting a metacognitive false belief, in that people stopped studying early, and worsened their recall as a result. Because of the centrality of this study to the present thesis, it will be described in detail.

1.3.1 Murayama, Blake, Kerr and Castel (2016)

In their first experiment, Murayama et al. (2016) showed participants a list of 50 words, with the aim of remembering as many words as they could for a subsequent free-recall test. This was repeated for three word lists. The words used were nouns of four to six letters in length of an average HAL frequency of 9.26 and were taken from the English Lexicon Project website (elexicon.wustl.edu; Balota, Yap, Cortese et al., 2007). Participants were split into either a standard list-learning condition, in which all 50 words were studied sequentially (control condition) or they were allowed to terminate the list where they judged that their recall would be maximised (stop condition). If participants stopped the word lists, they would move instantly to the test phase for that list. Additionally, to encourage participants to maximise their recall, they were offered 10 cents for every word they correctly recalled.

The majority (62%) of lists were stopped, with an overall mean stopping position of 32.9 out of 50. This finding includes those who did not choose to stop and thus saw all 50 words. The mean recall in the stop condition was 7.11, whereas the control condition had a mean recall of 8.96. As well as this, within the stop condition, the number of words seen positively correlated with performance ($r = .65$), therefore it is surprising that participants still chose to stop considering that doing so worsened performance. This is conceptually similar to more naturalistic studies showing that limited engagement in studying predicts poor academic achievement (e.g. Cohn & Johnson, 2006; Landin & Perez, 2015; Schmulian & Coetzee, 2011).

These findings are consistent with the list-length effect discussed earlier (e.g. Murdoch, Lissner, & Marvin, 1962; Ward, 2002; Ward, Tan & Grenfell-Essam, 2010).

Within the context of Murayama et al.'s (2016) first experiment, those in the control condition had only a slightly higher mean recall than those in the stop condition (8.96 vs. 7.11). Therefore, as the mean stopping position was 32.9, those who saw all 50 words saw on average 17.1 more words than those in the stop condition to only gain 1.85 in their recall, reflecting a declining rate of acquisition, and thus could be why participants stopped more often than not.

In subsequent experiments, Murayama et al. (2016) aimed to remove any confounding factors that may tax participant cognitive resources. In their second experiment, the serial position of each word in the study phase was indicated by an onscreen counter, so that participants would not have to keep track of how many words they had seen. In their fourth experiment, participants were not told the total length of the list, to prevent this from influencing the decision to stop. In both cases, the results were similar to Experiment 1. For example, their second experiment stop rate was 51% with an average stopping position of 34.6. Their fourth experiment average stop rate was 67% with an average stopping position of 30.2. As for recall, average recall for stop lists in their second experiment was 6.74 and control lists was 8.04, with average stop list recall of 7.36 in their fourth experiment. Correlations across their experiments 2 and 4 were also similar to that found in their first experiment (Expt 2: $r = .64$, Expt 4: $r = .54$).

Murayama et al.'s (2016) Experiment 3 was designed to address the question of whether participants in the stop condition had poorer memory performance because they saw fewer words, or because the decision about whether to stop the list acted as a distracting secondary task during the study phase. Each participant in a yoked group saw the same number of words as a participant in the stop group, with the difference that the participants in the yoked group did not choose their stopping positions. The number of words recalled during the test phase did not differ between groups, suggesting that the number of words seen determined performance rather than the stopping decision itself.

Interestingly, although a positive correlation between the number of words seen and recall performance was seen in both groups (stop group: $r = .53$, yoked group: $r = .31$), Murayama et al. posited this was somewhat weaker in the yoked group. One possible explanation for this result is that participants in the stop group with poorer memory abilities chose to stop earlier than those with better memories. In the yoked group memory ability should not correlate with stopping position, leading to a poorer correlation between the number of words seen and recalled.

In Murayama et al.'s (2016) fifth and final experiment, participants were tested on their beliefs in learning the materials. Two groups of participants read a description of a hypothetical experiment that had a similar procedure to Experiment 1, except that they were told only a single list of 50 words would be used. All participants were told that the goal would be to maximise the number of words recalled. Those in the stop condition were told they would hypothetically be able to stop the list at any point and asked to predict their stopping position and subsequent recall. Those in the control condition were only asked to predict their recall. Participants in the stop condition predicted they would stop after an average of 30.4 words, and that they would recall an average of 16.22 items with an overall stopping rate of 59%. The control condition, who could not stop, predicted they would recall an average of 14.8 items. These data are consistent with the idea that participants were unaware of the harmful effects of stopping. Thus, Murayama et al. concluded that participants in the stop conditions of the earlier experiments were likely to have stopped because of this incorrect belief, which they characterised as a metacognitive illusion and that they are "unaware of the possible advantage of viewing all the words in the list to enhance recall performance" (p. 8).

This account is consistent with the 'information overload' account, where people often have the belief that seeing too much information can be harmful (Eppler & Mengis, 2004), thus, leading to participants stopping prematurely. This could be related to the fact that when a person is presented with a large amount of information, they often feel overwhelmed and cognitively strained (Eppler et al. 2004). Thus, this could lead to the decision to restrict what information people see.

Murayama et al.'s (2016) study posited the idea that participants stopped due to a metacognitive error; however their experiments did not fully explore this. To date, there is no published replication of this study; however, the work in the present thesis is informed by my undergraduate project, which provided a replication and extension. This used a similar paradigm as Murayama et al. (2016) but utilised a within-subjects design rather than a between-subjects design. The aim of this was to correlate participant performance on the control lists with stopping position within the stop lists, to see whether there was a relationship between overall memory ability and stopping decisions. Seventy-one participants were used in this experiment, who were instructed that their goal was to maximise their total recall. Participants were asked to complete four study-test cycles for lists consisting of 50 words; two of the lists they could stop at any time they wanted and the other two they could not. Each word was shown in the centre of the screen one by one for 2 seconds, with a 0.5-second interval between each word where the screen was blank. After each list was shown, the participants were then instructed to write down as many words as they could remember from the list.

The average stopping rate (64%) and stopping position (M = 31.20) was similar to that found by Murayama et al. (2016). As well as this, I found a significant positive correlation (r =.546) between stopping position and recall replicating the key behavioural findings reported by Murayama et al. (2016). Additionally, I found a positive significant correlation between stopping position and control list recall (r =.274) as shown in Figure 1-1.

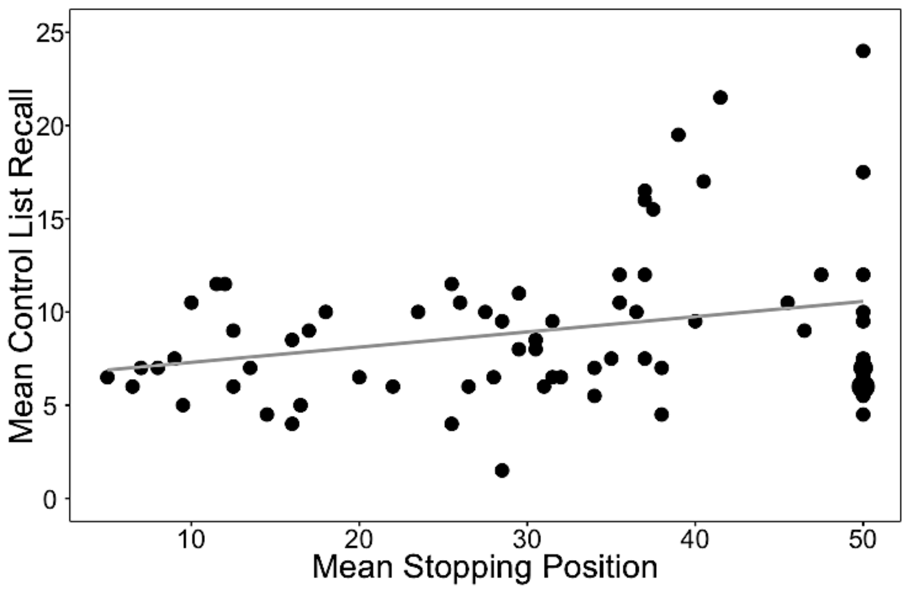

Figure 1-1. Scatterplot demonstrating the correlation between stop list stopping position and control list recall from my undergraduate project. Each dot represents a participant and the grey line shows the relationship between the two variables.

While the behavioural effect is replicable, it is still unclear as to why people might choose to stop studying when it appears to be maladaptive. Potential explanations (to be explored in the thesis) for this pattern are covered in the next section.

1.4 Factors that could influence stopping

The factors that could influence stopping can be distinguished as either being ‘experience-based’ or ‘information-based’. Experience-based factors can also be considered as hot-cognition factors, due to being linked to the emotional state of the experience, leading the person to be more responsive to the task at hand and could lead to biased thinking and decision making (Roiser & Sahakian, 2013). Information-based factors could also be considered as ‘cold cognition’ due to their independence of any emotional processing (Roiser & Sahakian, 2013).

Experience-based factors are ones that inform people’s heuristics usage, which are based on mnemonic cues and subjective feelings, including other emotional cues that may not be related to task progress (Koriat, Nussinson, Bless & Shaked, 2008). Koriat (2000) put forward that such factors have a two-stage process. The first stage involves subjective feelings (for example perceived progress in the task or feelings of boredom) which then inform memory predictions. Information-based factors (theory based) rely on pre-conceived notions about one's knowledge about metacognition (Koriat, Nussinson, Bless & Shaked, 2008) or when making judgments about a task without actually experiencing it (Sarac & Karakelle, 2012). An example of information-based cues are the beliefs people often hold about a task or their own cognitive abilities. However, it has been found that in some circumstances, participants behave against these information-based judgments, whereby the experience of the task over-rides how they planned or think they should study, which has been found in previous research. For example, Blasiman, Dunlosky and Rawson (2017) asked participants to give their planned studying across a semester. Specifically, they were asked to provide an estimate of hours per day they will study in two weeks before an exam, as well as what strategies they will use across the semester: rereading, copying notes, summarising, practice testing, highlighting, flashcards, elaboration and/or outlining. Participants were also asked to rate how effective they thought each strategy was. Students were followed up every few weeks, where they were asked how long they spent studying and what strategies they had used and what material they had covered. It was found that the most intended strategy was rereading notes, followed by the use of flashcards, copying notes and test practice. Actual strategy usage was highest for rereading of notes, followed by the rereading of textbooks and highlighting. Thus, even though students planned to reread notes, which is often ineffective (Dunlosky, Rawson, Marsh, Nathan & Willingham, 2013), their other planned strategies are usually effective ones (e.g. test practice: Roediger & Karpicke, 2006) but the students did not use them in practice. As well as this, students were found to mostly mass their study, which again has been found to be more ineffective than spacing studying (Kornell, 2009). Therefore, it should be noted that even if a person holds certain beliefs and knowledge of an effective study strategy, the task experience may dominate over their ability or willingness to execute this.

1.4.1 Beliefs

Murayama et al. (2016) posited that stopping was informed by the particular information-based cue that is a pre-conceived belief regarding how best to study the information. In Murayama et al.'s fifth experiment, participants were asked to read a hypothetical experiment and predict their stopping for a list of 50 words, along with subsequent recall. This experiment found that participants predicted stopping more often than not, without considering any detriment to their predicted recall. Thus, Murayama et al. (2016) suggested that participants believed that stopping was an effective study strategy. Experiment 4 within the thesis will explore beliefs in more detail, due to Murayama et al. (2016) not fully exploring this in detail. Beliefs are also being considered here as an experience-based cue, due to their influence at the time of study. For example, when studying a list of words, depending on the experience this may cause a person to believe that stopping is beneficial at that time and thus lead to study termination.

The role of experience-based beliefs in studying was touched upon previously, with the cue-utilization framework (Koriat, 1997) positing that judgments about memory, and consequently study behaviour, are partly influenced by beliefs. Therefore, if memory beliefs are inaccurate then poor strategies may be adopted. There are many demonstrations of dissociations between memory beliefs and memory outcomes, especially at the time of the task experience. For example, spaced versus massed practice (Kornell & Bjork, 2008). This is where the use of spacing items improves memory performance when compared to massed presentation. However, people tend to believe that massing is superior. Linking back to the idea of hot and cold cognition, massing often leads to an inflated sense of fluency (Kornell & Bjork, 2008) and thus makes the person feel that their learning rate is higher than it actually is. Thus, the experience (hot cognition factor) is positive, yet realistically learning is not reflective of this. Another example is the testing effect (Roediger & Karpicke, 2006), where self-testing enhances performance more so than restudy. However, participants tend to have the belief that self-testing is only useful for monitoring learning (Karpicke, Butler & Roediger, 2009; Kornell & Bjork, 2007). Another example of inaccurate beliefs about study is the lack of sensitivity towards the effect of delays (Koriat, Bjork, Sheffer & Bar, 2004), whereby participant JOLs fail to take into account that after a longer retention period, recall will decay and thus predict that recall will remain stable after a delay. The processing fluency of items can also impact the beliefs surrounding memory performance. For example, it has been documented that presenting items in a larger font size inflates JOLs, even when this is not reflected in performance (Rhodes & Castel, 2008). This is also the case when items are repeated, which has been found to increase processing fluency (Whittlesea, Jacoby & Girard, 1990), which can inflate JOLs (e.g. Begg, Duft, Lalonde, Melnick & Sanvito, 1989; Dunlosky & Matvey, 2001; Jacoby & Dallas, 1981; Kornell, Rhodes, Castel & Tauber, 2011; Mueller, Tauber & Dunlosky, 2013).

Overall, beliefs have a big influence on study behaviour, where people tend to act in ways that are not consistent with their stated beliefs (Bjork, Dunlosky & Kornell, 2013; Blasiman, Dunlosky & Rawson, 2017; Wissman, Rawson & Pyc, 2012) and also where people select ineffective strategies believing they are effective (e.g. McCabe, 2011; Tauber, Dunlosky, Rawson, Wahlheim & Jacoby, 2012). Therefore, stopping could be an example of this; participants may stop because they erroneously believe that this is beneficial for performance. As touched upon by Murayama et al. (2016), participants may hold the belief that seeing more is harmful for recall, when in reality this is not the case.

In the next section I discuss a number of potential factors that might influence stopping that are alternative to the role of beliefs. A part of the thesis will test whether beliefs are strong enough to influence stopping alone, however other factors will be considered as well. These include the role of experience-based cues, which will be in the form of the monitoring of memory processes, as well as the role of motivation.

1.4.2 Monitoring of memory and forgetting

One factor that could influence stopping is the person's memory ability. Research has found that the use of study strategies is somewhat informed by a person's memory capabilities, or rather a person's perception of their memory capabilities, often known as 'metamemory' (Nelson & Narens, 1990). The use of JOLs are often known as metamemory judgments, as they concern the person judging the acquirement of information. As mentioned previously (see Figure 1-1) my undergraduate project discovered a small yet significant positive correlation between the number of items studied in a stop list and the performance within the control lists, suggesting a link between memory ability and stopping. Therefore, this will also be explored in my thesis, using a similar analysis to explore whether stopping could be somewhat influenced by memory capabilities.

This can also relate to the idea of forgetting, that stopping could be governed by a perceived loss of items whilst studying. Previous research has found that people are often able to monitor their forgetting (e.g. Halamish, McGillivray & Castel, 2011) as well as that our JOLs can be sensitive to forgetting (Ariel, 2010; Ariel & Dunlosky, 2011; Koriat, Bjork, Sheffer & Bar, 2004). For example, in Experiment 2 of Koriat et al. (2004), they gave participants a description of an experiment where the hypothetical participants studied 60 Hebrew word pairs with the test phase occurring either immediately, after a day or after 1 week. The real participants were then asked to predict recall for the hypothetical participants. They found that predicted recall reflected knowledge of forgetting, with the real participants predicting a large drop in forgetting in the immediate test, with a steady decline thereafter. Thus, participants were able to accurately predict forgetting and the magnitude of its occurrence, reflecting the much earlier research by Ebbinghaus (1885) on the forgetting curve. Whilst list learning, participants may be susceptible to retrospective interference, when the newer items interfere with the remembering of older items (e.g. Baddeley & Dale, 1966; Deffenbacher, Carr, & Leu, 1981). An important part of working memory control is the ability to append new items to our memory, whilst reducing the over-writing of previous items (e.g. Vogel, McCollough & Machizawa, 2005). In terms of the current research, when participants are learning a list of words, it could be that the addition of new words strains the capacity of working memory; the addition of new words requires additional rehearsal of previous items. Therefore, this could promote stopping to reduce the potential forgetting of older items. Experiment 1 in the current project will aim to look at forgetting and whether having a heightened perception of forgetting could influence stopping behaviour.

Linking into the perception of memory gain and forgetting is the idea that people are able to monitor their rate of learning. As put forward by Metcalfe and Kornell (2005), JOLs (and therefore potentially stopping behaviour) can be influenced by the perception of rate (jROL). This reflects the speed of information uptake, whereby those who have a high jROL tend to continue studying, whereas those with jROLs that are low or reaching zero, stop. Moreover, when jROL is high, participants are more likely to be engaged in the task, with low jROL leading to boredom and therefore making the task aversive for participants. Thus, it could be that stopping within the current experiments is influenced by rate, that is that as the rate decreases, the worthiness of continuing studying declines and therefore encourages stopping. This relates to the list-length effect referenced earlier, showing that as the number of words studied increases, the proportion of items recalled decreases, but the overall total number recalled increases. Thus, this could lead to the perceived slowing rate of learning, resulting in participants stopping.

The core idea behind these ideas (memory ability, forgetting rate and learning rate) is the principle that stopping relies on a cost-benefit analysis by the learner. It is important that when monitoring learning, the person weighs up what benefit will come from continuing studying and whether there are any potential costs or little value to continuing. For example, within the factor of memory ability, if a person perceives that they will not learn much more from seeing more words, they are more likely to stop. This also applies to the forgetting account, in that if the person feels that they are likely to forget more items the more they study, they will perceive little value in continuing and are more likely to stop. Overall, if the person judges that the rate of acquisition is declining and thus sees little value in continuing, they are more likely to stop.

1.4.3 Motivation

Many studies have found that when regulating their study, people allocate time towards items based on value rather than monitoring (e.g. Ariel, Dunlosky & Bailey, 2009; Ariel & Dunlosky, 2013; Dunlosky & Ariel, 2011; Lipowski, Ariel, Tauber & Dunlosky, 2017; Soderstrom & McCabe, 2011). This has been referred to as the Agenda-Based Regulation model (ABR). ABR puts forward that the reward structure of the task governs what people believe to be efficient study decisions and is also quite important when considering academic study situations, for example when a student decides what material to revise according to what is more likely to come up in an exam. To efficiently allocate time in consideration of rewards, the person would require the development of an agenda which aims to maximise the reward by allocating more time to items that are worth more or have a higher likelihood of being tested. Ariel et al. (2009) first posited this model, when they found that rewards drove item selection more so than item difficulty. Results from their study found that when items were more likely to come up in tests, participants were more likely to restudy them than to restudy items with a lower likelihood of appearing, regardless of difficulty level. For example, if the easier or harder items were more likely to come up in the test, these were restudied more than those that were not as likely. As well as this, more time was also allocated to items that had higher rewards associated to them, and again this was regardless of item difficulty. Ariel et al.'s (2009) conclusions were that the rewards drove item selection more, and thus was the overriding factor, than the perceived difficulty of the item. This is supported by previous literature (e.g. Castel, 2008; Castel, Murayama, Friedman, McGillivray & Link 2013) that has demonstrated that value is an important factor when constructing agendas for studying and often overrides other factor such as item-level difficulty. In terms of the current research, with participants not choosing what to study and for how long, it is important to consider that people generally are motivated by intrinsic (e.g. interest, sense of purpose and reason for studying) and extrinsic factors (e.g. those with instrumental gains and incentive) (Cerasoli, Niklin & Ford, 2014; Pinder, 2011) . In relation to Murayama et al.'s (2016) study, participants were given the incentive of 10 cents per word correctly recalled, which did not seem to motivate the continuation of studying. However, Murayama et al. (2016) assumed that participants were fully incentivised by this and subsequently manipulating this was not explored.

A broader perspective when considering motivation as a factor for stopping, is to look at the motivational state of the participant. The act of studying can be seen as unappealing and aversive, due to the effort needed for it be effective, for example a combination of metacognitive and strategic processes (Vrugt & Oort, 2008). In addition, continued study is time consuming. Relating to the idea that studying is aversive is the 'information overload' account referred to earlier, which is consistent with people often having the belief that seeing too much information can be harmful (Eppler & Mengis, 2004). This idea is supported by research that has found that people often decide to avoid cognitive demand due to its aversive nature (Kool, Mcguire, Rosen & Botvinick, 2010) and that people tend to restrict the intake of information in order to reduce this negative affect (e.g. Soucek & Moser, 2010). This suggests that people are likely to have a pre-determined attitude that they do not enjoy studying due to its demanding nature, which may impact a person's perseverance in studying novel information. Referring back to Murayama et al.'s (2016) and my undergraduate study, participants are effectively being asked to endure a task that they may find aversive (studying word lists) to earn a small and uncertain benefit, which relied on participants recalling more words. Within Murayama et al.'s (2016) first experiment, participants shortened their studying by 17.1 items. Although this led to poorer performance, they only recalled on average 1.85 fewer words than in the control condition, which equated to a financial penalty of approximately 18.5 cents. Participants who were not motivated by the prospect of earning an additional few cents, or those who weight current experience over potential future benefit may therefore choose to stop. The potential rewards of studying are in the future, are uncertain and require the learner to model their studying behaviour according to what the test will entail. The idea that the any future reward of studying is uncertain, is a form of delay discounting, which is the depreciation of a reward value the longer it takes to receive it (Loewenstein, 1988). Many studies have found that this can alter decision-making where the immediate gratification of the outcome is valued more highly than if it is delayed (e.g. Tesch & Sanfey, 2008). However, this can often lead to decisions that are less advantageous overall (e.g. Hirsh, Morisano & Peterson, 2008). Relating to Murayama et al. (2016)'s study, the small and uncertain future monetary reward may not reflect any value to participants, compared to stopping. Therefore, the immediate gratification of stopping could outweigh the potentially small reward, leading to more restrictive decisions being made.

Thus, experiments within the current project aim at combining the motivational factors of incentives and aversiveness on study behaviour; in particular, they will explore incentivising participants by using a punishment, to see whether this motivational factor can impact stopping behaviour. In particular, Experiment 2 will explore having a punishment for stopping and whether this influences stopping behaviour, with Experiments 3, 6 and 9 exploring stopping of lists and whether having a delay between stopping and test can influence participant stopping decisions.

1.5 Applications

An aspect of the current thesis is to apply the stopping behaviour found in relation to word lists to text materials. These materials are more applicable to an educational context and where learning from reading is needed. Assessing one's reading requires the use of metacognition (Flavell, 1979). Maki and Berry (1984) were one of the first to coin the term 'metacomprehension' for the use of metacognition in relation to text material. Similarly to judgments made for list items, measures of metacomprehension usually rely on the participant to rate how well they feel they have learnt the text, with the accuracy of this varying according to different variables. For example, compared to difficult and easy texts, medium-difficulty texts produced higher metacomprehension accuracy (Weaver & Bryant, 1995). Weaver and Bryant (1995) suggested that this was due to a process similar to that outlined by the Proximal Learning theory; that participants' metacomprehension accuracy is higher when the readability of the texts is closer to their own reading ability. Maki (1998) replicated this finding, using 'easy' texts that were of a similar readability to the medium texts in Weaver and Bryant's (1995) study. Whether text length has an effect on metacomprehension accuracy has mixed findings (e.g. Commander & Stanwyck, 1997; Glenberg, Wilkinson & Epstein, 1982; Maki, 1998), however the general consensus is that it depends on what extra information it provides students in their reading.

The current project will be focusing on stopping when learning new materials, with these materials including text paragraphs, and so it is important to consider previous research into the studying of texts and study time allocation. Some studies do focus on this in relation to denser materials such as paragraphs and sentences (e.g. Mazzoni & Cornoldi, 1993; Rawson, Dunlosky & Thiede, 2000, Son & Metcalfe, 2000; Thiede, Anderson & Therriault, 2003) and provide participants the opportunity to restudy the materials. These studies tend to find that the allocation of study time for texts follows a discrepancy reduction mechanism (Mazzoni et al., 1993; Son et al., 2000; Thiede et al., 2003).

Some gaps do exist in this literature, in that they do not incorporate stopping. Applying this to more in-depth, structured materials is important; students are often faced with information-rich materials and thus are required to judge when to stop studying. The principles discussed above still apply to text learning. The information (cold) and experience-based (hot) cues are still factors to consider, regardless of the material being studied.

Firstly, pre-conceived beliefs have an impact on how texts are studied. For example, students often think that restudying is more effective than testing their knowledge of the texts they have studied (Bjork, Dunlosky & Kornell, 2013). As well as this, people often believe that massing of texts is more beneficial than spacing (Kornell & Bjork, 2008; McCabe, 2011). This demonstrates that inaccurate beliefs surrounding study strategies are universal across material type. As well as this, if a person perceives they have weaker memory, they are likely to stop earlier the more information they study. This links back to the concept of metamemory (Nelson & Narens, 1990) whereby people often self-reflect on their memory abilities and use this to inform study decisions. Referring back to the findings by Ebbinghaus (1885), memory for material increases and decays quickest after first exposure, suggesting that continuing study is optimal regardless of materials being studied.

The idea of delay discounting (Lowenstein, 1988) is also universal to these materials. Thus, if a person feels that stopping holds more value compared to the continuation of studying, they are more likely to stop. This idea is supported by research that suggests that the discounting of delays can lead to ineffective decisions (e.g. Hirsh, Morisano & Peterson, 2008). However, it is possible that when studying texts, the gain in extra study may be perceived as higher due to the volume of material to be studied, as well as due to the fact that texts are coherent and structured in nature, which may make them more straightforward to read. Therefore, it may be that discounting any future gain in recall may be less likely. Experiments 7, 8 and 9 will explore the use of text materials in the stopping paradigm, looking at whether there is a relationship between memory ability and stopping and whether having a delay between stopping and test can change stopping behaviour.

1.6 Current Research

The work in this thesis aims at exploring why people choose to stop input of novel information to the detriment of their performance.

Chapter 2 will describe experiments that replicate the effect found by Murayama et al. (2016), utilising the same word-list paradigm. Studies in this chapter explore a number of potential reasons for stopping that go beyond a simple maladaptive belief account. In particular they look at whether stopping is influenced by perceived forgetting of earlier items, by motivational factors and/or by participant beliefs regarding studying.

Chapter 3 also uses a similar word-list paradigm but explores re-studying of the word lists. Within this, words will be shown one by one to participants, but once the list has ended it will loop and show again. Within these experiments, stopping will involve the termination of the list but also the opportunity to re-study the items. Chapter 3 will involve experiments looking at the stopping of restudy of lists and whether this is influenced by motivational factors and/or processing fluency.

Chapter 4 will focus on applying the previous experiments to more applicable materials: text paragraphs. Within the experiments, participants will have time to study multiple texts and will be asked multiple-choice questions after each study phase. Like Chapter 3, Chapter 4 will include manipulations to the experiments which will aim to investigate whether stopping is influenced by motivational factors, as well as seeing whether memory ability can impact stopping.

Across all chapters, the study phase will involve the participants studying word stimuli with the aim of maximising their performance within each test. Stopping will give the participants the opportunity to terminate their study phase early, and depending on the experimental manipulation, will lead to an earlier test phase or not. My aim is to see what can influence participant stopping decisions and ultimately whether this can improve their performance at test.

2 Chapter Two –Stopping of Word Lists

2.1 Introduction

As discussed in Chapter 1, previous research has focused extensively on the allocation of study time to different items once participants have already seen the items paced by the experiment. In contrast, when the information is novel and the participant is unaware of what will be presented next, the literature is a little scarce. Murayama et al. (2016) reported that when people have the opportunity to maximise their learning, they tend to not study all of the materials. They asked participants to maximise their recall from a study-list of 50 words, allowing some people to stop studying at any point if they thought it would improve their final recall. Murayama et al. (2016) found that on average, participants stopped around 62% of the time which led to a loss of recall later on compared to those who could not stop. Murayama et al. (2016) believed this to be a metacognitive error, whereby people stopped due to a false belief that stopping would avoid cognitive overload and so improve recall. Chapter 2 aims to explore this in depth, using both experimental and non-experimental methods. The experimental methods will aim to explore what factors may influence a person's decision to stop studying whilst they are experiencing the task, whereas the non-experimental method will be a survey and will investigate potential beliefs about the task which may impact stopping behaviour.

This chapter will outline experiments that follow two main perspectives: a cognitive approach and a motivational approach. The former will focus on whether the adding of new words, and therefore increasing the likelihood of the forgetting of older items, will influence stopping. Essentially, participants will have to balance the adding of new items with the potential loss of older items in memory, which Experiment 1 will look at. In this paradigm, if participants believe that seeing more affects the memory for previous items, they may decide to stop to reduce this having a negative impact on recall. This is plausible; previous research mentioned before has found that people can monitor their forgetting (Halamish, McGillivray & Castel, 2011) which can impact JOLs (e.g. Ariel & Dunlosky, 2011; Koriat, Bjork, Sheffer & Bar, 2004) and so if participants perceive they are forgetting items, they may stop.

Another perspective that Chapter 2 focuses on is the role of motivational factors, as outlined by Experiments 2 and 3. These factors include that the cost of studying further items could be judged as too costly and aversive to continue, and any potential future reward may not be worth the cost. Rather than being a maladaptive decision, stopping here could actually be seen as adaptive due to the reduction in effort and time put towards studying. Multiple studies have shown that studying can be governed by rewards associated with different items (e.g. Ariel, Dunlosky & Bailey, 2009; Dunlosky & Ariel, 2011) as well as wanting to experience the immediate gratification of their decision making, rather than wait for a delayed reward (e.g. Tesch & Sanfey, 2008). Thus, stopping could be a function of such motivational factors, rather than a metacognitive decision. Alternatively, these perspectives could be combined to account for stopping, even though the person may know continuing will provide some benefit, because they value time-saving more than gain in recall.

Previous research has found that beliefs surrounding study strategies can inform the decisions made in relation to learning the material (e.g. Bjork, Dunlosky & Kornell, 2013; Witherby & Tauber, 2017). Therefore, it is important that this is also considered and whether it could influence a person's decision to stop studying novel information. These beliefs could interact with the perspectives discussed above, in that reasons for stopping may show a metacognitive belief or a motivational belief. This will be explored in Experiment 4. Overall, the aim is to see whether stopping can be manipulated and to understand potential influencing factors and to see why stopping is so common when it can be maladaptive.

2.2 Experiment 1

Experiment 1 was a follow up experiment to my undergraduate project as mentioned in Chapter 1, which found similar results to those in Murayama et al.'s (2016) research. This experiment used a similar word-list paradigm, where participants were given four lists of 50 words to learn, two of which they could stop and two they could not. If they stopped, they would move straight to the recall phase of that list. It was found again that when participants could stop, they did so more often than not and to the detriment of their recall (stop recall = 7.27, control recall = 9.03). Experiment 1 of the current work was the first experiment aimed at investigating stopping in terms of potential metacognitive factors influencing the decision, in particular, the role of forgetting previous items. This experiment will aim to explore stopping via the first perspective outlined in the introduction to Chapter 2, exploring whether stopping could be a function of preventing more items being lost from memory.

In Experiment 1, participants were allocated to two groups: one group who saw only the currently-to-be-studied item (the hide-previous group) and a group for whom all the previously studied items remained in view as well as the current-to-be-studied item (the show-previous group). Participants in the show-previous condition therefore saw an accumulating list of words, with each new word being appended to the list at the same rate as the appearances of words in the hide-previous condition.

In both conditions, words appeared on the screen at the same rate as in my undergraduate project. It was expected that participants in the hide-previous condition would experience a higher rate of perceived forgetting, as they have to rehearse the previously-seen words while encoding new words, while those in the show-previous group would be able to scan the list on screen to help refresh their memory. Thus, it was anticipated that participants in the show-previous condition would stop later as they are expected to experience less forgetting than the hide-previous group. Participants in each group were shown stop lists (lists they could stop at any point from being presented) and control lists (lists they could not stop), with recall in the stop lists predicted to be lower than recall from the control lists, following my undergraduate project and Murayama et al. (2016).

2.2.1 Method

Participants. Fifty-six undergraduate psychology students (49 female, 7 male) from the University of Plymouth were recruited. Participants were undergraduate volunteers participating for course credit. Participants were randomly allocated to either the show-previous condition (n = 27) or the hide-previous condition (n = 29). This sample size was chosen to be similar to the between-subjects sample size used by Murayama et al. (2016).

Materials. The experiment program was created in Java, and run on a desktop computer with a 21.5-inch LED monitor, with all words presented in black Arial bold font on a white background. All instructions given on screen is shown in Appendix B. A total of

200 nouns were used, that ranged from four to six letters in length. The words were generated via the English Lexicon Project website at http://elexicon.wustl.edu/ (Balota et al., 2007). Words used in Chapters 2 and 3 are in Appendix A. Words were randomly assigned for each participant to each of the four 50-word lists. For two of the lists, participants could stop the words from being presented (stop lists) and the other two they could not (control lists). The order of list presentation was counterbalanced across participants. Words were presented on the screen using a grid-like presentation. The first word was presented in the top left of the screen, with the next word presented underneath and so on for 10 words. The next word then appeared at the top of a second column, with the following word presented underneath. In the show-previous condition, all words remained visible on the screen until the termination of the study phase. In the hide-previous condition, only the single current study-item was visible, with each item disappearing upon presentation of the successive item. In total, the words were presented in five columns, with 10 words in each column at an approximate height of 1cm. During the recall phase, participants recorded words by typing them on the computer keyboard. Figure 2-1 gives a visual representation of how the list would look at serial position 15 on screen for the show-previous (left panel) and hide-previous (right-panel) conditions.

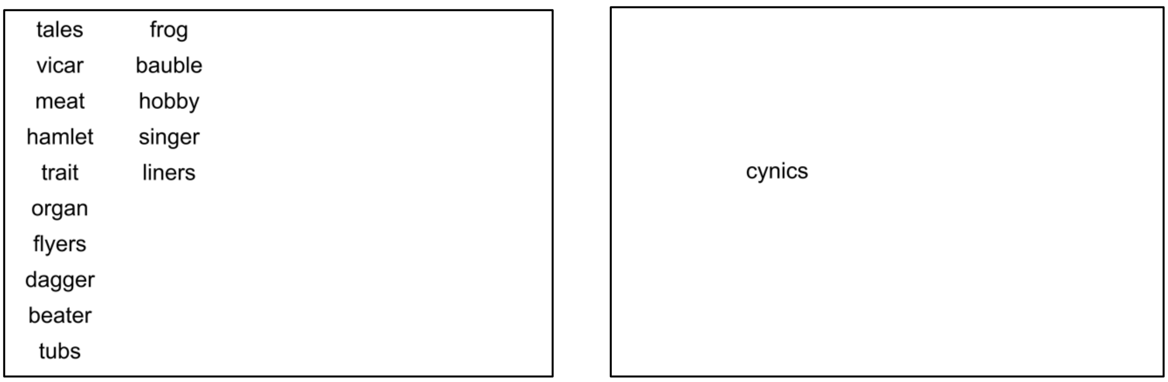

Figure 2-1. Screenshots of the word presentation style according to condition. Both screenshots show the word list at position 15 for those in the show-previous (left-panel) and hide-previous (right-panel) conditions.

Procedure. Participants were randomly allocated to either the show-previous condition or the hide-previous condition. Upon arrival, participants read on-screen instructions stating that participants' goal was to recall as many words as possible during a subsequent free recall phase for each list. After reading these instructions participants saw four lists of 50 words. Instructions for the stop lists informed participants that they could stop the presentation of words at any time by pressing the space key, and this would move them straight to the recall phase for that list if they did. Words in all lists were shown for 2 s each with a 0.5-s interval between each word. In the show-previous condition, a new word was appended to the list every 2.5 s, with the previous words remaining on-screen in the same location, as described above. In the hide-previous condition, each word disappeared after 2 seconds. Once the list terminated (either after 50 words, or after a stop decision), the list disappeared from view, and participants had 60 s to recall as many words as they could, by typing them into an on-screen box. The time left to recall the words was shown on the screen via a timeline. Once the recall phase for a list was finished, the screen would move onto the instructions for the next list. The approximate duration of the experiment was 15 minutes.

Statistical Analysis. Bayesian Analysis was conducted using JASP (Jasp Team, 2019) version 0.9.2, from which the BF_{10} was calculated using the BayesFactor R package version 0.9.12-4.2. Bayesian analysis for the subsequent experiments was also conducted using JASP and the BayesFactor R package version 0.9.12-4.2. ANOVAs were conducted for both stopping position and recall analysis. Assumption checks were run to ensure these met the assumption of equal variance. These ANOVAs automatically met the assumption of Sphericity due to consisting of only two repeated measures levels. Levene's tests were run on the between-group variable. Any necessary corrections are reported in the results.

2.2.2 Results

Overall stopping rates for the stop lists is presented in Table 1. Split into condition, participants chose to stop 24.1% of stop lists in the hide-previous condition, compared to 18.5% of lists in the show-previous condition. This difference in frequency of stopping was not statistically significant, $U = 431.50$, $p = .414$, $BF_{10} = 0.326$. These results lend no support to the idea that stopping is a consequence of the perception of forgetting. Table 9 outlines the mean stopping position, and resultant recall for each list in Experiment 1. Additionally, descriptive statistics are presented in Table 10 for stopping position and recall split into the counterbalance sequences.

For overall stopping position, list number did influence stopping position where list two tended to be stopped earlier ($F(1, 54) = 5.41$, $p = .024$, partial $\eta^2 = .091$, $BF_{10} = 2.180$). As for condition, there was not a significant between groups difference in stopping position ($F(1, 54) = 0.90$, $p = .346$, partial $\eta^2 = .016$, $BF_{10} = 0.452$). The main effects of list number with condition was not qualified by a significant interaction, ($F(1, 54) = 1.93$, $p = .171$, partial $\eta^2 = .034$, $BF_{incl} = 0.615$). Levene's test for homogeneity of variance was significant and therefore was violated for stop list two ($F(1, 54) = 7.110$, $p = .010$). To overcome this, a Welch Independent Samples t-test was conducted. This found a non-significant difference between groups ($t(49.514) = -1.413$, $p = 0.164$, $BF_{10} = 0.60$).

For overall recall, list number did not influence recall ($F(1, 54) = 1.53$, $p = .222$, partial $\eta^2 = .027$, $BF_{10} = .320$). List type (stop lists versus control lists) did not influence recall ($F(1, 54) = 1.88$, $p = .177$, partial $\eta^2 = .034$, $BF_{10} = .336$). As for condition, there was not a significant difference in overall recall ($F(1, 54) = 2.06$, $p = .157$, partial $\eta^2 = .037$, $BF_{10} = 0.622$). The main effect of list number with condition was not qualified by a significant interaction, ($F(1, 54) = 0.24$, $p = .624$, partial $\eta^2 = .004$, $BF_{incl} = 0.218$) and neither was list type with condition ($F(1, 54) = 2.21$, $p = .143$, partial $\eta^2 = .039$, $BF_{incl} =$ 0.504).

Mean stopping position was positively correlated with mean recall from stop lists, $r = .486$, $N = 56$, $p < .001$ (see Figure 2-2).

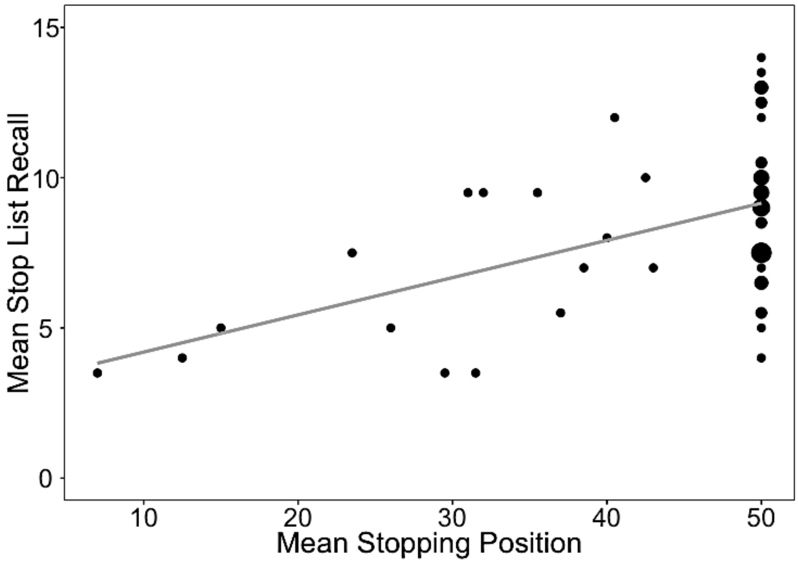

Figure 2-2. Scatterplot of the relationship between mean stopping position and stop list recall in Experiment 1 (y = 2.96 + 0.12 (mean stopping position), adjusted $R^2 = 0.222$)). Each dot is a mean value, the dots are sized relative to the number of averages of that particular value. The grey line represents the trend of the relationship between the two variables.

To investigate whether stopping position was related to memory ability, a correlation was conducted between mean stopping position and recall from control lists. However, no significant correlation was observed $r = .162$, $N = 56$, $p = .234$.

2.2.3 Discussion

Experiment 1 aimed to investigate the function of the metacognitive factor of perceived forgetting on stopping behaviour, particularly whether this would increase the rate of stopping. It was posited that those in the hide-previous condition would experience a higher rate of forgetting and thus would have a higher rate of stopping with an earlier stopping position, which would negatively impact word recall. The first noteworthy aspect of these results is that they replicated the effect found by Murayama et al. (2016) and my undergraduate project, whereby lists that were stopped were recalled less (albeit weakly), and a positive correlation was found between number of words seen and recalled.

However, no significant difference between the presentation conditions was found; the evidence actually favoured the null hypothesis. Overall stopping rate was found to be much lower across both conditions, compared to previous research (Murayama et al.'s 2016 Experiment 1: 62%, Experiment 2: 51%, Experiment 3: 50%, Experiment 4: 67%, my undergraduate study: 64%). The difference in stopping between groups (Show Previous: 18.5%, Hide Previous: 24.1%) was not significantly different but was in the direction that had been predicted. This lower stopping rate is inconsistent with previous results from Murayama et al. (2016) and my undergraduate project, whereby stopping rate has been found to be much higher, as demonstrated above. These results suggest that stopping is less likely due to the metacognitive experience of forgetting the earlier items and could be due to the influence of another factor such as motivation. The regression equation from Figure 2-2 supports this, suggesting that there was only a small benefit in continuing studying. As well as this, stopping could have been reduced simply due to how the word stimuli were presented on screen. In previous experiments, each word was presented in the centre of the screen, whereas the current paradigm included words being presented on screen in a position that was respective to their serial position. This could have created a sense of ease in learning the words due to the added knowledge of their respective serial position. This added information could have provided a cue for their learning and reduced the potential overwhelming nature of the list. The Cue Utilisation Framework (Koriat, 1997) puts forward that certain cues can influence a person's JOL, including intrinsic cues that refer to the properties of the stimuli, extrinsic cues which are those concerning the conditions of learning, and mnemonic cues which indicate to the person how much something has been learned. The serial position of the item can be considered an extrinsic cue and has been found to influence JOLs (Castel, 2008), which may also be the case here. The fact that participants knew where they were in the list and how long they had left could have reduced any metacognitive monitoring effort. This could have conceived a sense of ease of learning and rehearsal of the words. However, a manipulation to reduce this was used in Experiment 2 of Murayama et al.'s (2016) study, where the serial position of the words was made available to participants, and this did not influence stopping. Thus, it seems unlikely that this is a plausible factor in the current experiment.

Even though recall was not significantly higher in the show-previous condition compared to the hide-previous condition for both list types, numerically the recall for the show-previous condition was higher across both list types. This is suggestive that having the previous items remain on screen did somewhat help in recall and that the hide-previous lists could have led to lower recall because of stopping. Therefore, keeping words on the screen seemed to help in reducing some forgetting, which could help to reduce stopping.

Like Murayama et al. (2016) and my undergraduate project, Experiment 1 also found a significant correlation between stop position and recall, providing further support for the idea that stopping is maladaptive.

Experiment 1 provided tentative evidence that the rate of forgetting influenced recall, in that keeping words on screen seemed to help in retaining more information. However, this did not have an impact on stopping behaviour. Therefore, considering these two factors together, there seems to be little evidence that the rate of forgetting influences stopping. However, stopping did still occur, and the results suggest that this leads to impaired recall.

2.3 Experiment 2

Experiment 1 suggested that forgetting rate did not influence stopping and so Experiment 2 focused on the broader motivations that drive study decisions, following the second research perspective as outlined in the introduction for Chapter 2. There were two reasons to pursue this line of inquiry. Firstly, prior research (e.g. Ariel, Dunlosky & Bailey, 2009; Lipowski, Ariel, Tauber & Dunlosky, 2017) has demonstrated a strong, positive link between self-regulated study and motivation, suggesting that when studying is valued higher, students are more likely to allocate their time towards it. Therefore, stopping in Murayama et al.'s (2016) experiments could be a function of this. Secondly, Murayama et al. did not test this idea experimentally, with motivation assumed to be high in all conditions. The central hypothesis of the information overload account is that people stop studying when they believe further information will impair subsequent recall. This should occur whether people are seeking to maximise financial gain (for good recall) or to minimise negative outcomes. Experiment 2 introduced a punishment associated with poor recall. All participants initially studied a control list of 50 items and completed a recall test. This established their individual baseline performance. For three subsequent lists they were allowed to stop if they wanted to, to maximise recall. For the control condition, there were no additional instructions, but for the aversive condition, participants were told that their recall performance on each list would be compared to their baseline performance, and they would have to complete additional mathematics problems for every item recalled below their individual baseline. That is, participants in the aversive condition were told that they would have to complete an additional aversive task that would be both effortful and lengthen the duration of the study.

If stopping behaviour results from a lack of motivation to perform well on the recall test, participants in the aversive condition should stop less than those in the non-aversive condition. Alternatively, if stopping results from a belief that it improves recall, the threat of a punishment for poor performance should not discourage stopping.

Furthermore, if motivation is an important factor in stopping, it would be expected that this may lead to more stopping.

2.3.1 Method

Participants. Sixty undergraduate psychology students from the University of Plymouth were recruited. Participants were undergraduate volunteers participating for course credit. Sixty-four participants were initially recruited, but three participants' data were excluded because they reported that they stopped the lists by accident and one was excluded due to an error in recording their recall. Participants were randomly allocated to either the aversive condition (n = 31) or non-aversive (control) condition (n = 29). The sample size was chosen to be comparable to Murayama et al.'s (2016) between-subjects sample size.

Materials. Math questions sheets were created for use in the aversive condition. The word lists were presented and recall recorded in the same manner as in Experiment 1, except for the instructions and the sequence of stop and control lists (see below). All instructions given on screen is shown in Appendix C.

Procedure. All participants started with a control list, for which they were instructed to maximise their recall. The remaining three lists were stop lists, which they could stop by pressing the space bar. When given the baseline list, participants were not told that the subsequent lists were stop lists and therefore were unable to deliberately underperform to create a low bar for performance. For the aversive condition, recall for each list was compared to the baseline measure from the control list. Participants were instructed that recalling fewer words than baseline would result in an equivalent increase in the number of maths questions they had to complete in a later test. For example, if they recalled 10 words from the baseline list and six words from a stop list, four problems would be added to the maths test. Participants were not given feedback on their recall for each list or how this compared to baseline. In order to maintain motivation to maximise performance across all lists, participants were told that the number of maths problems to be completed would cumulate across the three study lists, and the maths test would be completed after the final recall phase. Those in the non-aversive condition received a baseline list followed by three stop lists, but without any instruction that there would be a maths test. Other details were the same as for Experiment 1. At the end of the third test, participants were debriefed and told that they would not have to undertake the maths problems.

Statistical Analysis. A 2 x 3 Mixed ANOVA was conducted for both stopping position and recall analysis. Assumption checks were run to ensure these met the assumption of equal variance. Mauchly's Sphericity tests were run on the within-subjects variables. Levene's test were run on the between-group variable. Any necessary corrections are reported in the results.

2.3.2 Results

Experiment 2 investigated whether the possibility of an aversive task encourages participants to see more words, stop less and ultimately have higher recall performance. Overall stop rate split into each list is presented in Table 2. Stop lists in the Non-Aversive Condition were stopped 70.1% of the time, whereas stop lists in the Aversive Condition were stopped 50.5% of the time. This difference in frequency of stopping was not statistically significant, $U = 569.50$, $p = .064$, $BF_{10} = 0.704$. Table 11 outlines the mean stopping position, and resultant recall for each list in Experiment 2.

List number did not influence stopping position overall $F(2, 116) = 0.46$, $p = .632$, partial $\eta^2 = .008$, $BF_{10} = 0.078$, and nor did the threat of a penalty $F(1, 58) = 3.69$, $p = .060$, partial $\eta^2 = .060$, $BF_{10} = 1.223$. However, these two main effects are qualified by a significant interaction, $F(2, 116) = 3.71$, $p = .027$, partial $\eta^2 = .060$, $BF_{incl} = 1.979$. This significant interaction prompted a follow up, which indicated that there was no effect of penalty on stopping for list one $t(58) = 0.19$, $p = .852$, $BF_{10} = 0.266$, but there was for lists two $t(58) = -2.44$, $p = .018$, $BF_{10} = 3.018$ and three $t(58) = -2.25$, $p = .028$, $BF_{10} =$ 2.092.

The equivalent analysis on free recall found a significant effect of list number, $F(2, 116) = 4.76$, $p = .010$, partial $\eta^2 = .076$, $BF_{10} = 3.424$, but no effect of penalty, $F(1, 58) = 2.51$, $p = .119$, partial $\eta^2 = .041$, $BF_{10} = 0.862$, and no interaction $F(2, 116) = 2.89$, $p = .060$, partial $\eta^2 = .047$, $BF_{incl} = 0.969$.

An Independent Samples t-test was conducted to investigate whether there was a difference in baseline recall between groups. This did not find a significant difference $t(58) = -1.686$, $p = .097$, $BF_{10} = 0.857$.

As in Experiment 1, stopping position correlated with recall within the stop lists across the aversive ($r = .438$, $N = 31$, $p = .014$) and non-aversive ($r = .406$, $N = 29$, $p = .029$) conditions.

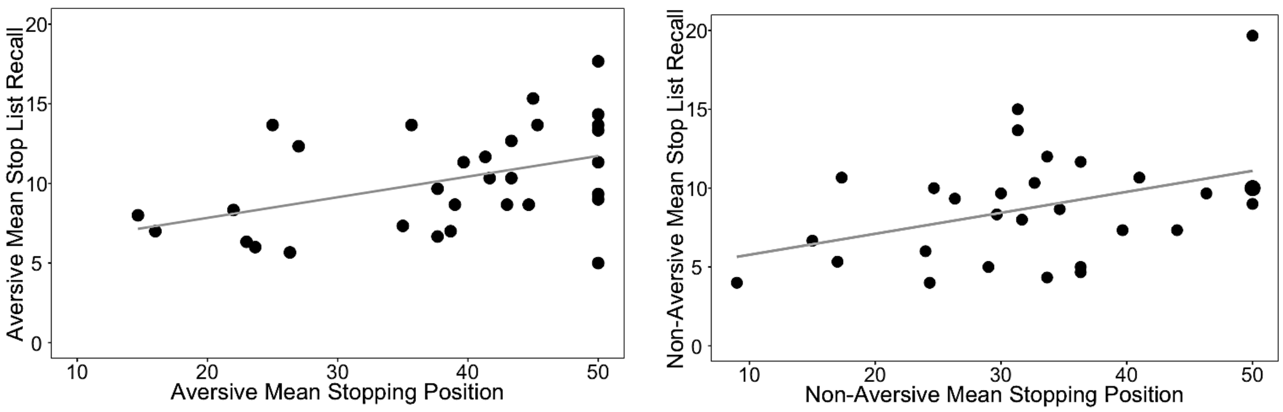

Figure 2-3. Two scatterplots demonstrating the relationship between stopping position and stop list recall in Experiment 2 for the aversive condition (left-panel) (y = 5.25 + 0.13 (mean stopping position), adjusted R^2 = 0.164)) and the non-aversive condition (right-panel) (y = 4.45 + 0.13 (mean stopping position), adjusted R^2 = 0.134)). Each dot is a mean value for each person, the dots are sized relative to the number of averages of that particular value. The grey lines represent the trends of the relationship between the two variables.

Experiment 2 replicated the overall stopping pattern: a substantial proportion of participants chose to stop seeing study items when given the opportunity, and this impaired their final recall. The earlier they stopped, the worse their recall.

2.3.3 Discussion

Experiment 2 investigated whether incentives in the form of an aversive maths task can influence the rate of stopping. The aversive task was intended to act as a deterrent against stopping, whereby participants would want to study for longer in order to avoid the maths task. The results from Experiment 2 replicated aspects of the results found by Murayama et al. (2016) and my undergraduate project, in that stopping rate was similar at 61% and a positive correlation was found between mean stopping position and recall. The results showed a significant interaction between condition and stopping position in the stop lists, which suggest that the stopping position pattern was different between the two groups. From subsequent analysis, it was found that those in the Non-Aversive condition decreased their stopping position significantly in stop list two. From Table 10 and the trends seen in Figure 2-3, it can be seen that numerically, the non-aversive Condition had lower mean recall than those in the aversive Condition. Therefore, even though their stopping could have had a detrimental impact on their recall, this was not taken into account due to the lack of consequence for stopping (i.e. no maths questions).

However, neither an information overload account, nor a motivational account can fully explain the pattern of stopping across the three lists used in this study. The information overload account can explain the pattern seen for list 1; participants stopped regardless of the presence or absence of a potential punishment for poorer recall. However, it struggles to explain the pattern thereafter. If participants continued to be firm in their belief that stopping is beneficial for recall, it would predict that both groups would continue stopping at a similar rate, but they do not. Thus, it could be argued that after list 1 recall is complete, the participants learn that stopping is disadvantageous, and so adapt their behaviour accordingly. But once again, this does not explain why the two groups diverge in response to this.

A motivational account also struggles to explain the whole pattern, but for different reasons. If participants are motivated toward avoiding punishment in the aversive condition, then they should have stopped later in list 1, but they did not. However, they do show this pattern on subsequent lists, perhaps as a result of learning about the efficacy of stopping. To elaborate, after learning from list 1 recall, the aversive group change their behaviour because they care about the outcome, whilst the non-aversive condition continue to stop at a similar rate, presumably because they are not motivated toward improving their recall even in the face of clear evidence of the negative impacts of stopping. As well as this, from the regression equation in Figure 2-2 it can be seen that although extra study does relate to higher performance, this gain is quite small. This strongly indicates that the decision to stop is motivated by factors other than wishing to maximise recall.

As mentioned previously, the issue of immediate gratification applies to the decision to stop, but in the present experiment, there are two future states to consider. The first is the future likelihood of recall. However, here there is an additional future state to consider - the final maths test. It could be argued that the threatened punishment of a maths test increases in salience through the experiment: it could be least salient for list 1, and most salient for list 3. Additionally, the feedback made by participants following each recall attempt may further increase the salience of the punishment. In particular, participants may not weigh the threat of the maths test very heavily at all, until they discover the negative effects of stopping on their recall performance.

2.4 Experiment 3

Experiment 3 was designed to examine a different potential motivation for stopping, as per the second research perspective put forward in the introduction for Chapter 2. In the original study by Murayama et al. (2016), the focus was entirely on the potential negative impact of additional items on the overall ability to recall. However, this neglects two crucial aspects of the experimental situation: the alternate motivations of the participants, and the fact that the experiment (and the factor of interest) extends over time. Put bluntly, participants may not enjoy taking part in psychological experiments, and may wish to shorten the experience. In this particular paradigm, participants are given an escape clause: they can stop the study phase and skip straight to the test. Thus, in this view, there is an alternative reason why stopping may occur, that has little to do with optimising recall. Murayama et al. (2016) tried to address this through financial incentives, but these incentives may not have been sufficient to overcome some participants' aversion to studying long lists, or to reduce their wish to be somewhere else. Realistically, the financial benefit of seeing a full list of words in Murayama et al.'s (2016) experiments was quite small. If participants were to carry on, this would not have surmounted to a significant enough amount to have motivated participants to view the full list. The Control group had a mean recall of 8.96, whereas those in the Stopping group had a mean recall of 7.11, meaning that their gain in recall was 1.85 words. Therefore, saving time may have seemed more beneficial than carrying on studying for such a small gain.

Consequently, in this experiment, for half the lists the link between stopping and the duration of the study phase early was removed, by having a fixed starting point for the recall test. For these lists, the test began at the point the end of the list would have been reached, regardless of when stopping occurred. For the remaining lists, testing followed immediately after the study period was terminated, with no delay. Participants could still choose to stop a list if they believed it would benefit their final recall. If stopping is motivated only by the goal of maximising recall, the delay prior to the test should not alter stopping behaviour. In contrast, if stopping is motivated by the wish to save time, then stopping should occur later in the delayed test condition, because there is no timesaving to be gained.

One potential concern with this experiment is that the retention intervals are not matched for immediate and delayed test lists. There are three responses to this concern. The first is to point out that the intervals were also not matched in previous demonstrations that have compared control and stopped lists, where recall has been initiated immediately at the end of the study phase. This approach means that the two forms of list (control vs stopped) are matched only on the retention interval for the final items, and not for the average retention interval across all items on the list. This follows because the earliest items on a stopped list are closer in time to the test than the equivalent items on a control list.

The second response is that the primary interest within the current experiment is in stopping itself, more than the downstream effects on recall. For the choice of design for Experiment 2 to influence stopping requires that participants have a pre-conceived model of the effects of a short retention interval on future recall. There is good evidence against this from studies of judgements of learning (e.g. Koriat, Bjork, Sheffer & Bar, 2004).

The final rebuttal is to point out that within the delayed test, there is an *unfilled* retention interval, during which participants are free to rehearse previously studied items. Consequently, for stopping decisions to be influenced by the potential difference in retention intervals, it would require participants to have a clear expectation that short unfilled intervals impact negatively upon future free recall. Given that it is known that judgements of learning are influenced relatively little by the retention interval between study and test even up to a week (Koriat, Bjork, Sheffer & Bar, 2004), or by list lengths between 10 and 100 items (Tauber & Rhodes, 2010), this seems unlikely.

To summarise: in this experiment, participants studied four separate lists, with half of the lists being tested immediately after completion of the study phase (the immediate test condition), and the other half being tested after a delay equivalent to the period saved by stopping early (the delayed test condition). If participants stop to limit their exposure to new words, stopping position should be the same irrespective of delay. However, if stopping is motivated by a desire to finish the experiment sooner, participants should stop later and less often for delayed tests than immediate tests.

2.4.1 Method

Participants. Forty-two undergraduate psychology students (35 female, 7 male) from the University of Plymouth were recruited. Participants were undergraduate volunteers participating for course credit. Forty-four participants were initially recruited, but two participants' data were withdrawn from analysis due to participant error. The sample size was chosen to be comparable to Murayama et al.'s (2016) within-subjects sample size.

Materials. The task was administered using the same type of computer and monitor as previous experiments and was also programmed in PsychoPy (version 1.9.1). For all instructions and words presented on screen, the background was white, and all words were in black bold text. All instructions given on screen is shown in Appendix D. For delayed tests, text was presented in white font after participants made the stop action, rendering the text invisible. For word lists, the text was in Arial font (approx.1.4cm height on screen). The materials were otherwise identical to those used for Experiment 2.

Procedure. All participants saw four lists: two with stopping leading to a delayed test, and two with stopping leading to immediate tests. These were presented in an alternating sequence, and the type of list presented first was random for each participant. Before each list, participants were presented with instructions stating what kind of test it would be. For delayed tests they were informed that if they pressed stop, they would be shown a blank screen for the full length of the rest of the study phase, before being allowed to begin the test phase. For immediate tests, they were told that if they stopped at any point in the list, they would begin the test phase immediately. During the recall phase for each list, participants wrote their responses on paper. Other details of the procedure were the same as Experiment 2.

Statistical Analysis. Repeated Measures ANOVAs were conducted for both stopping position and recall analysis. Assumption checks were run to ensure these met the assumption of equal variance. Mauchly's Sphericity test was automatically met due to only having 2 repeated measures variables.

2.4.2 Results

Overall participants stopped the delayed-test lists 27.4% of the time, and stopped the immediate-test lists 48.8% of the time. This is split into list number in Table 3. This difference in frequency of stopping was statistically significant, Z = 26.00, p = .004, BF_{10} = 10.704. Table 12 provides descriptive statistics for stopping position and recall. Additionally, descriptive statistics are presented in Table 13 for stopping position and recall split into the counterbalance sequences.

To explore whether there was a main effect of list type on stopping position, a 2 (Delay: immediate vs delayed test) x 2 (List order: List 1 vs List 2) ANOVA was performed. People stopped earlier when the test was immediate, $F(1, 41) = 8.45$, p = .006, partial η^2 = .171, BF_{10} = 174. There was no effect of list number $F(1, 41) = 0.06$, p = .816 , partial η^2 = .001, BF_{10} = 0.165, and no interaction between delay and list number , $F(1, 41) = 0.24$, p = .631, partial η^2 = .006, BF_{incl} = 0.258.

The equivalent analysis on recall showed no effect of Delay, $F(1, 41) = 0.07$, p = .796, partial η^2 = .002, BF_{10} = .170, or list number, $F(1, 41) = 0.44$, p = .513 , partial η^2 = .011, BF_{10} = 0.202, and no interaction, $F(1, 41) = 1.25$, p = .270, partial η^2 = .030, BF_{incl} = 0.402.

Independent-samples t-tests were conducted to see whether the number of words recalled per list type was different between those who chose to stop and those who did not. This is true for delayed-test list one ($t(40) = 3.164$, $p = .003$, $BF_{10} = 12.689$) and delayed-test list two ($t(40) = 3.131$, $p = .003$, $BF_{10} = 11.761$), and for immediate-test list one ($t(40) = 3.981$, $p < .001$, $BF_{10} = 89.725$) and immediate-test list two ($t(40) = 3.750$, $p < .001$, $BF_{10} = 50.422$). It was found consistently across all list types that the number of words recalled was lower when participants chose to stop, compared to those who did not.

As for previous experiments, Pearson correlations were calculated to investigate whether there was a significant relationship between the number of words seen and recalled. This was the case for both the delayed-test lists ($r = .488$, $N = 42$, $p = .001$), and the immediate-test lists ($r = .631$, $N = 42$, $p < .001$). See Figure 2-4 for these relationships.

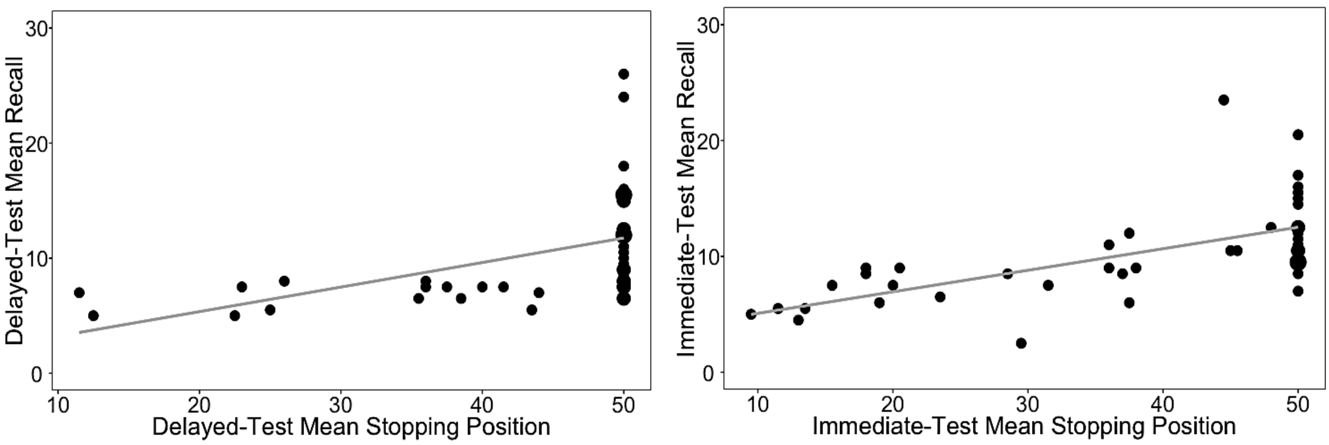

Figure 2-4. Two scatterplots demonstrating the relationship between stopping position and stop list recall in Experiment 3 for the delayed-test list type (left-panel) ($y = 1.09 + 0.21$ (mean stopping position), adjusted $R^2 = 0.219$)) and the immediate list type (right-panel) ($y = 3.22 + 0.19$ (mean stopping position), adjusted $R^2 = 0.382$)). Each dot is a mean value, the dots are sized relative to the number of averages of that particular value. The grey lines on each graph represents the trend of relationship between the two variables.

The results of Experiment 3 showed that regardless of the fact that the delay before testing had no impact upon recall, participants stopped more often, and earlier, when the test followed immediately. Overall, when there was no time benefit to stopping, fewer participants stopped.

2.4.3 Discussion

Experiment 3 was conducted to explore further the idea that motivational factors have a significant influence on a person's decision to stop the presentation of novel information, when the goal is to maximise their learning. Experiment 3 used a different approach to Experiment 2, utilising a time delay between stopping and test as a method of motivating participants to view more words. The overall rate of stopping was lower (38%) than expected, however stopping rate and stopping position were found to be significantly different between the list types. Recall was not found to be significantly different, but a significant correlation was found between average stopping position and recall of the words, replicating the effect found by Murayama et al. (2016) and my undergraduate project. Overall, when there was no time benefit to stopping, fewer participants stopped. This pattern is entirely consistent with the view that stopping behaviour is a function of the general motivations of participants, who weigh the costs of continued studying (in terms of effort and time) against the value they place on the potential benefits of additional future recall. To further support this, the regression equations in Figure 2-4 suggest a relatively small gain in recall for every extra word seen.

In contrast, a straightforward information overload account struggles to explain this pattern. It might be argued that participants weigh the costs of the delay, perhaps in terms of the need to rehearse, or the likely forgetting that will occur in this interval. This might be the case, but there is no direct evidence for it. While continuing to study would indeed reduce the time needed to rehearse, and the likelihood of forgetting, it would also increase the burden of how much needs rehearsing, and the amount that could be forgotten. If participants truly adhered to the view that their memory capacity is “full” at the point they would normally stop, it is by no means clear why they should continue studying beyond their capacity.

Experiments 2 and 3 provided more of an explanation as to why stopping is a common decision to make, which was not explored by Murayama et al. (2016). Experiment 2 showed that the threat of punishment can reduce stopping, while Experiment 3 showed that removing the time benefit of stopping also reduces stopping. As mentioned previously, Murayama et al. assumed that participants were fully incentivised throughout their experiments, however this was only using a small financial benefit for every word correctly recalled, which may have not seemed worthwhile to participants for their extra time. Experiments 2 and 3 used stronger manipulations of motivation, which were able to manipulate stopping.

Stopping need not be a consequence of a belief in ‘information overload’, as suggested by Murayama et al. (2016), if participants think that a guaranteed time saving is valuable enough to risk a small decrease in recall. There is no evidence in any of the experiments reported so far for a belief that seeing more words will be harmful for recall. Accordingly, the final experiment was designed to test for the presence of this belief.

2.5 Experiment 4

Experiment 4 used a survey to investigate whether beliefs about study strategies govern stopping decisions, which have been found to affect metacognitive memory judgments (e.g. Koriat, 1997) and study strategies (e.g. Bjork, Dunlosky & Kornell, 2013). In fact, Bjork et al. (2013) found that students often believe that they are employing effective strategies, when in matter of fact, they are not. Thus, it is clear that students often hold inaccurate beliefs about how is best to learn new material.

In Murayama et al.’s (2016) final experiment, one group of participants were asked to hypothetically indicate if they would stop a list of 50 words, where they would stop and how many they believed they would recall according to their stopping position. Their predicted stopping position was 30.4 out of 50, which was associated with a mean predicted recall of 16.2. This compared to a control group who estimated that they would recall 14.8 items if they were required to study a 50-item list. Thus, these data are consistent with the view that participants hold the belief that there is no benefit to be gained from studying more than around 30 items, and that they are "unaware of the possible advantage of viewing all the words in the list to enhance recall performance" (p. 8).

However, a flaw with this argument is that it is presumptive in nature as participants were not explicitly asked *why* they would stop. This leaves open the possibility that participants might choose to stop for many other reasons, as it has been discussed here. As well as this, Murayama et al. (2016) did not map out participants' predicted recall across multiple list lengths, making it harder to conceptualise the trend of this and to see where the maximum point for predicted recall was. From the broader motivational view taken here, it may be that participants would predict a higher level of recall having studied more items, but nonetheless would still choose to stop for the other benefits that stopping might bring.

If stopping occurs because participants believe that memory will be impaired by further study, then people should choose to stop at a point they believe future memory is maximised. Being asked to predict recall for studying beyond this point should therefore result in a reduction in predicted recall, or at least no increase in predicted recall. In contrast, if people predict increased recall from study of further items, but nonetheless indicate that they would stop, this indicates that stopping is not driven by the desire to maximise recall.

Thus, Experiment 4 aimed to solve these omissions and test these ideas by running a modified version of Murayama et al.'s (2016) hypothetical memory test. This modification included a question on reasons for hypothetical stopping, to see if reasons given fit the information overload account, as well as asking participants to predict their recall for list lengths other than just 50. Participants were asked to predict their recall for lists of 10 different lengths: 5, 10, 15, 20, 25, 30, 35, 40, 45 and 50. If information overload is a belief held by some participants, then it would be expected to see their predicted recall show an inverted U function across this distribution of list lengths (with a peak in recall equivalent to where their stopping position would be).

2.5.1 Method

Participants. One-hundred-and-six undergraduate psychology students (91 female, 14 male and 1 'prefer not to say') from the University of Plymouth were recruited. Participants were undergraduate volunteers participating for course credit. A further eleven responses were excluded because they were either incomplete or from students who had completed the questionnaire previously. The sample size was chosen to be comparable to Murayama et al.'s (2016) survey sample size.

Materials and Procedure. The questionnaire was hosted online using Survey Monkey (SurveyMonkey Inc.). Participants were asked to imagine being 'presented with words one by one on a screen' with the aim of recalling as many of the words as possible. The instructions informed participants that the words would be nouns between four and six letters in length, presented for 2 s at a time. Participants had to predict their immediate recall for lists of different lengths, once each word within the list is shown, for example: 'If you saw 5 words on the screen, how many do you think you would be able to recall? Ten such questions were included, asking about lists of 5, 10, 15, 20, 25, 30, 35, 40, 45, and 50 words in that order. After this, participants were asked if they would stop when given the option to and their task was to maximise their recall from a potential list of 50 words. This was followed by a question asking why they would or would not choose to stop. For those who indicated that they would choose to stop, they were asked where in the list of 50 they would stop. All instructions given on screen are shown in Appendix E. Participants completed the questionnaire on their own computers, recording responses by typing into on-screen text fields.

Statistical Analysis. A 2 x 10 Mixed ANOVA was conducted for predicted recall analysis. Assumption checks were run to ensure these met the assumption of equal variance. Any necessary corrections are reported in the results.

2.5.2 Results

The main interest in this experiment is whether participants who report stopping would predict a non-monotonic relationship between list length and recall. That is, whether people would expect their total recall to decline if they were asked to study more items. Out of 106 participants, 63 indicated that they would choose to stop during the study of a 50-word list, with a mean stopping position of 22.98 (*SD* = 7.99). Figure 2-5 shows the average overall predicted recall split by whether or not participants indicated that they would stop.

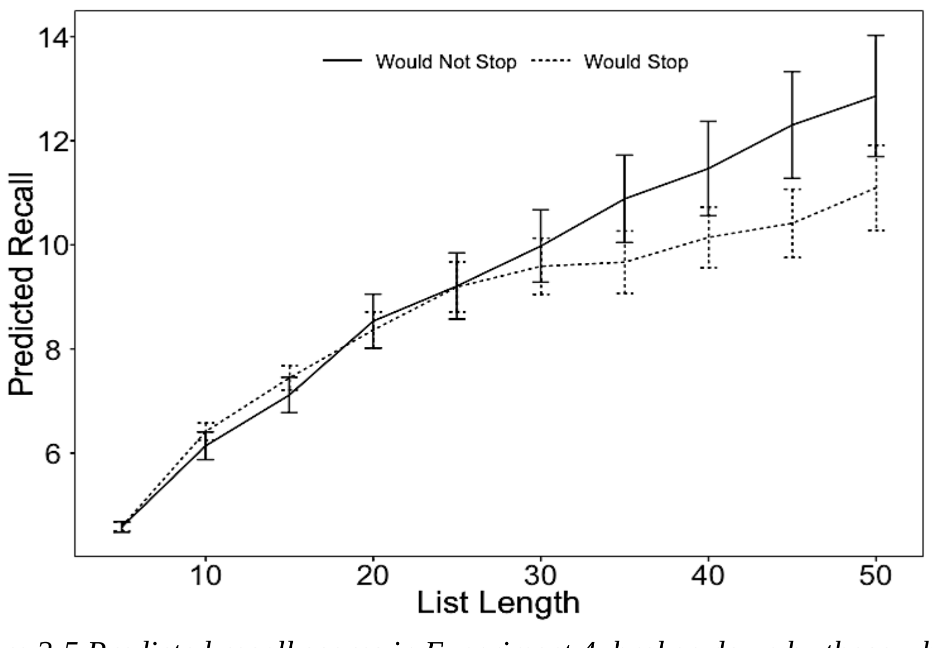

Figure 2-5 Predicted recall scores in Experiment 4, broken down by those who indicated that they would not stop study (n = 43), and those who indicated that they would stop (n = 63). The errors bars represent the SE of the mean.

Clearly, the overall pattern is for recall to increase monotonically with list length up to 50, regardless of stated intention to stop. That is, as a group, those who say they would stop nonetheless indicate that they believe recall would be higher if they were to continue studying.

The predictions made by those who predicted stopping and those who did not were compared. The correlation co-efficient for the each of the trends seen in Figure 2-5 were compared, however this was not significant (Z = 1.52, p = .129). To further support this, Independent-samples t-tests were conducted to compare predicted recall for each list length between those who did and did not predict stopping. At each list length, predicted recall was not significantly different (all list lengths p >.05, all BF_{10} < .60).

I then investigated the specific patterns of predicted recall by each participant, to look for evidence that they believed recall would be impaired by additional study items. Only 16 showed an inflection point in their predicted recall, such that they expected recall to peak with a list length lower than 50. That is only 15% of the sample – which is 25% of those who said they would stop – reported a pattern of recall compatible with the information overload account. For this minority of participants, they predicted recall at a peaked position of 23.13 (SD = 7.72) out of 50, with recall declining steadily thereafter, as shown in Figure 2-6.

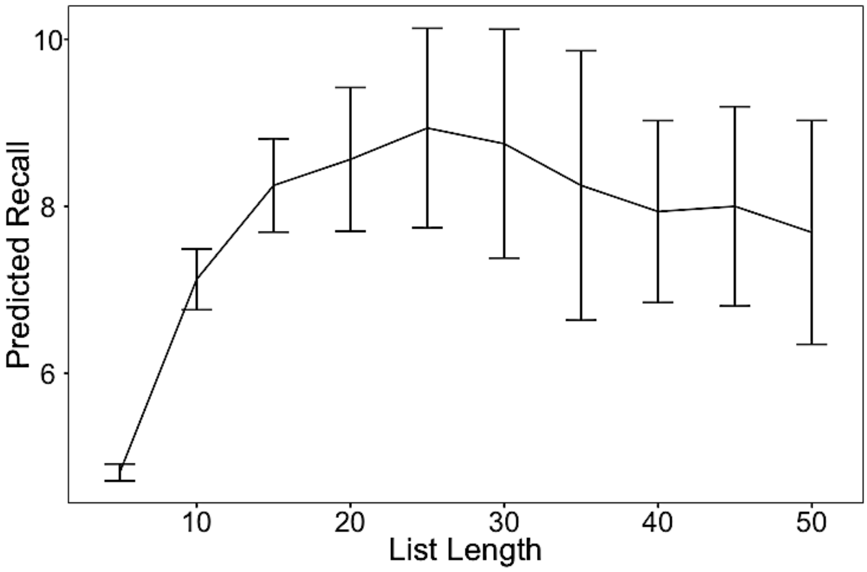

Figure 2-6. Predicted recall scores for those who predict a decline in Experiment 4 (n = 16). The errors bars represent the SE of the mean.

This suggests that there are some people who hold the central belief indicated by information overload theory – that memory can become overloaded – but it is very much a minority view, even among those who would choose to stop. The majority of those who said they would stop did so even though they predicted that recall would be higher if they continued to study more items.

Two researchers independently coded reasons given by participants that said they would stop. Two clear themes emerged with a third category used to encompass responses that were not clear enough to be categorised. The inter-rater agreement was substantial (k = 0.77). These ratings were compared, and any disagreements were discussed and re-classified accordingly. The resulting categories were Information Overload, No Benefit and No Category. Responses were put into the Information Overload category if there was any suggestion that the participant thought seeing more words could harm performance. Responses in the No Benefit category were those that stated that seeing more words would not increase recall and expressed reasons that were not in-line with seeing value in continuing the list. Responses were put into the No Category group if they did not explain their decision in terms of the relationship between list length and recall.

Of those who said they would stop, 52% were classified as reporting Information Overload, 22% as reporting No Benefit, and 25% gave other miscellaneous justifications for stopping. The mean stopping position for those reporting information overload was 24.36 (SD = 7.43), and for those reporting no benefit it was 19.64 (SD = 7.53), which was not significantly different $t(45) = 1.985$, $p = .053$, $BF_{10} = 1.435$. Out of those who predicted a decline, 11 were categorised in the ‘information overload’ group and 4 were in the ‘no benefit’ group.

I then compared predicted recall across participants reporting the two main justifications for stopping. As Figure 2-7 shows, there is no correspondence between the stated beliefs of Information Overload participants and their predicted recall, which increased in line with list length across all lists. In contrast, numerically participants in the No Benefit category predicted less benefit to further study for longer lists.

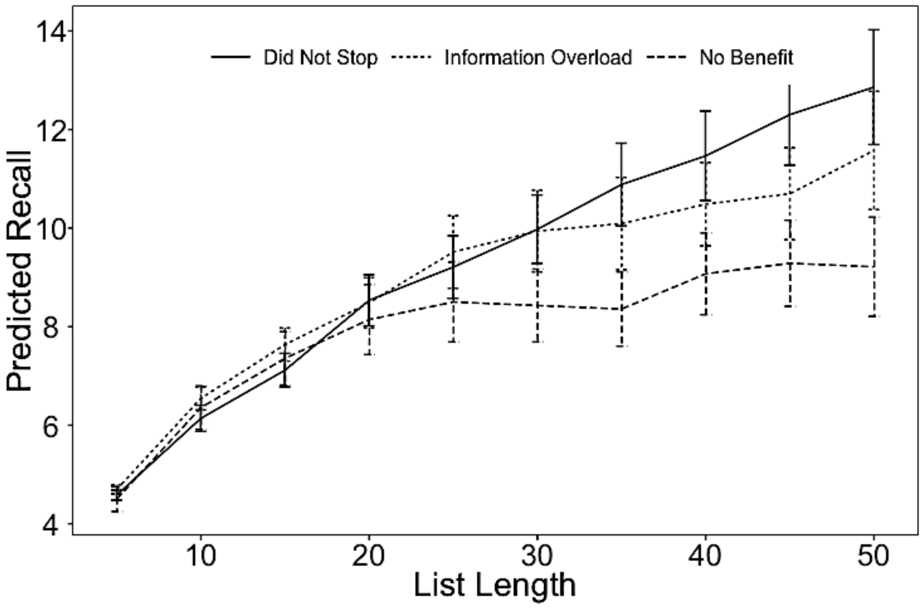

Figure 2-7. Line graph showing the predicted recall for participants in Experiment 4 that were classified in the 'information overload' (dotted line) and 'no benefit' (dashed line) compared to those who indicated they would not stop study (black solid line). The errors bars represent the SE of the mean.

Comparisons were made for predicted recall of the different list lengths between participants that did and did not predict stopping. A significant difference was found between list length ($F(1, 1.56) = 79.54$, p <.001, partial $\eta^2 = .026$), but a between-groups difference was not found ($F(1, 104) = 0.793$, $p = .375$, partial $\eta^2 = .008$, $BF_{10} = .294$). No significant interaction was found ($F(1, 1.56) = 2.57$, $p = .093$, partial $\eta^2 = .024$).

In summary, the results of Experiment 4 provide limited evidence that beliefs in information overload determine stopping. Only a minority of individuals made the prediction that recall would be lower if list length increased. When asked if they would prefer to stop during study of a 50-word list, many people indicated that they would indeed stop, and the majority of those individuals said that they would stop because their memories would be overloaded. However, those same individuals had previously predicted that recall would increase monotonically as list length increased. In fact, they had predicted higher recall performance for longer lists than a second subgroup of stoppers, who believed that there would be little benefit to continued studying.

2.5.3 Discussion

Experiment 4 intended to investigate whether predicted stopping behaviour is influenced by beliefs regarding whether stopping is effective. The results found a similar (predicted) stopping rate of 59% when compared to previous studies (e.g. Murayama et al., 2016). Therefore, participants predicted that they would decide to stop studying the words prematurely to move onto the recall phase early. Even though the stopping rate was quite high, this was not reflected in overall predicted recall; predicted recall of the word lists increased in a linear fashion and thus suggests that overall, participants were not predicting potential decline in their recall as the list length increased. What was intriguing about the results was that the reasons participants gave for their predicted stopping were more in line with a belief of information overload (53% of responses). However, when examining the predicted recall according to reason given (see Figure 2-7), it does not reflect what would be consistent with this belief, which would be a point after which predicted recall declines. In fact, only a small proportion of participants actually predicted a decline in their recall. As well as this, mean predicted stopping position for this group was 24 out of 50 and again when examining their predicted recall, this actually increases after this point, adding doubt to whether stopping is primarily due to the belief of information overload. Therefore, predicted recall does not reflect stopping behaviour nor reasons given for stopping.

To provide further doubt to Murayama et al.'s (2016) suggestion that stopping could be influenced by a sense of information overload, amongst the reasons given for predicted stopping in Experiment 4 were reasons consistent with the idea that seeing more would not add any benefit to participant recall. This is in contrast to the idea that seeing more words could harm recall. If it is the case that what was proposed by Murayama et al. (2016) is the reason for premature stopping, then it would not be expected to find that almost a quarter of responses (23%) were of a 'no benefit' nature or something else entirely (24%).

The results from Experiment 4 suggest that participants reasons for stopping are due to an ineffective belief, supporting prior research (e.g. Bjork, Dunlosky & Kornell, 2013). However, this is not consistent in their recall predictions. Specifically, participant reasons for stopping are in line with avoiding information overload, however when predicting recall, this is not reflected.

2.6 General Discussion

The aims of the studies reported in Chapter 2 were to determine what causes people to adopt the maladaptive strategy of stopping a study list, when their putative goal is to maximise future recall. This effect was originally demonstrated by Murayama et al. (2016), who proposed that stopping resulted from a maladaptive belief in information overload; participants thought that seeing more words would harm their performance. Chapter 2 has shown that the phenomenon of stopping during study is fairly ubiquitous, but also suggests that it stems from more than a maladaptive metacognitive belief.

Firstly, the experiments aimed to investigate whether stopping is a consistent behaviour. Across Experiments 2 and 4 it was found that participants stopped more often than not, both within the experimental setting (Experiment 2) and when hypothetically asked to predict their stopping (Experiment 4). The stopping rate in Experiment 3 (38%) was not as high as these experiments. Therefore, stopping was common when the task was to maximise recall of new information, replicating Murayama et al. (2016). However, the findings diverge from the predictions of information overload theory in a number of crucial respects.

Experiment 1 aimed to investigate whether forgetting of earlier items can influence stopping by altering the way in which the items were displayed on the screen. If stopping was believed to be advantageous for recall, then stopping should be consistently high, yet stopping position was actually later compared to prior experiments. Experiment 2 used the potential punishment of an additional mathematics test for poor recall. If stopping is seen as beneficial, then stopping should continue, but this was not seen after an initial performance test: peopled studied longer to avoid further penalties. Experiment 3 took a different approach and removed a potential reward for stopping, namely the time before the final test. Again, if stopping is perceived as beneficial to memory, this should not alter stopping behaviour, but the results showed reliably less stopping when the test was delayed. Finally, Experiment 4 showed that many people would choose to stop studying a long list of words, but nonetheless expected to remember more items if they did study more items. Even though participants expressed having a belief consistent with that put forward by Murayama et al. (2016), it demonstrated that participants' predicted recall was not reflective of this and thus supports previous research suggesting that people tend to act in ways that are not consistent with their stated beliefs (Bjork, Dunlosky & Kornell, 2013; Kornell, 2009; Wissman, Rawson & Pyc, 2012). Therefore, the experiments in Chapter 2 suggest that stopping is driven by a motivational account, rather than a metacognitive account.

What drives stopping?

The act of studying can be seen as unappealing and aversive, due to the effort needed for it be effective, for example a combination of metacognitive and strategic processes (Vrugt & Oort, 2008), as well as it generally being quite time consuming.

Much research exists showing that learning plateaus after initial study time (Son & Sethi, 2006), often referred to as an 'S' learning curve. Thus, the marginal benefits of continuing to study drops, as well as the aversiveness of the task will increase. Participants in Experiment 4 predicted a non-linear function of their recall, with increase slowing as list length increases, suggesting they are aware of this aversiveness. Continuing to study may produce a 'labor in vain' effect (Nelson & Leonesio, 1988) whereby further study does not produce an increase in recall reflective of this further effort. Stopping may therefore partially be a result of participants recognising that studying for longer is not worthwhile. As well as this, stopping may be influenced by the participants discounting any future and uncertain small reward of further study. Instead, they are choosing to stop studying as they know this will immediately reduce cost of study time and effort. This relates to the fact that students often behave against their beliefs; the experience of the task over-rides how they think they will study and the knowledge that seeing more will still provide *some* benefit. An example of this was found by Blasiman, Dunlosky and Rawson (2017), where the plan to study material was not executed. The students created efficient plans of study but failed to follow these through at the time of studying. The plan (offline cognition) was not executed once participants were confronted with the items (online cognition) due to the challenge of doing so.

Within the final experiment, participants expressed a predominant belief that seeing more words would harm recall, thus predicting that their performance would be overloaded the more they studied. However, their predicted recall does not reflect this and so it could be possible that they responded how they felt they 'should', justifying stopping rather than expressing that they do not value maximising performance. Reasons for this could be that they perceive this as not being socially accepted, due to it being against the 'norm' of having a high goal and ambition, as usually set out in learning

(Cautinho, 2007; Locke & Latham, 1990;) and where positive study attitudes are encouraged (e.g. Hussain, 2006).

In summary, stopping is likely a result of a cost-benefit trade off, which only partly is rewarded by the experimenter as motivation. Doing so is known as value-based decision making, which involves weighing up the cost of the activity such as effort and discounting rewards (Sidarus, Palminteri & Chambon, 2019) and thus choosing to act in a way that is perceived as more beneficial in the short-term.

2.6.1 Conclusion

The experiments in Chapter 2 examined the stopping decisions made when people are presented with novel information and when the aim is to maximise performance. Prior research has suggested that the decision to do so is due to an erroneous belief that seeing more is harmful for performance. However, the current results cast doubt on this and suggest that stopping is a function of optimising motivation. In the context of education, students often have to make decisions to optimise their performance and restricting what they see could be a function of their motivational state. Future experiments should aim at exploring this in depth, as well as applying it to materials that are more applicable to real world studying, for example, text paragraphs. This will aid in the understanding in why such a maladaptive decision is frequently made and allow recommendations for optimising performance.

3 Chapter Three – Repeated Lists and Stopping

3.1 Introduction

The aim of Chapter 3 was to develop the motivational account of stopping tested in Chapter 2, by adapting the experimental approach to be more applicable to real-life study behaviour. In particular, the experiments in Chapter 3 will introduce an element of restudying, rather than participants having one chance to study the materials, which is not applicable to what students usually face. Often, students will have much more time to study and often will reread study materials, for example textbooks and lecture slides. The restudying aspect of the experiments will involve participants studying a list up to four times, rather than once like prior experiments, but as in Chapter 2, the focus will remain on decisions to terminate (re)study when the goal is to maximise performance.

Little research exists on the restudy of computer-paced word lists. As mentioned previously, research tends to focus on how a person is able to select what items they restudy (see Chapter 1 for literature on study-time allocation), however these studies are self-paced and allow participants to control their study time. Murayama et al. (2016) conducted a study that looked at stopping of computer-paced word lists, but this did not involve the opportunity to restudy the words. Contrarily, there is a wealth of studies that examine the restudying of materials, particularly texts rather than word lists, either in rereading and metacomprehension literature (e.g. Rawson, Dunlosky & Thiede, 2000; Thiede, Anderson & Therriault, 2003) and involve participants making judgments of learning (JOL) assessments of them, as well as deciding how to allocate their study time to the materials once they have already studied them. These studies also allow participants to be selective in their restudy, and usually find that participants allocate their time in particular to harder items, however this research does not tell us about stopping when restudying is allowed.

As well as the limited research into the restudy of computer-paced word lists, there is no research that focuses on the stopping of the restudy of computer-paced word lists. While there is research into multi-trial learning (e.g. Karpicke & Roediger, 2007; Nelson, Dunlosky, Graf & Narens, 1994; Tulving, 1966;), these studies do not allow stopping but involved repeated learning or items presented at a fixed rate. The main experimental design used in Chapter 3 included four 30-word lists being repeated up to four times, with two lists allowing participants to stop at any point on any list, with the remaining two lists not allowing stopping. The test consisted of free recall, which took place either immediately after participants stopped or once all four repeats were shown. Thus, the focus of Experiment 5 in Chapter 3 was to see whether having the word lists repeated alters stopping behaviour. Experiment 6 will use a similar design but will also include a delay between stopping and test on two of the lists, like Experiment 3 in Chapter 2. Like Chapter 2, the experiments in Chapter 3 will explore whether stopping of repeated word lists is governed by a metacognitive illusion, motivation, or whether an alternative mechanism related to processing fluency could also alter stopping behaviour.

One potential argument for stopping is that participants have the metacognitive illusion that stopping is beneficial. Murayama et al. (2016) put forward that it is likely that participants are unaware of the benefit of seeing all of the words and thus, if this is the case in the current experiments, stopping rate is likely to be consistent across both Experiments 5 and 6, regardless of additional manipulations. As the current experiments will include the repetition of word lists, it is plausible that under this account, participants will firstly feel that seeing more words within a list could be harmful, as well as seeing more repeats of that word list could be harmful. Seeing more words and repeats of those words could create a sense of 'information overload' (e.g. Eppler & Mengis, 2004), whereby the more information participants see, the more overwhelming it feels. If stopping is consistent with this account, it is expected that stopping of the word lists would be relatively early in the number of repeats of the lists due to the nature of the list learning task, for example in the first presentation, regardless of number of repetitions thereafter. This may be governed by the belief that seeing more repeats would be overwhelming and thus seeing less would be better for performance. Overall, under this account it is predicted that stopping would lead to poorer recall, with stopping correlating with lower recall.

Another potential account for stopping is motivation, whereby the motivational state of the participant leads to the early termination of word lists. The second experiment outlined in Chapter 3 aims to firstly see whether stopping of repeated word lists can be influenced by manipulating the motivational aspect of the experiment. Motivation has been found to be a large component of study time allocation (e.g. Ariel, Dunlosky & Bailey, 2009; Lipowski, Ariel, Tauber & Dunlosky, 2017) and thus it felt logical to address this within the current chapter. As well as this, the motivations of the participants may be to maximise their time rather than their performance. As put forward in multiple studies looking at the function of recall across multi-trial learning (e.g. Ebbinghaus, 1885; Klein, Addis & Kahana, 2005; Tulving, 1964; 1966), the gain in recall is highest after the first couple of list exposures, after which the learning of new items reduces in rate. Therefore, under the motivational account, participants could perceive that viewing more repetitions is worth less in their time and effort, considering that the return in recall is declining, and therefore are more likely to stop. As mentioned previously, the role of immediate gratification and discounting any future gain (Tesch & Sanfey, 2008) could be influential in participant stopping behaviour, whereby they value moving on to the test early higher than seeing more of the words. If this were to be the case, this would increase the reliability of there being an effect of motivation on stopping, due to its consistency across paradigms used in Chapter 2. Thus, in the current chapter, if stopping was influenced by a motivational account, in Experiment 6 it would be expected that earlier stopping would occur when the test was immediate, compared to when the test is delayed. If motivation did not play a role, then a difference in stopping in Experiment 6 is not expected.

Alternatively, it could be that the opportunity to study the list again could create a sense of fluency and thus increase stopping rate. For example, having something repeated can increase processing fluency by creating a sense of familiarity with the items

(Whittlesea, Jacoby & Girard, 1990) which in turn is known to inflate JOLs (e.g. Koriat, 1997; Mueller, Tauber & Dunlosky, 2013). Therefore, having the lists repeated may inflate participants' perceived fluency of the items and therefore encourage stopping, if they feel they have learnt the item better than they actually have. It is recognised that this account is only applicable for the further repeats of the list, rather than to account for any potential stopping on the first list. Alternatively, the increased sense of fluency could increase a perceived ease of learning, which could encourage participants to *continue* studying, rather than stop. Thus, from repeating the lists, it is possible participants could either feel a sense of mastery, encouraging them to stop or they could perceive a sense of ease, which could encourage the continuation of studying. Overall, under the fluency account, stopping rate is expected to be consistent across Experiments 5 and 6, regardless of manipulations on when the test is expected to be. As well as this, if people were to stop the further repetitions, stopping would be expected to have a negative impact on word recall.

Overall, the aim of these experiments was to see whether the stopping of repeated word lists is consistent with a metacognitive illusion, whether an alternative motivational mechanism is being optimised, or whether a factor such as processing fluency of the stimuli is influencing stopping. If motivation or processing fluency are likely accounts, then this puts further doubt that stopping is due to a belief that seeing more is harmful, and is actually a function of something else entirely. I also aimed to use these experiments to bridge the experiments in Chapter 2 to a more applied area of studying, to then lead on to using more text-heavy materials in Chapter 4.

3.2 Experiment 5

Experiment 5 used a list-learning paradigm like that in Murayama et al. (2016), and incorporated list repetition to look at re-study behaviour and stopping. Rather than studying a single word list and then have a recall test, participants studied a list of 30 words that repeated for a total of 4 times and then had a recall test for that list. It was decided to have a list of 30 words rather than 50 like previous experiments, due to the nature of these re-study experiments. Having a longer list of words may cause fatigue after one presentation and thus would make participants less inclined to see repeats. To have 30 words to learn is still a substantial task, with the possibility of participants feeling it could be harmful to continue studying, but not long enough to cause aversive reactions before the opportunity to restudy was provided. The repeats of the words occurred at a list level; once a list had been shown, it would be shown again with the words in the same order. It was decided to have the lists in the same order, rather than a random order, for each repeat to reduce the potential interaction of having random lists being too hard to monitor. To elaborate, if a word list is shown for the first time, having the repeats in the same order makes it easier for participants to monitor what repeat they are on and when a list repeat has finished. This reduces any extra monitoring effort they are having to do being a confounding factor, when the aim is to remember as many words as they can and to decide whether to stop a word list. The words appeared on screen at the same rate as previous experiments and the participants' aim was to maximise their recall. In total, participants studied four word lists: for two they could stop the words and move straight to the test phase, and for the other two they were not able to stop and subsequently viewed all four repeats. The aim was to investigate whether the stopping of repeated word lists is consistent with a metacognitive illusion, like that put forward by Murayama et al. (2016).

3.2.1 Method

Participants. Forty-nine undergraduate psychology students (39 female, 10 male) from the University of Plymouth were recruited. Participants were undergraduate volunteers participating for course credit. Fifty-two participants took part in the study, however two sets of data were removed due to errors recording data for two participants and one due to a participant stopping a list by mistake. This sample size was reflective of the resources available at the time of participant recruitment.

Materials. The task was administered using the same type of computer and monitor as previous experiments and was also programmed in PsychoPy (version 3.1.1). For all instructions and words presented on screen, the default background settings were used (the background was grey, and all the words were in white text). All instructions given on screen is shown in Appendix F. The word lists were made of words generated from the same website as Experiment 1 in Chapter 2. Each list contained 30 words generated at random for each participant. For word lists, the text was in Arial font (approx. 1.4cm height on screen). Recall was recorded via recall sheets provided to the participants, one for each list. Participants were also given a consent form and information sheet at the beginning of the experiment, and a debrief sheet at the end.

Procedure. All participants saw four word lists: two they could stop (stop lists) and two they could not (control lists). Each list repeated for a total of four times, unless the lists were stop lists and participants chose to stop the words. Each word within the list was shown for 2 seconds each with a 0.5 second interval between presentations. The lists were presented in an alternating sequence, and the type of list presented first was random for each participant. Before each list, participants were presented with instructions stating whether they could stop it or not. For the repeated stop lists, participants were informed that they could stop the words being presented at any point, which would cut short the list and subsequent repetitions to move them straight to the test phase. For the repeated control lists, instructions regarding stopping were omitted. When the lists were presented, there was no other information presented regarding what number repeat was being shown. Once each list had finished repeating, or were stopped, participants recorded their recall on the recall sheets provided. Once all lists were studied, participants were debriefed.

Statistical Analysis. Repeated Measures ANOVAs was conducted for both stopping position and recall analysis. Assumption checks were run to ensure these met the assumption of equal variance. Mauchly's Sphericity test was automatically met due to only having 2 repeated measures variables.

3.2.2 Results

Overall participants stopped 40.8% of the stop lists, stopping on average at position 100.39 out of 120. Stop rate spit into list number is presented in Table 4. When average stopping position per participants was split into how many people stop in each of the list repeats, it showed that zero participants stopped within the first list presentation, 3 people stopped within the second, 10 within the third and 36 within the fourth (including anyone who saw all words possible). Table 14 outlines the mean stopping position, and resultant recall for each list in Experiment 5. Table 15 shows additional descriptive statistics for stopping position and recall split into the counterbalance sequences.

To explore whether there was a main effect of list type on recall, a 2 x 2 ANOVA was performed, which found that the within-subjects factor of list type was statistically significant with higher recall in control lists ($F(1, 48) = 23.68$, $p < .001$, partial $\eta^2 = .330$, $BF_{10} = 916.873$), as was list number with higher recall after list two $F(1, 48) = 4.42$, $p = .041$, partial $\eta^2 = .084$, $BF_{10} = 1.615$). The list type by list number interaction was not significant ($F(1, 48) = 1.00$, $p = .323$, partial $\eta^2 = .020$, $BF_{incl} = 0.272$).

As for previous experiments a Pearson correlation was calculated to investigate whether there was a significant relationship between the number of words seen on the stop lists (out of a possible 120 : 30 x 4 repeats) and stop list recall. A significant relationship was found between the two variables r = .389, N = 49, p = .006. See Figure 3-1 for this relationship. From this scatterplot, a pattern can be seen that on average, participants are stopping nearer the end of the lists, with relatively fewer people stopping mid list. For example, on average participants are stopping more at around positions 60 (end of list 2) and 90 (end of list 3). As well as this, on average no-one stopped on the first list.

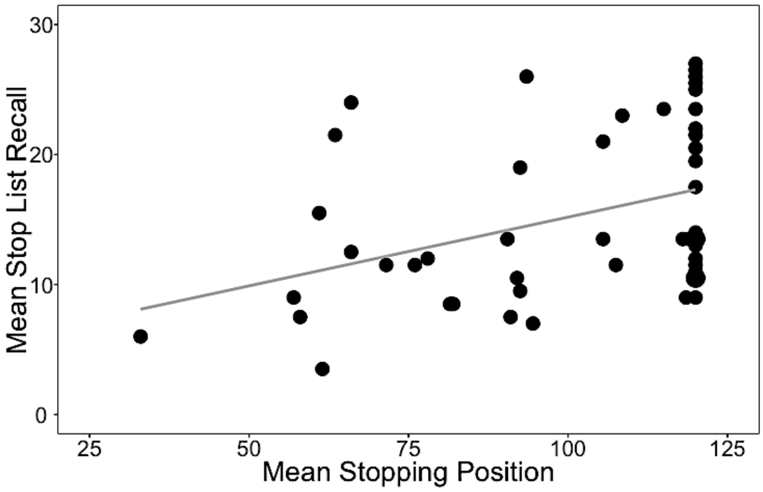

Figure 3-1. Scatterplot showing the relationship between stopping position and recall on the stopping lists. A stopping position of 120 reflects seeing all 4 list repeats. Each dot is a mean value, the dots are sized relative to the number of averages of that particular value. The grey line on the graph represents the trend of the relationship between the two variables (y = 4.61 + 0.11 (mean stopping position), adjusted R^2 *= 0.133).*

Similar to the analysis in Experiment 1 in Chapter 2, to investigate whether stopping the repeats of word lists is influenced at all by memory ability, a correlation was conducted to see the relationship between stop list stopping position and control list recall. A significant relationship was found between the two variables *r* = .308, *N* = 49, *p* = .031. See Figure 3-2 for this relationship. Thus, having a poorer memory ability may have influenced some participants to stop the repetition of the words.

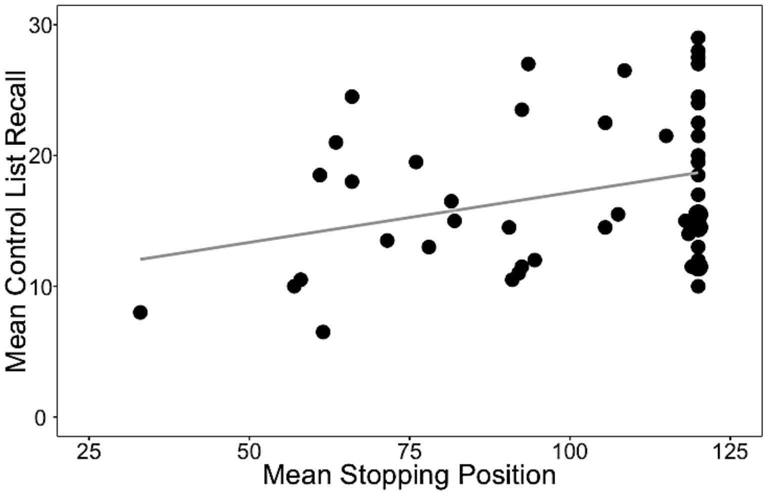

Figure 3-2. Scatterplot showing the relationship between stopping position on stop lists and recall on the control lists. A stopping position of 120 reflects seeing all 4 list repeats. Each dot is a mean value, the dots are sized relative to the number of averages of that particular value. The grey line on the graph represents the trend of the relationship between the two variables (y = 9.54 + 0.08 (mean stopping position), adjusted R^2 = 0.076).

The results from Experiment 5 firstly found similar results to prior experiments in Chapter 2, whereby a correlation was found between number of words seen and recalled. Experiment 5 found this whilst using a different paradigm to that in the previous word-list experiments, whereby the lists were repeated up to four times. The correlation found that the longer the participants studied the word lists (i.e. studied each list repeat), the better their word recall. Yet, similarly to previous experiments, participants still stopped the lists.

3.2.3 Discussion

Experiment 5 aimed to investigate whether having the word lists repeated would encourage participants to stop and whether doing so would negatively impact on performance. Within this experiment, a list of 30 words was repeated four times, with recall tested after the four repeats. Participants were given four 30-word lists: two they could stop and therefore stop it from repeating and two they could not. Stopping was still apparent when the lists were repeated, and this did have a negative effect on participant recall. This was the first experiment to adapt the word list experiments in Chapter 2 to restudying, and to bridge the stopping of word lists to restudying.

The results replicated the previous word list experiments, and those found in my undergraduate study and Murayama et al. (2016). Participants still stopped the lists and performed worse than those who did not, with a significant difference found between stop list recall and control list recall, and a positive correlation found between stopping position and recall (see Figure 3-1). However, like previous experiments, the gain to be had for recall was quite small for every extra word studied, thus suggesting that participants may have been stopping to avoid putting extra study effort in for little return in recall.

An interesting finding from Experiment 5 was that on average, stopping did not fall within the first list. This suggests that participants were less likely to stop after only seeing the list once and thus were more likely to stop when the lists were repeated. It was predicted that if the participants were stopping because of a metacognitive illusion, then stopping is likely to occur in the first list regardless of any further repeats. As this was not found in Experiment 5, it suggests that stopping is not consistent with this account. Alternatively, a potential explanation as to why participants stop the repetition of word lists is that these repeats create a sense of processing fluency. The fact that participants are not stopping on the first list suggests that the knowledge of further repeats are influencing stopping, which could be due to perceived fluency. This will be investigated further in Experiment 6; if similar behaviour is found this will support further the idea that stopping is due to a sense of fluency. As well as this, from Figure 3-2, it could be suggested that stopping was somewhat clustered around the end of each list (e.g. 60, 90, 120), suggesting that participants were waiting until the end of the list repeat to stop and before a new repeat began. This suggests that participants were monitoring where in the list they were and made a decision on how many repeats they felt sufficed to benefit performance. This decision could be based on motivational factors, whereby participants are deciding not to begin more repeats due to the immediate gratification of stopping.

Experiment 6 will aim to further explore the stopping of repeated word lists and whether it can be manipulated. Due to the apparent role of motivation highlighted in Experiments 2 and 3, Experiment 6 will aim look at motivation in a similar fashion. The manipulation used in Experiment 3 seemed to be more effective, and so it is logical to use the same experimental approach in Experiment 6, as well as to maintain consistency between experiments.

3.3 Experiment 6

Experiment 6 aimed to investigate whether motivational factors could still be at play, even when the lists are repeated. It is possible that the participants' motivational state had an impact in their stopping in Experiment 5, whereby they stopped in order to bring the test forward. As mentioned previously, participants could have valued saving any extra studying over potential gain in their recall, a form of delay discounting (Loewenstein, 1988). Therefore, Experiment 6 aimed at exploring motivation in more depth. Using a similar paradigm to Experiment 5, participants will study four lists that will be repeated, however in two lists if they stop there will be a delay before the test, and in the other two lists, stopping will result in participants moving straight to test. If participants stop because they believe that it is an optimal study strategy, then the results should show consistent stopping behaviour across the list types. However, if they stop because they are wanting to cut short the lists in order to optimise time and effort over recall, then the results should show earlier stopping when the test is immediate compared to it being delayed. Previous research has suggested that across multiple trials (e.g. Dunlosky & Salthouse, 1996; Karpicke & Roediger, 2007; Klein, Addis & Kahana, 2005; Nelson, Dunlosky, Graf & Narens, 1994; Tulving, 1964; 1966), the marginal benefit of studying across further trials begins to decline roughly after the first couple of exposures. Thus, participants may perceive this reduction in value once exposed to further repeats of the word lists and therefore are inclined to stop. If this is the case, this is predicted to occur when tests are both immediate and delayed, due to participants being able to save time and reduce effort for smaller gain. However, when the tests are delayed, the cost of sitting and doing nothing may be greater than carrying on due to the potential length of time this will take. In Chapter 2, this was explored but only using one list; the current experiment uses this paradigm but using repeated word lists and therefore the delay between stopping and tests may be greater. Therefore, if participants value seeing the word more than stopping and having a potentially long delay, we would expect less stopping when the tests are delayed.

3.3.1 Method

Participants. Seventy undergraduate psychology students (64 female, 6 male) from the University of Plymouth were recruited. Participants were undergraduate volunteers participating for course credit. Seventy-seven participants had taken part, however seven data sets were removed for the following reasons: one due to illness, two due to not waiting at the delay to recall the words, two due to pressing 'escape' and therefore mistakenly exiting the experiment, and two due to errors in the programme. This sample size was reflective of the resources available at the time of testing.

Materials. The task was administered using the same type of computer and monitor as previous experiments and was also programmed in PsychoPy (version 3.1.1). For all instructions and words presented on screen, the background was white, and all words were in black bold text. This was to allow words in the delayed-test lists to 'disappear' if participants pressed the stop key. For repeated lists with a delayed test, text was presented in white font after participants made the stop action, rendering the text invisible. All instructions given on screen is shown in Appendix G. For word lists, the text was in Arial font (approx.1.4cm height on screen). The materials were otherwise identical to those used for Experiment 5.

Procedure. Like Experiment 5, all participants saw four lists however two had delayed tests, and two had immediate tests. These were presented in an alternating sequence, and the type of list presented first was random for each participant. Before each list, participants were presented with instructions stating what kind of test it would be. For delayed tests, they were informed that if they stopped the lists from repeating, they would be shown a blank screen for the length taken for the remaining repeats, before being allowed to begin the test phase. For example, if they pressed stop after repeat two, the screen would be blank for the duration of the remaining two repeats. For immediate tests, they were told that if they stopped at any point in the list, they would begin the test phase immediately. Other details of the procedure were the same as Experiment 5.

Statistical Analysis. Repeated Measures ANOVAs were conducted for both stopping position and recall analysis. Assumption checks were run to ensure these met the assumption of equal variance. Mauchly's Sphericity test was automatically met due to only having 2 repeated measures variables.

3.3.2 Results

Overall participants stopped the stopping lists with delayed tests 17.8% of the time, and stopping the lists with immediate tests 31.4% of the time, which was a significant difference, Z = 77.00, p =.004, BF_{10} = 7.557. Stopping rate for each list number is shown in Table 5. Table 16 gives the mean stopping position and recall for each list type, with additional descriptive statistics provided in Table 17 for stopping position and recall split into the counterbalance sequences. When average stopping position per participants was split into how many people stop in each of the list repeats, it showed that within the delayed test list type, zero participants stopped within the first list presentation, one participant stopped within the second, two on the third and 67 on the fourth (including those who saw all words possible). When the test was immediate, zero participants stopped within the first list presentation, four participants stopped within the second, six on the third and 60 on the fourth (including those who saw all words possible).

To explore whether there was a main effect of list type on stopping position, a 2 x 2 ANOVA was performed, which found that the within-subjects factor of list type was statistically significant with delayed-test lists being stopped later $F(1, 69) = 10.61$, $p = .002$, partial $\eta^2 = .133$, $BF_{10} = 252.785$, but list number was not $F(1, 69) = 1.00$, $p = .660$, partial $\eta^2 = .003$, $BF_{10} = 0.142$. The list type by list number interaction was not significant $F(1, 69) = 1.25$, $p = .267$, partial $\eta^2 = .018$, $BF_{incl} = 0.252$.

To also explore whether there was a main effect of list type on recall, a 2 x 2 ANOVA was performed, which found that the within-subjects factor of list type was not statistically significant $F(1, 69) = 0.49$, $p = .488$, partial $\eta^2 = .007$, $BF_{10} = .172$, but list number was significant with recall higher after list two $F(1, 69) = 4.72$, $p = .033$, partial $\eta^2 = .064$, $BF_{10} = 1.400$. The list type by list number interaction was also not significant $F(1, 69) = .010$, $p = .934$, partial $\eta^2 = .000$, $BF_{incl} = 0.218$.

Independent-samples t-tests were conducted to see whether the number of words recalled per list type was different between those who chose to stop the list and those who did not. This was only true for delayed-test list two ($t(68) = 2.581$, $p = .012$, $BF_{10} = 4.194$).

As for previous experiments, Pearson correlations were calculated to investigate whether there was a significant relationship between the number of words seen and recalled. This was the case for both the delayed tests ($r = .435$, $N = 70$, $p <.001$), and the immediate tests ($r = .350$, $N = 70$, $p =.003$). See Figure 3-3 for these relationships.

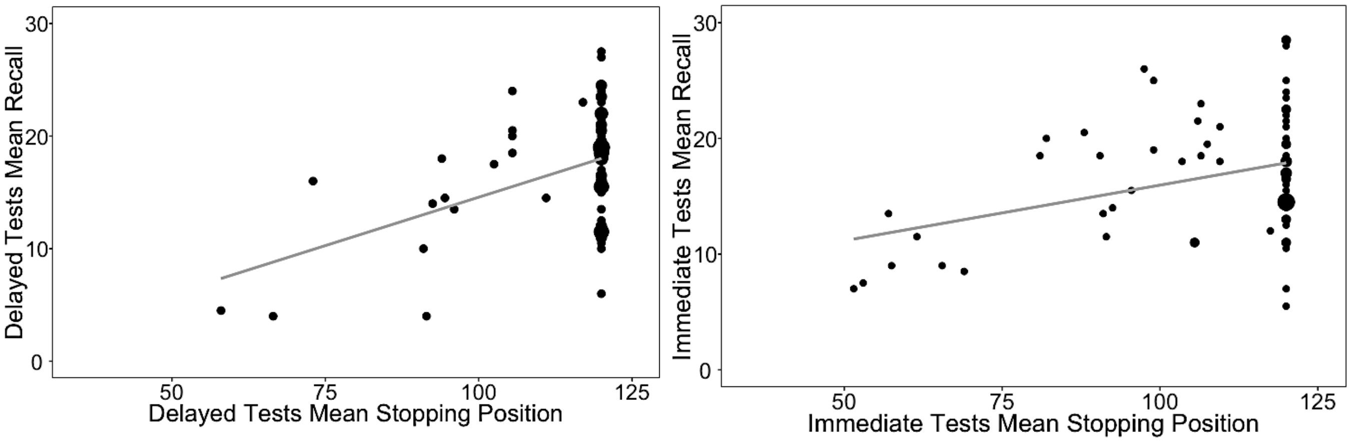

Figure 3-3. Two scatterplots demonstrating the relationship between stopping position and recall in Experiment 6 for the delayed-test list type (left-panel) (y = -2.63 + 0.17 (mean stopping position), adjusted R^2 = 0.177) and the immediate-test list type (right-panel) (y = 6.35 + 0.10 (mean stopping position), adjusted R^2 = 0.110). Each dot is a mean value, the dots are sized relative to the number of averages of that particular value. The grey lines on each graph represents the trends of the relationship between the two variables.

The results of Experiment 6 suggest that stopping repeated word lists is driven by motivation. When the lists are repeated and the tests are delayed, it seems apparent that participants are encouraged to continue viewing the lists, rather than to stop. When the tests are not delayed, it seems that participants are more likely to stop the restudying of the lists and even though a significant effect was not found on recall, a strong correlation was found between stopping and recall.

3.3.3 Discussion

Experiment 6 was conducted to investigate what role motivation has on the stopping of repeated word lists. Like previous experiments outlined in Chapter 2, the goal for participants was to maximise their recall. Both stopping rate and stopping position was significantly different between the list conditions, but recall was not. As well as this, a significant correlation was found between stop position and recall, finding similar results to Murayama et al. (2016) and my undergraduate study. Experiment 6 also replicates Experiment 5, finding that participants stopped which is linked to poorer performance, but adding that delaying tests can discourage the stopping of repeated lists. Specifically, when participants have a choice to stop the words and see a blank screen or to carry on viewing the words, they are more likely to do the latter. However, like Experiment 5, little gain was had for every extra word studied, suggesting that stopping could have been motivated by this, in order to avoid exerting study effort for little return.

Relating back to the accounts put forward in the introduction to Chapter 3, like Experiment 5 participants on average were not stopping within the first list, suggesting that stopping was not governed by a metacognitive illusion that continuing study is harmful for recall. If participants thought that seeing more was harmful, the studying of further repetitions would have been restricted much earlier than in list four, which was shown as the average stopping position for Experiment 6. Another account discussed in the introduction was a motivational account, whereby the participants are weighing the benefit of seeing more of the words, against the time and effort needed to study them. As previous research suggests (e.g. Dunlosky & Salthouse, 1996; Karpicke & Roediger, 2007; Klein, Addis & Kahana, 2005; Nelson, Dunlosky, Graf & Narens, 1994; Tulving, 1964; 1966), the marginal benefit for seeing more repeats slows down as the number of repeats increases. The results from Experiment 6 support this account, as when the test was immediate, participants were more likely to stop compared to when the test was delayed. Thus, participants may have weighed that seeing more was less beneficial. However, less stopping when the test was delayed could have also been caused by the aversive nature of sitting and viewing a blank screen. Thus, even though viewing more repeats of the words may not create a substantial increase in learning, this was valued more by participants than seeing a blank screen. The third and final potential account for stopping discussed in the introduction of Chapter 3 was the repetitions of word lists was creating a sense of fluency for the items. Like Experiment 5, it was found that no participants stopped within the first list presentation, suggesting that knowledge of further repeats had an influence on stopping behaviour, which could be due to the perceived sense of fluency of seeing more repeats. As well as this, it was predicted that if fluency did have a meaningful influence on stopping, then stopping should have been similar across lists, regardless if the test was immediate or delayed. This was not found, as Experiment 6 found that delayed-test lists were on average stopped later than the lists with an immediate test. This combined with the finding of no participants stopping in list one provides mixed evidence towards a fluency account and therefore suggests that an alternative mechanism is at play, like motivation.

As well as this, according to Figure 3-3 there seems to be less stopping around the ends of each list repeat within the delayed-test list types, which is most likely a reflection of fewer participants stopping these list types compared to the immediate-test list types. Like Experiment 5, Figure 3-3 shows stopping occurring around the ends of the list repeats (e.g. 60, 90, 120), again suggesting that participants were valuing stopping over beginning a new repeat of the word list.

This finding is similar to that found from Experiment 3 in Chapter 2, thus suggesting that the role of motivation on stopping is quite compelling and is not likely influenced by the possibility of further study (i.e. when the list is repeated).

3.4 General Discussion

The current chapter aimed to investigate what influences the stopping of repeated word lists. The results from the current chapter provide evidence that stopping can be observed when the lists are repeated, and this can have a negative effect on performance (Experiments 5 and 6). This is consistent with previous findings that use only a single list of words. Within Chapter 3, the aim was to see whether stopping was caused by a metacognitive illusion, fluency of the lists and motivational factors, all of which will be discussed below.

What drives stopping of repeated lists?

As previously discussed, studying motivated by value seems to be a compelling factor when guiding our study behaviour (e.g. Ariel, Dunlosky & Bailey, 2009). From the current results, it seems that this is still an important factor when we have the option to restudy material in a given moment. Experiment 6 found that when restudying is followed by a delayed test, people are less likely to stop compared to if the test is immediate. Therefore, it could be that stopping was governed by the immediate gratification of stopping compared to if they continued studying to gain an uncertain number of items to their recall. If participants generally thought that stopping was an effective study strategy, stopping behaviour would be consistent across list types, which it was not.

Even though motivation is a compelling argument here, an additional explanation for the stopping of repeated lists could be that participants are stopping because of the effect of item repetition on processing fluency (Whittlesea, Jacoby & Girard, 1990). Having the lists repeat could be inflating participants' sense of fluency, and therefore mastery for the items, which then could be making them decide to stop. It should be noted here that the idea of processing fluency influencing stopping behaviour is under the perspective that stopping is caused by a sense of mastery. An alternative perspective for fluency is that having items perceived as fluent could increase their perceived ease of learning, and thus could have encouraged participants to carry on studying. As I found that participants did stop, this suggests that this perspective is less likely and that perceived *mastery* of items could somewhat encourage stopping. It was demonstrated in Experiments 5 and 6 that repetition does increase recall, however in some cases lists were stopped. Furthermore, this sense of mastery could be falsely informing them that they will not benefit from further study (e.g. Mueller, Tauber & Dunlosky, 2013), which has been demonstrated to not be the case.

This combined with the idea of time optimisation could mean that participants are deciding to stop without fully calculating the consequences for their performance. Therefore, participants are choosing to stop even though it is maladaptive, which unlike the previous experiments, is now further informed by repetition. It would be understandable for participants to stop the repeating lists as there is a strong possibility that seeing a list more than once could not be significantly enhancing performance, and therefore creating an asymptote to their learning (e.g. Dunlosky & Salthouse, 1996; Karpicke & Roediger, 2007; Klein, Addis & Kahana, 2005; Nelson, Dunlosky, Graf & Narens, 1994; Tulving, 1964; 1966, for research on the function of learning across multiple trials) but this is not the case. As demonstrated across Experiments 5 and 6, studying for longer and seeing more of the items is positively correlated with recall, even though this increase is relatively small. Therefore, even when the lists are repeated, participants are still motivated to stop, without the consideration of their performance. This gives further evidence to the idea that stopping is more likely to be a function of time optimisation (i.e. motivation) rather than performance and even if it is informed somewhat by a judgment of performance, this judgement is most probably inflated and not accurate.

3.4.1 Conclusion

The experiments in Chapter 3 examined the stopping decisions made when participants are presented with novel word lists that are repeated. The current results suggest that stopping is a function of optimising motivation (Experiment 6) when seeing more has a positive relationship with recall. Thus, across experiments participants are making a decision that is maladaptive to their recall but seemingly are deciding to stop in order to reduce their time and effort in studying, particularly when there is an opportunity to restudy the items. In relation to real-life studying, it could be that when a student is studying something for the first time, the repeated restudy is creating a sense of mastery, motivating them to quit studying to save time. This in turn could be having a negative impact on their performance. Further experiments will be outlined in the next chapter using text stimuli to make these findings more applicable to real-life study situations.

4 Chapter 4 – Restudying novel texts

4.1 Introduction

The focus of Chapters 2 and 3 was to explore stopping using a word-list task, whereby participants study a word list with the aim of maximising their recall afterwards. It was found that participants stop more often than not, and this negatively impacts recall. In addition to this, Chapter 3 also found this to be the case when participants study a word list more than once and thus have the opportunity to restudy the items. Chapters 2 and 3 replicate and extend the previous findings from Murayama et al. (2016), suggesting that the stopping of word lists is likely due to motivational influences, which is the case whether lists are seen once or if they are repeated.

The aim of Chapter 4 is to take elements of previous experiments and combine with materials that are more applicable to an educational context, such as text paragraphs. Although much research exists into the allocation of restudy time of texts, including paragraphs and sentences, (e.g. Mazzoni & Cornoldi, 1993; Rawson, Dunlosky & Thiede, 2000, Son & Metcalfe, 2000; Thiede, Anderson & Therriault, 2003), these studies do not incorporate stopping. Addressing this gap in understanding is important, because students are often faced with new information-rich texts that require the person to engage in monitoring of learning and thus to judge when to stop studying. As suggested in Murayama et al. (2016) participants may stop studying because of an information overload belief, whereby they believe that studying more information could harm their recall for items they studied. However, Chapter 2 provided evidence that posed doubt on this and suggested that stopping is more likely due to motivational factors, which was further supported by Chapter 3.

The experiments in Chapter 4 will allow participants to self-pace their study and thus have more control over their study, which has been found to help performance (Tullis & Benjamin, 2011), even when the amount of time is equated to those who cannot self-pace. It is possible that, compared to word lists, denser texts and their more cognitively demanding nature could still induce a feeling of overload. If this is the case, participants should stop which therefore could lead to poorer performance. In relation to this, my undergraduate project and Experiment 5 in Chapter 3 found that stopping is somewhat related to memory ability, with stopping position correlating with control list recall. Thus, stopping of text materials could be related to the memory ability of the participants. If this is the case, it would be expected that study time within the study phase would correlate with performance for texts that participants could not stop. Alternatively, as highlighted by previous Chapters, stopping of texts could also be governed by motivational components. Previous research has suggested that motivation plays a role in self-regulated study (e.g. Ariel, Dunlosky & Bailey, 2009; Dunlosky & Ariel, 2011 & Lipowski, Ariel, Tauber & Dunlosky, 2017). As well as this, from a broader perspective, stopping of texts may be a form of delay discounting (e.g. Tesch & Sanfey, 2008), whereby participants stop due to its immediate gratification and value this higher than any further gain in performance. Therefore, if participants are stopping purely for the immediate gratification of it, it would be expected that participants would stop at a similar rate as previous experiments, regardless of the effect this may have on performance.

Alternatively, it may be that the texts and their integrative nature may entail a different learning experience for the participants, compared to the learning of word lists. In contrast to word lists, texts are more structured with sentences linking to the same idea and allow the participants to make sense of the overall topic being studied. Furthermore, the words used in previous experiments are unrelated to each other so that seeing one does not necessarily aid the participant in knowing the other words in the list. Therefore, even though the texts may take more effort to understand and thus could motivate participants to stop, their more structured and coherent nature may encourage participants to study all of the materials and therefore be less likely to stop. These conflicting sides of the argument regarding participant stopping behaviour for texts will be explored in Chapter 4.

Chapter 4 describes three experiments exploring stopping of text materials, as well as looking at potential factors that could influence stopping behaviour. Broadly the experiments involve the studying of four texts within a study phase, with the length of study chosen by participants. The study phases will be 15 minutes long, unless stopping is allowed and participants stop. The texts chosen for the current experiments were taken from the ‘Physiology of Behavior’ textbook (Carlson, 1942). These texts relate to various human biological processes, including the eye, hearing, smell, the skin, digestion, muscles, balance, and taste. The aim of using these was so that they were generally unfamiliar to participants. Level of familiarity with the topics was not measured, however the texts were designed so that they were not expected to be known by participants. It was aimed that having such texts would allow me to investigate the stopping of new information. The difficulty of the texts was controlled for, so that overall the readability scale for each text was relatively consistent between them. The average Flesch Kincaid Reading Ease rating for all 8 texts (with four texts per study phase) was 43.09, ranging from 36.6 to 49.8. The texts were classified as being understandable by those who were at least 18-20 years old. The average length of the 8 texts was 369 words. Unlike previous experiments, the current experiments will not use a recall test and instead will use multiple-choice questions to tap into fact recall from the texts. Texts and test questions used through the experiments in Chapter 4 are given in Appendices K and L.

Experiment 7 aimed to see if stopping can be replicated when text materials are used. It also aimed to see whether stopping is related to poorer performance for the stopping texts, like previous experiments have found. Experiment 8 looked at whether memory ability can be an influencing factor for stopping of text stimuli. In particular, I will see whether stopping of stop texts will correlate with memory performance for texts that cannot be stopped. This is plausible, due to the density of the texts and the amount of information participants need to remember. Lastly, Experiment 9 will look at the role of motivation, due to its influence in previous experiments. This will employ a similar paradigm to Experiments 3 and 6, whereby stopping will incur a delay before the test.

4.2 Experiment 7

The objectives for Experiment 7 were to see whether the basic stopping effect found within the experiments outlined in Chapters 2 and 3 can also be found in experiments using text stimuli. The rationale for this was to move towards generalising this effect to real-world study conditions, where people often have to regulate their studying of information-dense materials. Conceptually, Experiment 7 is similar to Murayama et al.'s (2016) experiments, in that stimuli will be split so that participants can or cannot stop them. In particular, Experiment 7 used a between-subjects design to see if stopping was a common decision made by participants, to investigate its rate of occurrence, and its impact on performance compared to those who did not have the option to stop. Participants had a 15-minute study phase to study four different texts, which they could divide their time between however they liked. The decision to give participants 15 minutes of study time was based on the pretesting of the experiment, and how long it took people to read the texts. On average, all four texts took approximately 5 to 6 minutes to read once, which meant that having 15 minutes would allow participants to restudy if they wished. They were split into two groups: those that are able to stop the materials (Stop condition) and those who cannot (Control condition). Participants were asked to maximise their performance for the test, without knowing the nature of the test or how many questions they would be given. It was predicted, from results in previous experiments, that those in the Stop condition will stop which will have a negative impact on their learning and thus lower their performance, compared to those in the Control condition.

4.2.1 Method

Participants. Eighty-two undergraduate psychology students (55 female, 27 male) from the University of Plymouth were recruited. Participants were undergraduate volunteers participating for course credit. Eighty-seven participants were initially recruited; however, five participants' data were excluded. One participant had experienced an error with the program, one participant had mistakenly pressed stop earlier than intended, and three participants had expressed that they had incorrectly interpreted the use of the self-navigation through the texts and thus accidently did not view all of the texts. Forty-three participants were randomly allocated to the Control condition and 39 were randomly allocated to the Stop condition. This sample size was chosen to be comparable to Murayama et al.'s (2016) between-subjects sample size.

Materials. An information sheet and consent form were given to the participants prior to their participation and they were also given a debrief sheet at the end of the experiment. The task was performed on a computer with a 21.5"/54.6cm Philips Brilliance LED monitor with a resolution of 1920x1080 using PsychoPy version 1.90.1. For all instructions and texts presented on screen, the background was grey and all words were in white bold text. Text instructing participants about the task as well as whether they could stop studying the texts or not, depending on what condition they were in, were shown on the screen. All instructions given on screen is shown in Appendix H. For each text paragraph presented, the text was font Arial (approx.1.4cm height on screen). In total, four paragraphs on human biological processes: the eyes, hearing, the skin, and taste, were the study stimuli taken from the 'Physiology of Behaviour' textbook (Carlson, 1942). The test materials were multiple choice questions based on the study materials, which were given on paper once the study phase was complete. Participants had 26 questions to answer, each with four possible answers with only one being correct. These 26 questions were split so that 6 were related to the eyes, 6 were regarding hearing, 8 were regarding taste and 6 were about the skin. Participants were informed to circle which answer they thought was correct for each question. The questions were designed to test the memory of details contained within the texts, which did not include participants having to make inferences but rather to remember facts from the texts.

Procedure. During the study phase, participants were instructed that they were going to study four texts, one at a time, regarding human biology. They were also informed that they would have to navigate themselves through the four paragraphs by using the arrow keys on the keyboard, left to go back to the previous text and right to move onto the next. Those in the Control condition were told they had 15 minutes in the study phase, whereas those in the Stop condition were told they had 15 minutes to study the texts but were allowed to stop studying the texts to move onto the test phase early. The test phase consisted of participants completing as much of a multiple-choice test as they could in 5 minutes, with time limit imposed to motivate participants to complete as many as they could. At the end of the test phase participants were debriefed. Overall, the study and test phases took approximately 15-20 minutes combined.

4.2.2 Results

The main aim of Experiment 7 was to see whether the stopping effect as found by prior experiments could be replicated using text stimuli. This was found to be the case, as the majority (71.8%) of participants stopped in the Stop condition. To investigate how participants were studying the texts, I looked at the number of times each participant switched between texts. The aim of this was to see whether participants were choosing to study each once, or whether they were going between texts and restudying them. On average, those in the Experimental condition switched 9.21 times (SD = 5.95), compared to those in the Control condition, who switched 11.35 times (SD = 6.32). This difference in switching was not significant ($t(80) = 1.577$, $p = .119$, two-tailed, $BF_{10} = .675$). Thus, participants were choosing to restudy the texts, rather than only selecting to study them once, and then stopping.

Between-Groups Analysis

The differences in average time allocation and performance is shown in Table 18. Performance here is measured as a percentage of the total number of questions in the test that were correct. It was decided not to calculate this as a number of questions attempted, due to this having the potential to bias the results. For example, if a participant only attempted one question in 5 minutes and got it correct, this would then equate to them getting 100% correct, which is not truly reflective of their effort at test. Rather, the percentage was out of the total number of questions, as this is more indicative of their knowledge at test. In theory, if a participant has a good knowledge of the materials, they should be able to answer the questions quicker and therefore get through most, if not all of the questions.

An Independent Samples t-test found that the test performance did not significantly differ between the groups ($t(80) = 1.224$, $p = .224$, $BF_{10} = 0.441$). Performance of those who did and did not stop within the Stop Condition was compared, which found a non-significant difference ($t(37) = 1.312$, $p = .197$, $BF_{10} = 0.648$).

Those in the Stop condition also had a positive relationship between study time and performance. Figure 4-1 shows this relationship ($r = .322$, $N = 39$, $p = .045$, two-tailed).

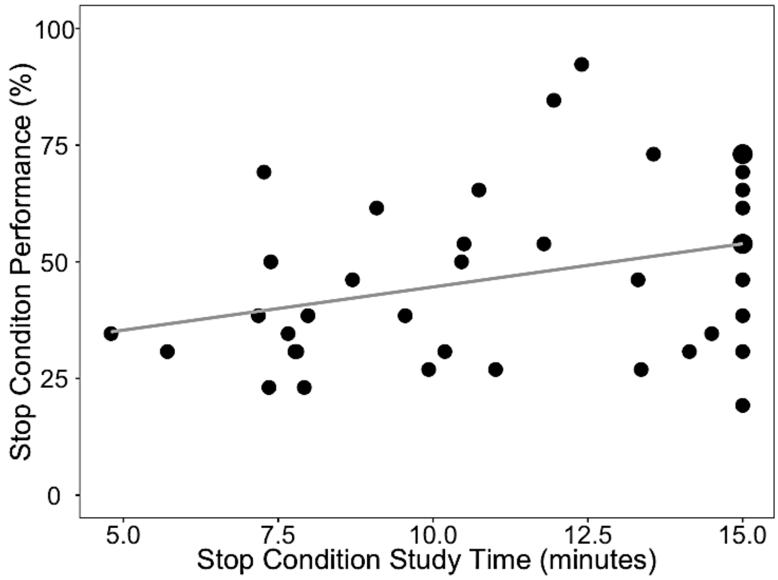

Figure 4-1. Scatterplot of the relationship between study time and performance for those in the Stop condition in Experiment 7 (y = 26.10 + 1.85 (study time), adjusted R^2 = 0.080). Each dot is a mean value, the dots are sized relative to the number of averages of that particular value. The grey line represents the trend of the relationship between the two variables.

The correlation reported within Experiment 7 found a replication of the general effect found in prior experiments, with more study time being positively related to performance. The experiment successfully replicated previous results using text stimuli, which were denser in information and thus aimed at replicating real-world study materials. As the experiment successfully found a stopping effect using these materials, whereby participants stopped more often than not, it led onto Experiment 8, exploring whether memory ability at an individual level could impact stopping decisions.

4.2.3 Discussion

Experiment 7 found that texts were stopped more often than not, with time spent studying also positively correlating with performance, which is conceptually consistent with previous experiments in Chapters 2 and 3. The regression equation from Figure 4-1 suggests that performance without any study was at approximately 26.10%, with one minute of study gaining an extra 1.85% in performance. Thus, participants could have been stopping adaptively due to the small gain in performance from extra study. As well as this, unlike previous experiments, there was no difference in test performance for those in the stopping condition compared to the control condition, which suggests that stopping is not as maladaptive, at least not for text materials. The factor of memory ability for texts could help to explain the lack of a difference in performance in Experiment 7, suggesting that no matter how long participants continue studying for, this would not help their memory for the texts. This potential factor is explored in Experiment 8 to investigate further why stopping is apparent when studying text material.

4.3 Experiment 8

From Experiment 7, we can see that participants stopped in response to texts that are more structured in nature in comparison to word lists. Study time had a positive relationship with performance, however, Experiment 7 did not find a difference at test between the groups, suggesting that stopping may have been adaptive. Experiment 8 therefore aims to explore this in further detail, to see whether stopping could be advantageous on an individual level, by using a within-subjects design. In particular, having participants study texts that can be stopped as well as texts than cannot be stopped will allow me to see whether there is a relationship between stopping time and performance on texts that cannot be stopped. If a relationship is found, it could be suggested that participants stop at a point they judge optimal for their memory, thus stopping will be optimising time and effort into studying. All participants had two study phases each containing four texts. One study phase could be stopped (Stop texts) and the other could not (Control texts). Doing this will aid in investigating whether study time for Stop texts is related to the participant's memory ability, represented by the memory performance for Control texts.

Within Experiment 8, participants studied four texts within a study phase and then had a multiple-choice test afterwards. In total, participants had two study phases and thus two test phases. It is expected, like prior experiments, that Stop texts will be stopped more often than not and this will have a negative relationship with performance.

4.3.1 Method

Participants. Seventy undergraduate psychology students (57 female, 13 male) from the University of Plymouth were recruited. Participants were undergraduate volunteers participating for course credit. Seventy-three participants were initially recruited, however three were removed from the data analysis due to one expressing they had stopped by accident, one because of a computer error and one because of a substantial over-run within their test phases.

Materials. The experiment task was performed on the same model of computer as Experiment 7 and using PsychoPy (version 1.9.1). For all instructions and words presented on screen, the background was white, and all words were in black bold text. All instructions given on screen is shown in Appendix I. Participants were given a total of eight text paragraphs to study, with four in each study phase. Four of these texts were identical to those used in Experiment 7, with the addition of four more from the 'Physiology of Behavior' textbook, which were on balance, the muscles, digestion and smell. The eight texts were split randomly into the two study phases, with each study phase being counterbalanced as to which would be presented first.

All instructions were presented on screen and study phases that could be stopped also included instructions stating that participants could stop at any point they wished. All other paper materials were consistent with Experiment 7, other than the questions being asked on screen rather than on paper. The number of questions after each study phase was either 27 or 28, depending on what topics were studied. A question was removed from Experiment 7's set of questions, due to it conflicting with one of the additional texts. To elaborate, the question asked participants to identify what a particular structure was within the 'taste' text, however this could be confused with a different structure described in the 'digestion' text. This was simply removed to avoid confusion. The questions were split so that the eyes, ears, skin, balance, digestion, muscles and smell were asked about 7 times each, with taste being asked about 6 times. To answer a question, participants needed to press the corresponding number key to their answer. For example, if they thought the answer was number '2' on screen, they needed to press number '2' on the keyboard. Once an answer was inputted, the next question was presented roughly 1.5 seconds later.

Procedure. Participants were presented with instructions onscreen regarding what study phase they were beginning with. Participants had two 15-minute study phases with a multiple-choice test after each, with questions regarding the four texts they had just studied. Participants did not have a time limit in the test phase due to only 22 out of 82 participants completing all questions in the previous experiment. Thus, to reduce this confound in analysis and to ensure all participants saw all questions, Experiments 8 and 9 did not have a limit at test. At the end of the experiment participants were given a debrief. Overall, the experiment took roughly 45 minutes.

4.3.2 Results

Experiment 8 aimed to investigate whether stopping occurs using a within-subjects design and to see whether it has a negative impact on performance. Overall, participants stopped the stop texts 70% of the time. Like Experiment 7, I investigated how participants were studying the texts and whether they were deciding to study the texts once or if they were likely to switch between them and therefore restudy the materials. On average, the stop texts were switched 9.73 times (SD = 5.71), whereas the control texts were switched 14.00 times (SD = 6.71). This difference was significant $t(69) = -4.024$, $p < .001$, two-tailed, $BF_{10} = 147.983$, however this is likely due to the control texts on average being seen for longer and thus giving more opportunity to be switched.

Performance was significantly different between the Stop and Control texts (*t*(69) = -2.230, *p* = .029, two-tailed, BF_{10} = 1.330), although the Bayes Factor indicates that the effect size was indeterminate. An independent samples t-test found that the difference in performance between those who chose to stop the stopping texts and those who did not was not significantly different (*t*(68) = 1.014, *p* = .314, two-tailed, BF_{10} = .407). See Table 19 for these values. In addition to this, descriptive statistics are presented in Table 20 for study time and performance split into the counterbalance sequences.

A correlation was conducted to see if study time in the stop texts was positively correlated with performance (*r* = .282, *N* = 70, *p* = .018). See Figure 4-2 for this.

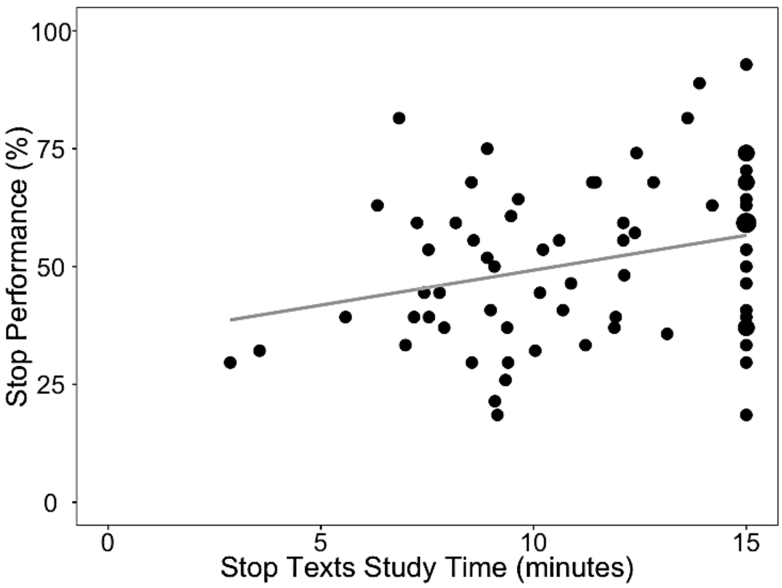

Figure 4-2. Scatterplot of the relationship between study time and performance for the stop texts in Experiment 8 (y = 34.42 + 1.48 (study time), adjusted R^2 *= 0.066). Each dot is a mean value, the dots are sized relative to the number of averages of that particular value. The grey line represents the trend of the relationship between the two variables.*

The equivalent correlation between stopping and control MCQ accuracy can be seen in Figure 4-3. This correlation was significant *r* = .254, *N* = 70, *p* = .034. Thus, there seems to be some evidence that stopping was decided based on memory ability and thus could be due to a perceived decrease in value for continued study.

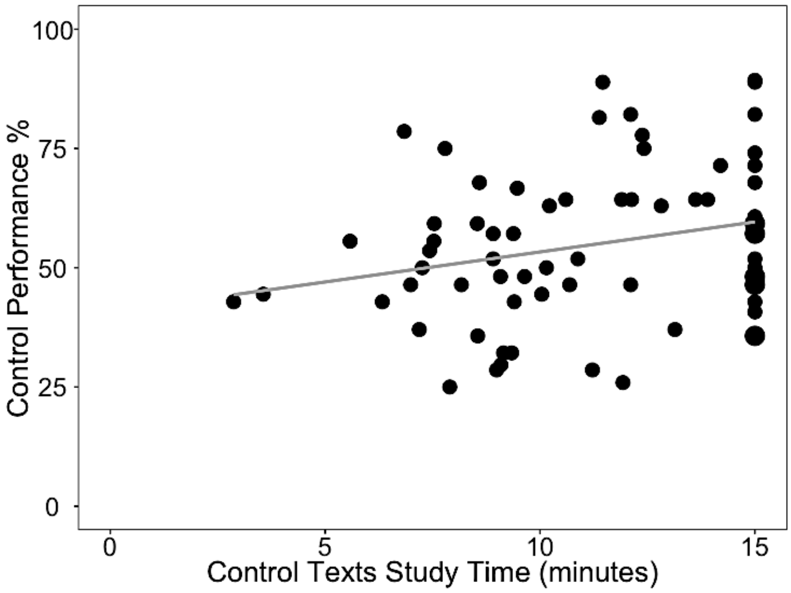

Figure 4-3. Scatterplot of the relationship between study time for the stop texts and performance for the control texts in Experiment 8 (y = 40.72 + 1.26 (stop texts study time), adjusted R^2 = 0.051). Each dot is a mean value, the dots are sized relative to the number of averages of that particular value. The grey line represents the trend of the relationship between the two variables.

4.3.3 Discussion

Experiment 8 used a within-subjects design with the main aim of exploring whether stopping of texts can be an adaptive memory strategy. As expected, participants stopped more often than not (70%) and participant performance for Stop and Control texts was significantly different. As well as this, study time of the texts was positively correlated with performance, thus suggesting that the more time spent studying the texts, the better memory performance for the texts. However, like Experiment 7, the regression equation from Figure 4-2 suggests little gain in extra study (1.48% per minute), suggesting that stopping may have also been adaptive in Experiment 8. Furthermore, those who stopped saved on average 3.79 minutes, which equated to a decrease of 3.82% in performance. Thus, participants could be stopping to optimise their time and effort rather than their performance. As suggested in Experiments 2 and 3 in Chapter 2 and Experiment 6 in Chapter 3, motivation seems to have a compelling role in stopping, at least for word lists. The results from these previous experiments were consistent with the idea that participants were optimising the immediate gratification of stopping, over any potential small gain that continuing studying may have on their performance. Thus, Experiment 9 aimed at exploring motivations and the role this has in relation to studying text materials.

4.4 Experiment 9

The results from Experiments 7 and 8 provided evidence that stopping of texts is consistent with the stopping of the restudy of word lists, where participants stop studying texts more often than not which is related to poorer performance. However, as suggested by the regression equations in Experiment 7 and 8, gain in extra study may have been small and thus encouraged participants to stop. Experiment 9 will look at whether including a delay between stopping and test influences stopping, similarly, to Experiments 3 and 6. A within-subjects design was used for Experiment 9, meaning that all participants experienced the two study phases; a delayed-test study phase and an immediate-test study phase. It was expected that when stopping does not incur a delay, stopping rate will be higher with an earlier stopping time compared to when stopping does incur a delay. Thus, having a delay is expected to motivate participants to study for longer and therefore perform better at test.

4.4.1 Method

Participants. Forty undergraduate psychology students (28 female, 12 male) from the University of Plymouth were recruited. Participants were undergraduate volunteers participating for course credit. Forty-two participants were initially recruited, however a participant's data were excluded due to mistakenly pressing stop earlier than desired and another participant’s data was excluded due to a misunderstanding of instructions. Like Experiment 8, a within-subjects design was used so that all participants experienced the same conditions.

Materials. The experiment task was performed on the same model of computer as Experiment 7 using PsychoPy (version 1.9.1). For all instructions and words presented on screen, the background was white, and all words were in black bold text. All instructions given on screen is shown in Appendix J. Participants were given a total of eight text paragraphs to study, identical to Experiment 8, with four in each study phase. The eight texts were split randomly into the two study phases, with each study phase being counterbalanced as to which would incur the delay and which would not. Participants were informed which study phase would incur a delay if they pressed stop and if they did press stop, the screen would go blank. All other materials were consistent with Experiment 8.

Procedure. Participants were presented with instructions onscreen regarding what study phase they were beginning with. The instructions were presented so that they were shown immediately before each task, rather than informing the participants of both conditions before the study was started. If the participants had a study phase where stopping the texts would lead to a delay before the test, they were informed that if they pressed stop when studying the texts, the screen would go blank and they would have a delay as long as the rest of the 15-minute study phase, before they were allowed to move onto the test phase. If the tests were immediate, they were told that if they stopped at any point in the texts, the screen would go straight to the test phase. All other elements of the procedure were the same as Experiment 8.

4.4.2 Results

Experiment 9 aimed to explore whether having a delay between stopping and test motivates people to view more of the study material, compared to if they could stop and go straight to the test. Overall delayed-test texts were stopped 37.5% of the time and immediate-test texts stopped 60% of the time. This difference in frequency of stopping was statistically significant, $Z = 14.00$, $p = .014$, $BF_{10} = 3.860$. Data concerning number of switches between texts was not collected for Experiment 9. Table 21 gives descriptive statistics for study time and performance in Experiment 9. In addition to this, descriptive statistics are presented in Table 22 for study time and performance split into the counterbalance sequences.

Total study time was longer for delayed-test texts ($t(39) = 3.542$, $p = .001$, two-tailed, $BF_{10} = 29.323$). Performance for the immediate and delayed-test texts was equivalent ($t(39) = -0.333$, $p = .741$, two-tailed, $BF_{10} = 0.180$).

Like previous experiments, I investigated whether the time spent on the texts was related to participant performance on the test afterwards (see Figure 4-4). This was the case for both delayed-test texts ($r = .332$, $N = 40$, $p = .036$) and immediate-test texts ($r = .554$, $N = 40$, $p <.001$). The left and right panel in Figure 4-4 shows this, providing evidence that the restriction of study time relates to poorer performance later on.

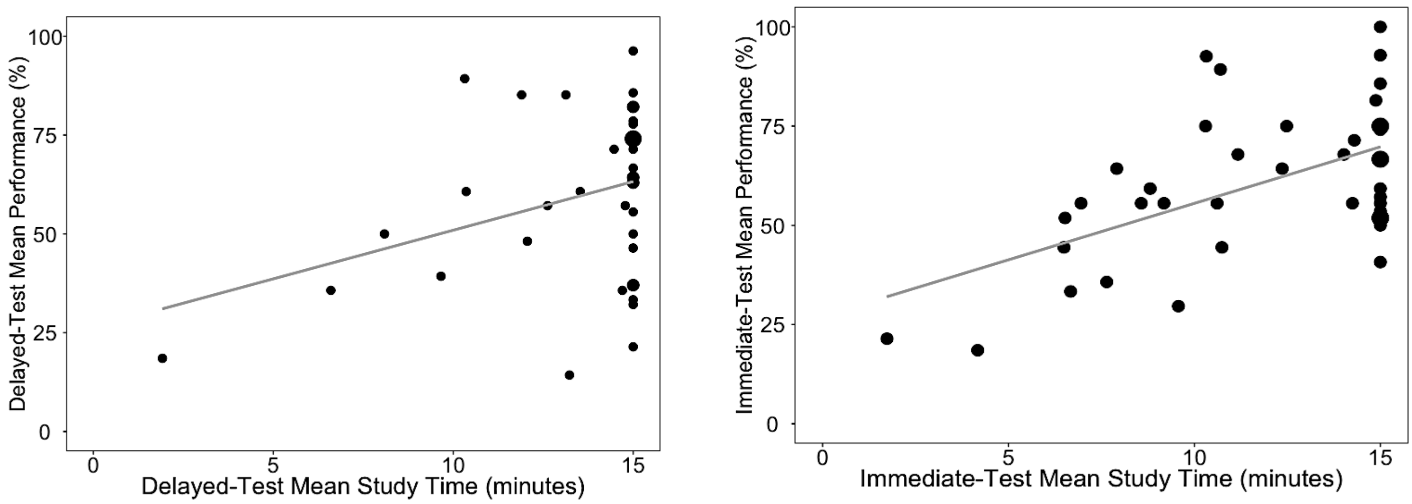

Figure 4-4. Two scatterplots demonstrating the relationship between study time and performance in Experiment 9 for the delayed-test text type (left-panel) (y = 26.32 + 2.46 (mean delay study time), adjusted R^2 = 0.087) and the immediate-test text type (right-panel) (y = 27.08 + 2.85 (mean immediate study time), adjusted R^2 = 0.289). Each dot is a mean value, the dots are sized relative to the number of averages of that particular value. The grey lines on each graph represents the trends of the relationship between the two variables.

Overall, Experiment 9 found that delaying the test once people stop studying text paragraphs does have a significant effect on both stopping rate and study time. In particular, if a text incurs a delay after it is stopped, participants were less likely to stop as well as spend more time studying the texts.

4.4.3 Discussion

The aim of Experiment 9 was to see if stopping could be influenced by factors that may influence participant motivation to continue studying. Participants studied eight different texts across two study phases and could stop in both. However, in one study phase stopping would incur a delay and in the other stopping would lead straight to the test phase. It was expected, like previous experiments that used a similar manipulation that incurring a delay would reduce participants' motivation to stop and therefore would lead to longer study times. Experiments 3 and 6 found this in relation to word lists, with Experiment 6 also finding this to be the case even if the word lists were repeated. Experiment 9 found this also when the study stimuli texts. As well as this, a positive correlation was found between study time and performance. However, and quite interestingly, there was little difference found in benefit from extra study depending on if the test was delayed or immediate (2.46% vs. 2.85%). Thus, like Experiments 7 and 8, extra study time reaped little benefit on performance which may have encouraged participants to stop. Therefore, even though increase in study time was related to higher performance, this increase in performance may have been seen as not worth the extra study, leading to stopping.

4.5 General Discussion

The main aims for the experiments in Chapter Four were firstly to see whether stopping could be found in response to text materials rather than word lists with the aim of applying this to real-life study contexts. Thus, the experiments included the studying of biology-related texts which participants could restudy as many times as they wanted within 15 minutes. These experiments are unlike those that have previously looked at the restudy of texts because participants could also stop at any point.

The results from Experiment 7 were similar to that of previous results, that participants do stop studying prematurely and this has a negative impact on performance. Experiment 8 used a within-subjects design to see whether stopping could be related to the memory ability of the participants. The correlation analysis found a significant relationship between the variables, however an overall correlation between study time and performance (Figure 4-2) suggested that stopping is related to poorer performance. Experiment 9 explored stopping from a motivation point of view, to see if the stopping of texts is influenced by this similarly to word lists (Experiments 3 and 6). The results indicated that stopping texts is consistent with a motivational account because removing the time-saving associated with stopping reduced its usage.

What drives stopping of text materials?

Murayama et al. (2016) argued that stopping was due to a belief in information overload: the belief that seeing more information would harm recall. As pointed out in the introduction to this chapter, it could be that the demanding nature of the texts could stimulate a feeling of overload simply because there is more information to remember. However, also mentioned in the chapter's introduction is that the nature of the texts compared to word lists may actually be less informationally demanding in the sense that they are structured more coherently, with the sentences within the same text linking together. Therefore, it is less likely that participants are stopping because they feel overloaded. If cognitive demand was affecting stopping, I would have expected to see a lower stopping rate to reflect the participants finding the texts easier to process and study. Due to stopping rate being consistently high across Experiments 7, 8 and in one condition in Experiment 9, it is likely that participants are stopping for a different reason.

Alternatively, participants could be optimising something else other than their performance, such as their motivational states. As explained previously, motivation in self-regulated learning has a compelling role, particularly in deciding how much time to allocate to study materials (e.g. Ariel, Dunlosky & Bailey, 2009). Within Experiment 9, motivation was manipulated through the cost of stopping in some texts. In one study phase, if a participant stopped, they would move immediately to the test phase. However, in the other study phase stopping would lead to a time delay before the test phase. As expected, this did have an influence on stopping and seemed to discourage participants from stopping. If participants really did believe that seeing more would harm their performance, I would have expected them to have stopped at a similar rate, regardless of the delay after stopping. The fact that having an immediate test led to more stopping suggests that stopping was due to the desire to save time and effort studying, suggesting they were discounting the value of further study and instead were valuing effort reduction.

This research addresses a gap in previous research into study time of texts, by including an element of stopping which has not been explored fully before. Instead, previous research suggests that study time of texts follows a Discrepancy Reduction model (e.g. Son & Metcalfe, 2000). Exploring stopping of text materials seemed important due to its applications to real-life studying contexts. For example, students often are provided with study information that requires them to study it enough to get some sort of memory gain, whether this is for an exam or a different test. The main point here is that students have to study in a way that maximises their learning of texts, especially at higher levels. This includes them deciding when they have studied something for long enough to stop. It could be that they are studying until they cannot remember anymore, but this is unlikely. Instead, what seems more compelling is that external factors that influence their internal motivation over-ride any further study, regardless of the effect this could have on their learning. Students may start reading/studying texts with the aim of learning as much as they can in a short time. However, as study time increases, the aversive nature of reading texts could increase and thus increase stopping. As well as this, it may be that any extra gain in study does not seem worthwhile. This is supported by the experiments within the current chapter, due to finding that gain in studying was relatively small per extra minute spent on the materials. To elaborate, Experiment 7 found that an extra minute in studying would gain 1.85% in performance, Experiment 8 found that one minute would gain 1.48% and Experiment 9 found that if the test was delayed, one minute led to a 2.46% increase, and when tests were immediate an extra minute in study led to an increase in 2.85%. Therefore, stopping can be seen as the optimal decision at that time, due to it leading to a reduction in effort and saving time that may be seen as more valuable allocated to an alternative task. This links to the idea that participants are stopping to avoid a 'labor in vain' effect, as found by Nelson and Leonesio (1988), that the restudy of materials only leads to a small increase in performance, which is not proportionate to the extra time spent. Thus, it could be that participants may have been stopping adaptively, rather than maladaptively.

As touched upon previously, the texts used within the current chapter were designed to be relative to texts students may study from a textbook, which are generally structured and coherent in nature. Thus, a future experiment could explore whether manipulating the coherence of the texts influences stopping behaviour. Those that did not stop the texts could have decided not to stop because of the text's coherent nature. For example, the texts were easy to follow, thus reducing flow of the texts could increase stopping. Doing this would help to further understand the nature of stopping of texts, and whether creating texts with less coherence would increase cognitive demand and therefore increase stopping.

4.5.1 Conclusion

The current body of experiments examined the stopping decisions made when participants are tasked with comprehending longer sections of texts. The current results suggest that stopping is a function of optimising motivation, especially that the immediate gratification of stopping is valued higher than continuing studying that leads to a small gain in performance. Thus, even though it could be seen that stopping was maladaptive due to the loss of performance gain, the gain of which was so small that it could actually be seen as adaptive. In relation to real-life studying, students often have to study more information-dense materials, for example textbooks, and may decide that stopping is more optimal than continuing studying. Put bluntly, reading texts can be perceived as tedious and boring; terminating study would be an immediate stop to this and could be valued more greatly by the student.

5 Chapter 5- General Discussion

5.1 Introduction

The experiments in this thesis aimed to explore stopping behaviour in depth, looking at why people terminate study when seeing the information for the first time, as well as terminating the restudy of novel information. The reason for this was due to stopping being found to be detrimental for performance in previous research (e.g. Murayama et al., 2016) with little explanation as to why people stop.

Chapter 1 described previous research into the allocation of study time, such as the Discrepancy Reduction model (Dunlosky & Hertzog, 1997) and the Proximal Learning theory (Metcalfe & Kornell, 2005), which focus on the allocation of study time between items and where participants can usually self-pace the items. More recent research into study time allocation outlined in Chapter 1 focuses on the allocation of study time in ongoing studying, where items are unknown and therefore novel to participants (e.g. Murayama et al., 2016). Within this research, participants are given a list of words to learn, one word at a time, with the aim of recalling as many words as possible. In one group, however, they could stop the words at any point, and move straight to the test phase early. Murayama et al. (2016) found that those in the stopping group had poorer recall than those in the control group. As well as this, the number of words seen was positively correlated with recall. However, this research did not fully address why people stop even though it is detrimental to recall. Therefore, the current research aimed at looking at why people decide to stop when it is maladaptive and to see whether this extends to other study materials.

Chapter 1 also outlines several possible explanations for why people decide to stop prematurely. These include the role of beliefs, memory and forgetting processes, and motivational factors that may impact what study strategies are used by students. Previous research has found that such factors can impact regulated learning. For example, people often employ metamemory monitoring (Nelson & Narens, 1990) in order to monitor their memory gain and loss. As well as this, forgetting has been found to influence our judgments of learning (Ariel, 2010; Ariel & Dunlosky, 2011; Koriat, Bjork, Sheffer & Bar, 2004). Time allocation has also been found to be influenced by motivational factors such as value (e.g. Ariel & Dunlosky, 2011; Ariel & Dunlosky, 2013; Ariel, Dunlosky & Bailey, 2009; Lipowski, Ariel, Tauber & Dunlosky, 2017; Soderstrom & McCabe, 2011). Research into the motivational account of delayed discounting (e.g. Tesch & Sanfey, 2008) suggests that the immediate gratification of stopping may be valued more than continuing study, considering its uncertain benefit on performance. Lastly, many studies have found that beliefs have influenced the implementation of poorer study strategies (e.g. spaced vs. massed practice, Kornell & Bjork, 2008; retrieval practice, Roediger & Karpicke, 2006; the effect of delays, Koriat, Bjork, Sheffer & Bar, 2004; and processing fluency, Rhodes & Castel, 2008). The main aim of the current experiments was to explore whether these factors can influence stopping decisions when learning novel information.

5.1.1 Summary of results

Chapter 2 explored the conditions under which participants stop the presentation of new words. Experiment 1 looked at the role of perceived forgetting on stopping, particularly whether having previously-shown words kept on the screen reduces forgetting and therefore reduces stopping. This experiment did not find a difference in stopping between those who had previous words shown (18.5%) or previous words hidden (24.1%), suggesting that this not likely to influence stopping. Experiments 2 and 3 found results consistent with a motivational account; creating a punishment for poorer recall (stopping rate: Aversive 50.5%, Non-Aversive 70.1%) and having a delay between stopping and test (stopping rate: Delayed test 27.4%, Immediate test 48.8%) created numerical differences in stopping, with stopping rate significantly different between conditions in Experiment 3. Particularly, stopping was reduced under these conditions, and number of words seen was related to recall. In Experiment 4, beliefs of participants were tested using a hypothetical experiment, which found that beliefs were consistent with those found by Murayama et al. (2016); participants expressed that seeing more would be harmful for recall, with 63 out of 106 participants predicting they would stop. However, when asked to predict their recall for varying list lengths, their predicted recall did not reflect this belief, suggesting a disconnection between what they think is effective and their predictions.

In Chapter 3, a similar paradigm to Chapter 2 was used, however the word lists were repeated four times. Often, students have to restudy materials rather than just once, thus repetition was incorporated to introduce an element of restudying to make the experiments more applicable to real-life study behaviour. Experiment 5 found that participants still decided to stop (40.8%), even when the lists were repeated, and this was detrimental to recall. As well as this, a small link was found between stopping position and memory ability, as shown by recall for lists that could not be stopped. Experiment 6 found similar findings to those in Experiment 3, whereby having a delay before the test phase discouraged stopping of repeated word lists (stopping rate: Delayed test 17.8%, Immediate test 31.4%). As well as this, both Experiments 5 and 6 found a correlation between number of words seen, and therefore number of repeats, and number of words recalled.

Chapter 4 used a stopping paradigm in relation to studying text paragraphs, rather than word lists. Similar to Chapter 3, this was to make the experiments more applicable to real-life study behaviour, as students often have to study large amounts of text material, for example within a textbook. Experiment 7 used a between-subjects design, where one group of participants could stop studying and another group could not. The results found those in the stopping group stopped often (71%), which was related to poorer recall of information. Specifically, study time within the stop condition was positively related to performance (r = .322). Experiment 8 expanded on this, and utilised a within-subjects design, also finding a high stopping rate (70%) for the stop lists and also found a positive correlation between performance and study time for the stop texts (r = .282), as well as a small link with performance on control texts (r = .254). Experiment 9 also found a link with motivational factors, with delay between stopping and test discouraging stopping, compared to when participants could move straight to the test phase (stopping rate: Delayed test 37.5%, Immediate test 60%). As well as this, a positive correlation was found between study time and performance in the test phase for both the delay-test texts (r =.332) and immediate-test texts (r = .554).

A mini meta-analysis was conducted using the ESCI package (https://thenewstatistics.com/itns/esci/) to look at the relationship between studying and performance across each experiment. From each experiment, the relationship between stopping position/study time and recall/test performance on stop lists/stop conditions was examined to look at the pattern across experiments. The meta-analysis result was r = .425

(95% CI [.327, .522]) with Figure 5-1 giving a visual representation of this analysis and the pattern across experiments. Experiment 4 was omitted from this analysis, due to it being a survey and not collecting data consistent with the other experiments.

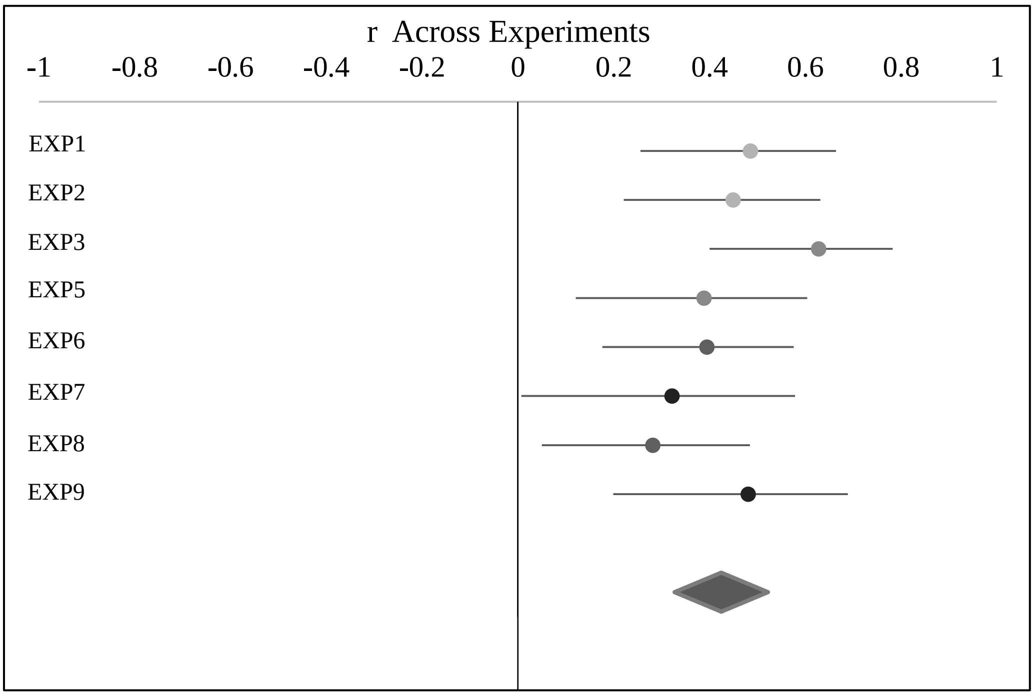

Figure 5-1. A forest plot representing the result from the meta-analysis conducted on the correlations found across the current experiments.

This meta-analysis highlighted that overall, there is a benefit from continuing studying, due to more studying being positively correlated with test performance. However, further examination of the regression equations reported in the experiments revealed that this benefit is quite small, and thus may encourage stopping. To elaborate, Experiment 1 revealed that on average, seeing an extra word gained 0.12 in recall, which was found to be similar across both the aversive and non-aversive conditions in Experiment 2 (both had a gain of 0.13 for seeing one word). Experiment 3 saw a slight increase in gain, with the delay-test lists having a gain in 0.21 words for every extra word seen, with the immediate-test list having a similar gain of 0.19 words. Within Chapter 3 when the materials were repeated, Experiment 5 found a gain in 0.11 words for every one word seen, with Experiment 6 finding that when the lists were delayed, the gain in recall was 0.17, with the gain being 0.10 when tests were immediate. Lastly, Chapter 4 found a gain of 1.85% in performance for every minute studied in the Experimental condition, with Experiment 8 finding a similar gain of 1.48%. Experiment 9 found an increase of 2.46% when the test was delayed, compared to when the test was immediate, which had an increase of 2.85% for every extra minute studying. Thus, across all experiments it could be suggested that a substantial gain in memory performance would require substantial extra study. For example, for a person to gain one extra word in Experiment 1, they would have to study 8.3 words. This was similar in Experiment 2. As well as this, gain in test performance for the Experiments in Chapter 4 was consistently low, suggesting a need for extra study across all experiments. This is evidence towards the idea that stopping may actually be adaptive in some circumstances, due to the lack of substantial benefit had from seeing more. Thus, this could be motivating participants to stop prematurely and therefore see less of the material.

5.1.2 Theoretical Implications

The current project explored potential accounts to explain stopping behaviour. These factors were split into those that were directly informed by the experience itself (experience-based cues) or those that were pre-conceived by the learner and are not directly informed by the experience (information cues) (Koriat, Nussinson, Bless & Shaked, 2008). The main reason for exploring alternative factors was due to Murayama et al. (2016) positing that participants were stopping because of an incorrect pre-conceived belief, which they characterised as a metacognitive illusion and that participants were "unaware of the possible advantage of viewing all the words in the list to enhance recall performance" (p. 8). This can be classed as an 'information overload' belief, whereby participants believe that seeing more is not beneficial for performance. However, this belief was not fully explored by Murayama et al. (2016) and thus warranted investigation. The current research highlighted that beliefs are an important factor when deciding to stop studying, but not due to a belief of information overload. If people believed that this was the case, I would have expected a similar, consistent stopping behaviour across the current experiments. However, as demonstrated above, this is not the case as depending on the manipulations used, stopping does vary. As well as this, even though Experiment 4 found reasons for hypothetical stopping to be consistent with an information overload account, predicted recall did not reflect this. Instead, predicted recall was consistent with the participants being aware that seeing more words creates a steady increase in recall, rather than causes a decline.

The current research also highlights that experience-based beliefs can determine stopping behaviour. As outlined in Chapter 1, research has often found that information-based judgments (for example, beliefs about efficient study strategies) are based on different cues to experience-based judgements, which stem from the act of studying itself (Koriat, Nussinson, Bless & Shaked, 2008). In relation to the current research, participants may be stopping due to the actual experience of studying and its aversive nature as suggested by literature into information overload (Eppler & Mengis, 2004) and the avoidance of cognitive demand (Soucek & Moser, 2010). Participants may have a pre-conceived idea that studying for longer is beneficial (as demonstrated in Experiment 4) but the actual experience of studying over-rides the execution of this. This has been found in more applied research, which has shown that a study strategy is not always executed as planned (e.g. Blasiman, Dunlosky & Rawson, 2017). However, this does not consider that participants did express an 'information overload' belief in Experiment 4, which is not consistent with their behaviour. Therefore, it may be that the reasons for stopping were considered to be acceptable, more so than expressing a sense of boredom or lack of effort with the study. Reasons for this could be that participants perceive this as not being socially accepted, due to it being against the 'norm' of having a high goal and ambition, as usually set out in learning (Cautinho, 2007; Locke & Latham, 1990).

Therefore, it is likely that an alternative motivation is at play in stopping behaviour. As previously outlined in Chapter 1, memory ability and forgetting could have an impact on stopping, which was tested in several experiments in the current research. It may be that the judgments of one's memory ability, an information-based cue, could have influenced stopping behaviour. This was also found in Experiments 5 and 8 in relation to the stopping of repeated word lists and text paragraphs. However, across the experiments, as outlined in the meta-analysis above, performance in the stop conditions was positively correlated with the number of words or time spent studying, therefore only a smaller set of participants with poorer memories could be stopping adaptively.

Another cognitive perspective discussed in Chapter 1 was the factor of perceived forgetting, which is something likely to be experienced at the time of studying (experience-based cue). Previous research has suggested that we are able to monitor our forgetting and thus this can impact study behaviour (e.g Ariel, 2010; Ariel & Dunlosky, 2011, Halamish, McGillivray & Castel, 2011; Koriat, Bjork, Sheffer & Bar, 2004). Experiment 1 in the current research looked at the role of perceived forgetting, utilising a manipulation where one group only had the current word on screen and thus were more likely to perceive forgetting of older items. This, however, was not found to cause a difference in stopping and therefore suggests this is less likely to be an influencing factor on stopping. Another cognitive perspective discussed in Chapter 1 was the idea that rate of learning experienced within the task could influence whether a person stops studying. Metcalfe and Kornell (2005) suggested that JOLs can be influenced by the perception of rate (jROL), with a lower rate of learning leading to stopping. The experiments within the current project support this idea, with findings usually showing only a small gain in recall if participants view all of the words or texts, compared to those who stop. As outlined above, the regression equations across the experiments suggest that to have a substantial gain in performance, the amount of time to put in to get this is also substantial, meaning that participants may judge any small gain in performance as not worth the effort and therefore choose to stop.

Another potential factor influencing stopping that was outlined in Chapter 1 was the role of motivation at the time of studying. This was not addressed fully by the experiments in Murayama et al. (2016), who assumed that participants were fully incentivised by being rewarded with 10 cents for every word correctly recalled. Multiple studies have found that motivation is an important component to self-regulated studying, with value governing how participants allocate their time (e.g. Ariel & Dunlosky, 2011; Ariel & Dunlosky, 2013; Ariel, Dunlosky & Bailey, 2009; Lipowski, Ariel, Tauber & Dunlosky, 2017; Soderstrom & McCabe, 2011). From the current research, stopping seemed to be changed using motivational manipulations, with the most convincing account coming from the experiments that utilised a delay between stopping and test. Experiments in Chapters 2, 3 and 4 looked at this and found a consistent effect across the experiments that used word lists, repeated word lists and text materials. When a delay was imposed between stopping and test, stopping occurred less than if the test was immediate. Thus, this suggests that having a delay meant that stopping no longer outweighed the benefit of continued study. If participants did believe that seeing more was harmful for recall, stopping would be consistent whether there was a delay or not. As well as this, participants may have been accurately judging that having a delay would harm their performance. In addition to this, the current research found that stopping was a more common decision if there was not a delay between stopping and test suggests that participants could be discounting any future study and thus are valuing stopping more. Thus, the immediate result of stopping is immediately gratified compared to a future and uncertain reward. Linking back to Murayama et al.'s (2016) first experiment, although not known by participants at the time, participants shortened their study period by 17.1

items (=34.2 seconds) and suffered a financial penalty of approximately 18.5 cents. Participants who were not motivated by the prospect of earning an additional few cents, or those who weight current experience over uncertain future benefit may therefore choose to stop, for reasons that have little to do with their belief about the efficacy of further study. This uncertainty in the benefit of future study is not irrational; previous research (as early as Ebbinghaus, 1885) has found that acquisition of information is faster at the start of study time and begins to slow down as time/exposure increases. As elaborated above, the gain in future study is quite slim and thus participants may be judging this uncertain gain in performance to not be valuable enough to continue. Thus, people may be rationally stopping on this basis.

5.1.3 Applications

The current research looked at stopping, involving the exploration of stopping of restudy of text materials similar to those in textbooks. This is an expansion on previous literature that has found that the allocation of study time for text-based materials usually follows a Discrepancy Reduction mechanism (Dunlosky & Hertzog, 1997). The experiments in the current thesis suggest that the motivations of the student play an important role in the premature stopping of studying novel information. The immediately gratifying decision to stop seems to be over-riding the goal of maximising performance. Thus, when students are learning information for the first time, stopping may be more likely due to the aversive nature of the task at hand. This can be the case for the studying of textbooks, for example when studying for a test or exam.

Linking back to the initial example of lecture attendance, students may decide not to attend because they value something else over the uncertain gain of attending a lecture. The content of a lecture may be tested in an exam, which may occur months after the lecture has taken place, meaning that the reward is delayed and therefore valued less to a student than if the test is immediate. As suggested in the literature into delayed discounting (Tesch & Sanfey, 2008), the value of a reward is reduced when it takes longer to receive it.

The current research highlights a disconnection between beneficial study behaviour and the carrying out of such behaviour. As previous research has found, there are disconnections between the knowledge of effective study strategies and the execution of these strategies (e.g. Blasiman, Dunlosky & Rawson, 2017). Therefore, this raises whether there are substantial interventions available that can help the implementations of effective study decisions. These interventions could strengthen the connection between prior knowledge of how to study material effectively, and the execution of effective studying. It could be that this connection is weakened when the task is being experienced, thus any interventions could help to strengthen one's resolve when studying aversive, yet important, information.

5.1.4 Future Research

As outlined in Chapter 1, there is limited research into the stopping of studying novel information, with Murayama et al. (2016) looking at the stopping of word lists. The current thesis also looks at word lists as well as extending to the use of text materials with the aim of applying stopping to more complex materials. Future research could branch out to different materials, such as lecture slides or diagrams, that have more similarities to those that students would experience in real-life studying. This would allow the findings relating to stopping to be applied to more complex materials and therefore help to understand further any restrictive behaviour students may decide. Using such stimuli may help to understand whether stopping in applied study behaviour is governed by a perception of ease of learning overload, especially when the materials combine multiple components such as texts and diagrams. Previous research has found that including diagrams and images have been found to increase the perceived fluency of the materials and thus inflate judgments of learning (Serra & Dunlosky, 2010).

Therefore, using such materials within a stopping paradigm may see an increase in stopping due to an increase in processing fluency. Alternatively, it could be that combining text with images may reduce stopping due its ease in processing. Using text with diagrams/images are similar to that studied, for example within a textbook, and so would help to explain why a student may stop studying prematurely when learning such materials.

Another future experiment could be to further explore the results found in Chapter 3, which found stopping was related to poorer recall even when the word lists were repeated. The results found here were partly thought to be because of processing fluency, which inflated the participants' sense of knowing the items better than they actually did. To further clarify this, a future experiment could look at varying the number of repeats of the word lists, for example 3, 4 or 5 times. If participant stopping was due to a processing fluency account, then stopping would be expected to be similar regardless of number of repeats. However, if stopping was caused by a sense of immediate gratification, stopping would be expected to be later, according to the number of repetitions. For example, if participants were motivated by a sense of control over their learning, they may monitor where in the list they are and stop at a point nearer to the end but also allowing them to cut short what they see. Seeing whether stopping differs for lists that are repeated for a different number of times will contribute to why people may stop repeated word lists.

Other potential future experiments could follow on from the themes that have been identified within the current research but were not formally tested. One such experiment could be one that tests the idea that further study is aversive to participants and therefore leads to increased stopping. An experiment looking at this could ask participants whether they enjoy studying, asking them to rate their experience as they are studying the materials using a paradigm similar to those used in the current thesis. If stopping is due to the aversiveness of future study, it would be expected that ratings would decline as study increases, leading to the suggestion that people are stopping to avoid any future unpleasantry of studying.

Another future experiment could look at the idea of delay discounting in more detail, by asking participants how much value they put on further studying from the point of stopping and whether any future gain in performance would be worth their time. Using a similar paradigm to the current experiments, participants could be given material to study that they are able to stop at any point. If participants stop, they could then be asked how much value they would get out of any future study, as well as how gratified they feel stopping is at that point. This would help to understand whether stopping is a function of immediate gratification, and whether participants are valuing stopping over any future uncertain gain.

In regard to the text experiments outlined in Chapter 4, future experiments could explore further whether stopping is governed by the cognitive load of the texts. Furthermore, an experiment could manipulate the properties of the paragraphs to account for differences in coherence and cognitive load, to see whether stopping is governed by a perception of load. Doing such experiments could involve manipulating the coherence of the text and increasing its level of difficulty, for example by using more complex terminology, longer sentences or even manipulating font size, which has been found to influence people's perception of judgment of learning (Rhodes & Castel, 2008).

5.1.5 Conclusion

The experiments in this thesis explored the factors that could influence a person stopping the studying of novel information. The results highlight similarities to Murayama et al. (2016), as well as adding novel findings. The research confirmed that stopping is a decision often made by people, leading to stopping incoming information, as well as finding an important role of people's motivations towards the task. This involves the value of stopping over any extra study and the uncertain benefit this may have on performance. Stopping of word lists does not seem to be influenced by the cognitive factor of forgetting and less likely due to a memory monitoring effect. Chapter 4 demonstrated that stopping is consistent across material types, finding that stopping of texts is also influenced by motivational factors. Overall, the results support the view that that stopping is influenced by more than an erroneous belief that seeing more is harmful. I have showcased that the task at hand and the motivational state of the person are determining factors for stopping and thus should be considered for broader applications.

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7 Tables

Table 1

Stopping rate split for Experiment 1.

Experiment 1	**Show Previous**	**Hide Previous**	**Overall**
List 1	14.8%	13.8%	14.3%
List 2	22.2%	34.5%	28.6%
Overall	18.5%	24.1%	21.4%

Table 2

Stopping rate split for list number and list type for Experiment 2.

Experiment 2	**Aversive Condition**	**Non-Aversive Condition**	**Overall**
List 1	54.8%	58.6%	56.7%
List 2	72.4%	51.6%	61.7%
List 3	79.3%	45.1%	61.7%
Overall	70.1%	50.5%	60.0%

Table 3

Stopping rate split for list number and list type for Experiments 3.

Experiment 3	**Delayed**	**Immediate**	**Overall**
List 1	28.6%	45.3%	36.4%
List 2	26.2%	52.4%	39.6%
Overall	27.4%	48.8%	38.1%

Table 4

Stopping rate split for list number for Experiment 5.

Experiment 5	**Stop List**
List 1	36.7%
List 2	44.9%
Overall	40.8%

Table 5

Stopping rate split for list number and list type for Experiment 6.

Experiment 6	**Delayed**	**Immediate**	**Overall**
List 1	18.6%	28.6%	23.2%
List 2	17.1%	34.3%	25.4%
Overall	17.8%	31.4%	24.6%

Table 6

Stopping rate for Experiment 7.

	Stop Text
Experiment 7	71.8%

Table 7

Stopping rate for Experiment 8.

	Stop Text
Experiment 8	70.0%

Table 8
Stopping rate split into each text type for Experiment 9.

	Delay Text	**Immediate Text**	**Overall**
Experiment 9	37.5%	60.0%	48.8%

Table 9

Experiment 1: Means (M) and Standard Deviations (SD) for stopping positions and free recall.

	Stop lists that were stopped				Stop lists that were not stopped				Control Lists				Stop Lists Overall			
	Show Previous		Hide Previous		Show Previous		Hide Previous		Show Previous		Hide Previous		Show Previous		Hide Previous	
	M	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
Stopping Position																
List 1	26.50	21.39	21.00	13.61	50.0	0	50.0	0	50.0	0	50.0	0	46.52	11.19	46.00	11.11
List 2	27.67	9.66	21.40	11.41	50.0	0	50.0	0	50.0	0	50.0	0	45.04	10.37	40.14	15.27
Overall	*28.17*	*12.22*	*20.15*	*11.06*	*50.0*	*0*	*50.0*	*0*	*50.0*	*0*	*50.0*	*0*	*45.78*	*10.16*	*43.07*	*11.11*
Recall																
List 1	4.75	2.87	5.25	1.89	10.13	3.23	8.68	2.59	8.74	3.01	7.66	2.54	9.33	3.67	8.21	2.76
List 2	7.67	3.32	5.60	3.24	9.43	2.75	8.26	2.56	9.56	2.89	9.72	4.49	9.04	2.92	7.35	3.04
Overall	*7.25*	*3.59*	*5.30*	*2.97*	*9.85*	*2.50*	*8.60*	*2.64*	*9.15*	*2.39*	*8.69*	*3.09*	*9.19*	*2.92*	*7.78*	*2.37*

Table 10

Experiment 1: Means (M) and Standard Deviations (SD) for stopping position and recall split into counterbalance orders. Within the sequences, S stands for Stop list, C stands for Control list.

	Stop list 1		Stop list 2		Control list 1		Control list 2	
	M	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
Stopping Position								
SCSC	50.0	0	45.37	10.49	50.0	0	50.0	0
CSCS	42.76	14.62	39.83	15.09	50.0	0	50.0	0
Recall								
SCSC	8.70	2.76	8.63	2.86	8.22	2.50	9.70	4.56
CSCS	8.79	3.68	7.72	3.25	8.14	3.10	9.59	2.93

Table 11

Experiment 2: Means (M) and Standard Deviations (SD) for stopping positions and free recall, for the 3 experimental lists, and for the initial baseline list.

	Stop lists that were stopped				Stop lists that were not stopped				Overall				Baseline lists			
	Aversive		Non-Aversive		Aversive		Non-Aversive		Aversive		Non-Aversive		Aversive		Non-Aversive	
	M	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
Stopping Position																
List 1	24.88	9.29	26.11	9.10	50.0	0	50.0	0	36.23	14.41	36.90	13.15				
List 2	28.75	9.98	22.90	9.13	50.0	0	50.0	0	39.03	12.90	30.38	14.54				
List 3	27.36	9.64	26.74	13.36	50.0	0	50.0	0	39.77	13.09	31.55	15.24				
Overall	*26.59*	*8.88*	*25.16*	*9.90*	*50.0*	*0*	*50.0*	*0*	*38.35*	*10.90*	*32.94*	*10.88*	*50*	*0*	*50*	*0*
Recall																
List 1	7.94	3.31	8.35	2.29	10.00	4.52	9.08	4.23	8.87	3.97	8.66	3.19				
List 2	9.75	2.91	8.19	3.94	12.40	3.62	10.75	5.57	11.03	3.49	8.90	4.50				
List 3	9.40	4.21	8.74	3.98	11.29	3.84	9.67	4.84	10.74	3.99	8.93	4.10				
Overall	*8.96*	*3.16*	*8.13*	*3.12*	*10.84*	*3.51*	*8.54*	*3.90*	*10.22*	*3.22*	*8.83*	*3.57*	*11.65*	*3.26*	*10.28*	*3.01*

Table 12

Experiment 3: Means (M) and Standard Deviations (SD) for stopping positions and free recall for each list studied.

	Stop lists that were stopped				Stop lists that were not stopped				Overall			
	Delayed		Immediate		Delayed		Immediate		Delayed		Immediate	
	M	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
Stopping position												
List 1	25.50	9.92	22.74	9.98	50.0	0	50.0	0	43.00	12.33	37.67	15.24
List 2	26.36	9.58	25.96	13.02	50.0	0	50.0	0	43.81	11.53	37.41	15.32
Overall	*26.63*	*8.71*	*25.44*	*10.77*	*50.0*	*0*	*50.0*	*0*	*43.41*	*10.92*	*37.54*	*14.22*
Recall												
List 1	7.08	1.24	7.79	4.04	11.57	4.81	12.87	4.18	10.29	4.58	10.57	4.80
List 2	6.18	1.88	7.73	2.68	11.90	5.91	12.15	4.77	10.41	5.74	9.83	4.38
Overall	*6.67*	*1.21*	*8.06*	*3.45*	*11.27*	*4.87*	*12.64*	*4.40*	*10.35*	*4.78*	*10.20*	*4.19*

Table 13

Experiment 3: Means (M) and Standard Deviations (SD) for stopping position and recall split into counterbalance orders. Within the sequences, D stands for Delayed, I stands for Immediate.

	Delayed list 1		Delayed list 2		Immediate list 1		Immediate list 2	
	M	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
Stopping Position								
DIDI	39.71	14.60	41.29	13.82	35.33	15.67	35.43	16.77
IDID	46.23	8.70	46.33	8.27	40.0	14.81	39.38	13.83
Recall								
DIDI	9.62	4.25	11.52	6.42	10.27	5.35	9.71	5.44
IDID	10.95	4.90	9.23	4.86	10.86	4.30	9.95	3.12

Table 14

Experiment 5: Means (M) and Standard Deviations (SD) for stopping positions and free recall for each list studied.

	Stop lists that were stopped		Stop lists that were not stopped		Stop lists overall		Control lists	
	M	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
Stopping Position								
List 1	72.89	31.18	120.00	0	102.69	29.51	-	-
List 2	76.09	22.13	120.00	0	100.29	26.48	-	-
Overall	*74.26*	*27.26*	*120.00*	*0*	*100.39*	*23.95*	-	-
Recall								
List 1	12.83	6.75	16.10	5.78	14.90	6.29	16.47	6.24
List 2	12.46	5.54	18.07	7.77	15.55	7.35	17.92	6.53
Overall	*12.44*	*5.75*	*16.39*	*6.65*	*15.22*	*6.52*	*17.19*	*5.93*

Table 15

Experiment 5: Means (M) and Standard Deviations (SD) for stopping position and recall split into counterbalance orders. Within the sequences, S stands for Stop list, C stands for Control list.

	Stop list 1		Stop list 2		Control list 1		Control list 2	
	M	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
Stopping Position								
SCSC	108.72	25.72	105.64	22.29	50.0	0	50.0	0
CSCS	96.42	32.35	94.71	29.69	50.0	0	50.0	0
Recall								
SCSC	14.16	5.96	15.40	6.92	17.24	6.02	17.12	6.26
CSCS	15.67	6.65	15.71	7.93	15.67	6.50	18.75	6.83

Table 16

Experiment 6: Means (M) and Standard Deviations (SD) for stopping positions and free recall for each list studied.

	Stop lists that were stopped				Stop lists that were not stopped				Overall			
	Delayed		Immediate		Delayed		Immediate		Delayed		Immediate	
	M	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
Stopping position												
List 1	86.46	14.84	80.55	19.95	120.00	0	120.00	0	113.77	14.52	108.73	20.78
List 2	85.00	22.81	81.21	20.91	120.00	0	120.00	0	114.50	15.49	106.70	22.13
Overall	*85.44*	*17.49*	*81.80*	*17.82*	*120.00*	*0*	*120.00*	*0*	*114.14*	*13.22*	*107.71*	*19.55*
Recall												
List 1	14.31	5.95	14.85	5.23	17.08	4.74	16.80	5.28	16.57	5.06	16.24	5.30
List 2	13.18	7.32	16.29	6.73	18.22	5.67	17.61	6.14	17.43	6.18	17.16	6.34
Overall	*14.25*	*6.84*	*15.55*	*5.29*	*17.67*	*4.89*	*17.28*	*5.33*	*17.00*	*5.23*	*16.70*	*5.37*

Table 17

Experiment 6: Means (M) and Standard Deviations (SD) for stopping position and recall split into counterbalance orders. Within the sequences, D stands for Delayed, I stands for Immediate.

	Delay list 1		Delay list 2		Immediate list 1		Immediate list 2	
	M	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
Stopping Position								
DIDI	112.64	16.93	112.49	19.30	109.30	21.14	104.61	25.45
IDID	114.78	12.13	116.23	11.03	108.22	20.73	108.57	18.85
Recall								
DIDI	15.94	4.78	17.30	6.31	17.33	5.61	16.76	6.65
IDID	17.14	5.30	17.54	6.15	15.27	4.89	17.51	6.11

Table 18
Experiment 7: Means (M) and Standard Deviations (SD) for time and performance.

	Stop texts that were stopped		Stop texts that were not stopped		Stop texts		Control texts	
	M	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
Study Time (minutes)	9.79	2.63	15.00	0	11.26	3.25	15.00	0
Performance (%)	44.51	18.74	53.18	17.86	46.94	18.68	51.79	17.17

Table 19
Experiment 8: Means (M) and Standard Deviations (SD) for study time and performance.

	Stop texts that were stopped		Stop texts that were not stopped		Stop Texts		Control texts	
	M	*SD*	*M*	*SD*	*M*	*SD*	*Me*	*SD*
Study Time (minutes)	9.58	2.50	15.00	0	11.21	3.26	15.00	0
Performance (%)	49.65	16.66	54.18	18.11	51.01	17.10	54.83	16.11

Table 20

Experiment 8: Means (M) and Standard Deviations (SD) for study time and performance split into counterbalance orders. Within the sequences, S stands for Stop text, C stands for Control text.

	Stop text		Control text	
	M	*SD*	*M*	*SD*
Study Time (minutes)				
SC	11.55	3.06	15.0	0
CS	10.86	3.45	15.0	0
Performance (%)				
SC	55.11	18.15	55.63	17.86
CS	46.91	15.16	54.03	14.38

Table 21

Experiment 9: Means (M) and Standard Deviations (SD) for study time and performance

	Stop texts that were stopped				Stop texts that were not stopped				Overall			
	Delay		Immediate		Delay		Immediate		Delay		Immediate	
	M	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
Study Time (minutes)	11.16	3.52	9.60	3.29	15.00	0	15.00	0	13.56	2.83	11.76	3.68
Performance (%)	53.90	22.95	56.90	19.75	63.18	19.31	66.00	16.69	59.70	20.96	60.54	18.91

Table 22

Experiment 9: Means (M) and Standard Deviations (SD) for study time and performance split into counterbalance orders. Within the sequences, D stands for Delayed text, I stands for Immediate text.

	Delay text		Immediate text	
Study Time (minutes)	*M*	*SD*	*M*	*SD*
DI	13.59	3.13	11.29	3.71
ID	13.52	2.57	12.23	3.70
Performance (%)				
DI	60.62	20.69	59.80	21.37
ID	58.78	21.72	61.26	16.61

8 Appendices

Appendix A - Word pool used in Chapters 2 and 3.

fury	shark	binary	hockey
plug	clause	lunch	honor
chains	plaza	drift	toilet
coffee	soap	cloak	tread
eight	towns	coil	angles
divine	chant	camera	mall
grace	cave	senate	bust
fellow	birds	bean	hotels
edit	canon	chairs	cent
ruby	glass	soccer	reform
genes	clay	soup	motif
apples	palm	earl	milk
affair	bowman	axis	gospel
deer	worker	module	beast
mood	sons	diesel	victor
stems	sister	trail	marine
scouts	route	shots	parity
mill	quark	jokes	glue
bend	coach	chorus	polls
scan	blonde	gate	habit
shield	novice	dances	zones
navy	stasis	knees	thesis
jungle	bacon	clinic	vacuum
shelf	aura	circle	idiot
fees	dial	bonus	riders
dare	tires	weapon	shops
regard	marks	whine	moss
trash	makers	fault	leaf
grad	titles	signs	ridge
ticket	carpet	packet	paste
curve	folk	rust	sore
collar	pairs	thorn	resort
latex	chips	tutor	ghoul
drum	palace	belly	grove
bowl	pizza	woods	tank
seat	treaty	branch	finds
cheeks	unity	plants	intent
bishop	injury	shoes	wishes
entity	hint	houses	roof
remedy	soda	fist	camel
finish	modes	profit	turkey
mice	stitch	gang	snail
dish	skull	scores	piano

lemur	votes	pace	mines
beard	goals	wheat	caller
hornet	ships	runner	cinema
excuse	waist	cereal	pile
guild	regime	roads	wisdom
babies	hero	planes	rats
shaw	mortal	whip	shed

Appendix B - Instructions provided in Experiment 1

Instructions before each Stop List

“Block _ of 4 blocks of 50 words.

Words in this block will now be shown one-by-one. Try to remember as many as you can.

For THIS BLOCK, you can press a key to move onto word recall early, if you feel this would help your performance.

Press the space bar to continue.”

Instructions before each Control List

“Block _ of 4 blocks of 50 words.

Words in this block will now be shown one-by-one. Try to remember as many as you can.

Press the space bar to continue.”

Instructions presented before each recall phase

“What words can you recall? Remember as many as you can IN ANY ORDER. Type recalled words into the boxes on-screen.

TIP: Keyboard keys left, right, up, down or TAB can be used to move quickly between boxes. If you prefer, you can use the mouse pointer to select boxes.

Press the space bar to continue.”

Appendix C - Instructions provided in Experiment 2

Before Presentation of first list (baseline list)

"You will now be presented with a list of words. Try to remember as many as you can.

Press any key to start the word presentation."

Before presentation of each subsequent stop list

"You will be presented with a list of words. This list will give you the option to stop the presentation of new words, if you feel this would help your performance. To stop the presentation of new words, press the space bar.

Press any key to start the word presentation."

At end of list presentations

"Thank you. Please inform the researcher that you have finished."

Appendix D - Instructions provided in Experiment 3

Welcome Screen

“Thank you for agreeing to take part in this study.

You will be shown a total of four word lists, and after each you will be asked to recall as many words as you can from that list.

To move on to the instructions for the first list, press the space key.”

Instructions before each Delayed Test lists

“You will now see a list of 50 words. It is your task to try and remember as many words as you can. Once the list has ended you will be asked to recall as many as you can using the recall sheets provided.

For this list, you can stop its presentation at any point you would like, if you feel this would help your performance. To do so, press the 'Enter' key.

If you press the 'Enter' key and stop the list, the words after this point will not appear and your screen will go BLANK. When the screen is blank, you will have to wait until the list would have ended if you had seen all of the words. Therefore, the earlier you stop, the longer the delay between stopping and the test.

To start the first list, press the space key.”

Instructions before each Non-Delayed Test lists

“You will now see a list of 50 words. It is your task to try and remember as many words as you can. Once the list has ended you will be asked to recall as many as you can using the recall sheets provided.

For this list, you can stop its presentation at any point you would like, if you feel this would help your performance. To do so, press the 'Enter' key.

If you press the 'Enter' key and stop the list, the words after this point will not appear and you will go STRAIGHT TO THE TEST phase for this list.

To start this list, press the space key.”

Instructions presented before each recall phase

“Please now use the piece of paper to write down as many words as you can, in any order, from the list.

You are not timed for this. Once you have done this, please press the space bar to move on to the instructions for the next list.”

At end of study

“Thank you for taking part in the experiment- you are now finished.

Please let the researcher know you have finished.”

Appendix E - Instructions provided in Experiment 4 – Survey Information

Page 1

“All questions are based on a scenario whereby you are shown words on a screen and are then asked to recall back as many as you can. These words are nouns that are roughly 4-6 letters long and examples of such include: 'Sailor', 'Tales', 'Walnut', 'Indigo', 'Luck' and so on. For example, one word is presented on the screen for approximately 2 seconds, then leaves the screen and then another takes its place. The words are completely random and have no relation to one another.

The questions below concern how many words you think you would be able to recall after all the words have been shown to you. For example, if 10 words were shown to you on a screen one by one, how many would you estimate you would be able to recall afterwards? Each question is asking the same thing, but the total number of words shown to you differs slightly each time. The purpose of these questions is for you to give an estimate as to how many words you think you would be able to recall based on seeing a certain number of items.

How many words do you think you would recall if you were shown a total of 5 words?*”

**This question was repeated, asking participants to predict recall in increments of 5, up to a total of 50 words.*

Page 2

“Stopping Decision

The next set of questions concern your stopping decisions in learning. Please answer as honestly as you can.

For this scenario, you will be shown a total of 50 words on a screen one by one. You will then be asked to recall as many words from this list as you possibly can. Whilst you are being shown the list of words, you can choose to stop them at any point you want to, cutting short what you see. Based on this, would you choose to stop the word presentation at any point?

- Yes
- No

Please provide a short statement explaining why you chose to do this (if you chose yes or no):

If you did choose to stop, roughly where in the list would you stop? (please give <u>one</u> number 1-50 based on whereabouts within the list you would choose to do this):”

Appendix F - Instructions provided in Experiment 5

Welcome Screen

"Thank you for agreeing to take part in the experiment. Across the experiment, you will study 4 word lists and have a test after each to recall as many words as you can from each list.

Each list will be repeated 4 times on a loop.

To start the study phase for the first list, press the space bar."

Instructions before each Stop List

"You are about to begin studying the word list. This will consist of 30 words that will loop on repeat for 4 times. Once this list has looped 4 times, you will be asked to recall as many words as possible on the new piece of paper in front of you.

One word will show on the screen at a time. However, you are able to STOP THE WORDS FROM BEING PRESENTED AT ANY TIME, if you feel this would help your performance, by pressing the ENTER key. If you do this, you will move straight to the test phase.

To begin studying the list, please press the space bar."

Instructions before each Control list

"You are about to begin studying the word list. This will consist of 30 words that will loop on repeat for 4 times. Once this list has looped 4 times, you will be asked to recall as many words as possible on the first piece of paper in front of you.

One word will show on the screen at a time.

To begin studying the list, please press the space bar."

Instructions presented before each recall phase

"You are onto the test phase for the word list. Please write down as many words as you can on the piece of paper in front of you. There are 4 pieces of paper in total - one for each list. Once you have finished with one, please put it to the side so the next piece of paper is available for the next list.

Once you have done this and are ready to start the next word list, please press the space bar."

At end of study

"You have finished the experiment. Please let the researcher know."

Appendix G - Instructions provided in Experiment 6

Welcome Screen

“Thank you for agreeing to take part in the experiment. Across the experiment, you will study 4 word lists and have a test after each to recall as many words as you can from each list.

Each list will be repeated 4 times on a loop.

To start the study phase for the first list, press the space bar.”

Instructions presented before each Delayed Test List

“You are about to begin studying the word list. This will consist of 30 words that will loop on repeat for 4 times. Once this list has looped 4 times, you will be asked to recall as many words as possible on the piece of paper in front of you.

One word will show on the screen at a time. However, you are able to STOP the words from being presented at any time, if you feel this would help your performance, by pressing the ENTER key. If you do this, the screen will go BLANK which will last the rest of the 4 loops. For example, if you press enter at the end of loop 2, the screen will be blank for the remaining 2 loops. You will THEN go to the test phase.

To begin studying the list, please press the space bar.”

Instructions presented before each Non-Delay Test List

“You are about to begin studying the word list. This will consist of 30 words that will loop on repeat for 4 times. Once this list has looped 4 times, you will be asked to recall as many words as possible on the second piece of paper in front of you.

One word will show on the screen at a time. You can STOP THE WORDS FROM BEING PRESENTED AT ANY TIME, if you feel this would help your performance, by pressing the ENTER key. If you do this, you will move straight to the test phase without a delay.

To begin studying the list, please press the space bar.”

Instructions presented before each recall phase

“You are onto the test phase for the word list. Please write down as many words as you can on the piece of paper in front of you. There are 4 pieces of paper in total - one for each list. Once you have finished with one, please put it to the side so the next piece of paper is available for the next list.

Once you have done this and are ready to start the next word list, please press the space bar.”

At end of study

“You have finished the experiment. Please let the researcher know.

Appendix H - Instructions provided in Experiment 7

Welcome Screen for those in Stop Condition

“Thank you for agreeing to take part in this study.

Within this experiment, you will be given texts to study and it is your task to read and understand these texts for a test later on in the experiment.
All of these texts are on the same general subject of human biology.

You have UP TO 15 MINUTES TO STUDY THESE TEXTS. It is up to you to read enough to be able to do well in the test later on, however, if you would like to stop studying altogether, PRESS THE ENTER KEY. If you do decide to stop, you will go straight to the test phase.

To move between the texts, please use the left and right arrow keys. Left will move you backwards to the previous text, right will move you forwards to the next text.

To begin your study time, press the space key.”

Welcome Screen for those in Control Condition

“Thank you for agreeing to take part in this study.

Within this experiment, you will be given texts to study and it is your task to read and understand these texts for a test later on in the experiment.
All of these texts are on the same general subject of human biology.

You have 15 MINUTES TO STUDY THESE TEXTS. It is up to you to read enough to be able to do well in the test later on. Once the 15 minutes are up, you will move onto the test phase.

To move between the texts, please use the left and right arrow keys. Left will move you backwards to the previous text, right will move you forwards to the next text.

To begin your study time, press the space key. From this point you will be timed for up to 15 minutes.”

Instructions presented at test phase

“You are now at the test phase of the experiment.

Please let the experimenter know.”

Appendix I - Instructions provided in Experiment 8

Welcome Screen

"Thank you for agreeing to take part in the experiment. Through the course of the experiment, you will study 8 different texts on different human biology processes. These texts will be split into 2 chunks of 4 and it is your task to learn as much of them as you can. Each chunk will run for 15 minutes each, with a test phase after each.

When studying, you will have the chance to stop the texts at any point you want if you feel this would benefit your performance. If you want to do so, please press the Enter key.

To move onto the instructions for the first 15-minute study phase, please press the space bar."

Instructions presented before the Stop Text

"You are now onto the first study phase. Here you will study 4 different texts. You will have to navigate yourself through each of the texts by pressing either the left or right arrow keys on the keyboard and you can go back and forth as much as you wish. Left will move you back to the previous text and right will move you forward to the next text. Overall, this phase will last 15 minutes, however you can stop the texts from being shown at any point by pressing the Enter key, if you feel this would help your performance. Please note that once you press stop you will not be able to go back and study the texts again.

Please let the experimenter know if you have any questions about what you need to do. If you are ready to start studying the texts, press the space bar."

Instructions presented before the Control Text

"You are now onto the second study phase. Here you will study 4 more different texts. You will have to navigate yourself through each of the texts by pressing either the left or right arrow keys on the keyboard and you can go back and forth as much as you wish. Left will move you back to the previous text and right will move you forward to the next text. Overall, this phase will last 15 minutes.

Please let the experimenter know if you have any questions about what you need to do. If you are ready to start studying the texts, press the space bar."

Instructions presented before each test phase

"You are now onto the test phase for the first 4 texts. This is a multiple-choice test and will last for 5 minutes so it is important you answer each question as quickly and accurately as you can. If you are unsure on an answer, please guess. Please note there is only one correct answer for each question. To answer the questions, please indicate your answer by pressing the corresponding number key on the keyboard. For example, if you think an answer is number 3, please press the '3' key on the top of the keyboard.

To start the test phase, press the space bar."

At end of study

“End of Experiment - Please let the experimenter know you are finished.”

Appendix J - Instructions provided in Experiment 9

Welcome Screen

"Thank you for agreeing to take part in the experiment. Through the course of the experiment, you will study 8 different texts on different human biology processes. These texts will be split into 2 chunks of 4 and it is your task to learn as much of them as you can. Each chunk will run for 15 minutes each, with a test phase after each.

When studying, you will have the chance to stop the texts at any point you want if you feel this would benefit your performance.

To move onto the instructions for the first 15-minute study phase, please press the space bar."

Instructions presented before the Delayed-Test text

"You are now onto the first study phase. Here you will study 4 different texts. You will have to navigate yourself through each of the texts by pressing either the left or right arrow keys on the keyboard and you can go back and forth as much as you wish. Left will move you back to the previous text and right will move you forward to the next text. Overall, this phase will last 15 minutes, however you can stop the texts from being shown at any point by pressing the Enter key, if you feel this would help your performance. Once you have pressed stop, the SCREEN WILL GO BLANK. This will be a delay between stopping and the test phase, the length of which will depend on where you decide to stop and will last for however long it takes to reach the end of the 15 minute study time. For example, if you decide to stop at minute 10 out of 15, the delay will last for 5 minutes. Please note that once you press stop you will not be able to go back and study the texts again.

Please let the experimenter know if you have any questions about what you need to do. If you are ready to start studying the texts, press the space bar."

Instructions presented before the Non-Delayed Test text

"You are now onto the second study phase. Here you will study 4 different texts. You will have to navigate yourself through each of the texts by pressing either the left or right arrow keys on the keyboard and you can go back and forth as much as you wish. Left will move you back to the previous text and right will move you forward to the next text. Overall, this phase will last 15 minutes, however you can stop the texts from being shown at any point by pressing the Enter key, if you feel this would help your performance. Once you have done this you will MOVE STRAIGHT TO THE TEST PHASE. Please note that once you press stop you will not be able to go back and study the texts again.

Please let the experimenter know if you have any questions about what you need to do. If you are ready to start studying the texts, press the space bar."

Instructions presented before each test phase

“You are now onto the test phase for the 4 texts. This is a multiple-choice test and will last for 5 minutes so it is important you answer each question as quickly and accurately as you can. If you are unsure on an answer, please guess. Please note there is only one correct answer for each question. To answer the questions, please indicate your answer by pressing the corresponding number key on the keyboard. For example, if you think an answer is number 3, please press the ‘3’ key on the top of the keyboard.

To start the test phase, press the space bar.”

At end of study

“End of Experiment. Please let the experimenter know you have finished.”

Appendix K- Texts used in Chapter 4. These texts were used as the study stimuli within Chapter 4.

Eyes : 'The eyes are suspended in the orbits, bony pockets in the front of the skull. They are moved by six extraocular muscles attached to the tough, fibrous outer coat of the eye (the sclera). Normally, we cannot look behind our eyeballs and see these muscles because their attachments to the eyes are hidden by the conjunctiva. These mucous membranes line the eyelid and fold back to attach to the eye (thus preventing a contact lens that has slipped off the cornea from falling behind the eye). The outer layer of most of the eye, the sclera, is opaque, not permitting entry of light. However, the cornea, the outer layer at the front of the eye, is transparent and admits light. The amount of light that enters is regulated by the size of the pupil, formed by the opening in the iris, which consists of a ring of muscles situated behind the cornea. The iris contains two bands of muscles, the dilator (whose contraction enlarges the pupil) and the sphincter (whose contraction reduces it). The sphincter is innervated by acetylcholinergic fibres of the parasympathetic nervous system, acetylcholinergic blockers (for example, belladonna alkaloids such as atropine) thus produce pupillary dilation by relaxing the sphincter of the iris. In fact, belladonna received its name from this effect. Belladonna means \"beautiful lady\" and was used in ancient times to enhance female sex appeal by producing large, dilated pupils. (Dilated pupils often indicate interest, and most men are attracted to a woman who appears to find them interesting). The lens is situated immediately behind the iris. It consists of a series of transparent, onion-like layers. Its shape can be altered by contraction of the ciliary muscles. Because of the tension of elastic fibres that suspend it, the lens is normally relatively flat. In its flat state, the lens focuses the image of distant objects on the retina, the light-sensitive tissue layer that lines the inner portion of the eye.'

Ears : 'We hear sounds, which are produced by objects that vibrate and set the molecules of the air into motion. When an object vibrates, its movements cause the air surrounding it alternately to condense and rarefy (pull apart), producing waves that travel away from the object at approximately 700 miles per hour. If the vibration ranges between approximately 30 and 20,000 times per second, these waves will stimulate receptive cells in our ears and will be perceived as sounds. Sounds vary in their pitch, loudness and timbre. The perceived pitch of an auditory stimulus is determined by the frequency of vibration, which is measured in hertz (Hz), or cycles per second. Loudness is a function of intensity, the degree to which the condensations and rarefactions of air differ from each other. More vigorous vibrations of an object produce more intense sound waves, and hence louder ones. Timbre provides information about the nature of the particular sound- for example, the sound of an oboe or a train whistle. Sounds are funnelled via the pinna (external ear) through the external auditory canal to the tympanic membrane (ear-drum), which vibrates with the sounds. We are not very good at moving our ears, but by orienting our heads, we can modify the sounds that finally reaches the receptors. A muscle in the tympanic membrane (the tensor tympani) can alter the membrane tension and thus control the amount of sound that is permitted to pass through to the middle ear. The ossicles, the bones of the middle ear, are set into vibration by the tympanic membrane. The malleus (hammer) connects with the tympanic membrane and transmits vibrations via the incus (anvil) and stapes (stirrup) to the cochlea, the inner ear structure containing the receptors.'

Skin : 'The somatosenses provide information about what is happening on the surface of our body and inside it. The cutaneous senses (skin senses) include several sub-modalities commonly referred to as touch. The cutaneous senses respond to several different types of stimuli such as pressure, vibration, heating, cooling and events that cause tissue damage. Feelings of pressure are caused by mechanical deformation of the skin. Sensations of pain can be caused by many different types of stimuli, but it appears that most cause at least some tissue damage. The skin is a complex and vital organ of the body, one we tend to take for granted. We cannot survive without it, for example, extensive skin burns are fatal. Our cells, which must be bathed by a warm fluid, are protected from the hostile environment by the outer layers of the skin. The skin participates in thermoregulation by producing sweat, thus cooling the body, or by restricting its circulation of blood, thus conserving heat. Skin consists of subcutaneous tissue, dermis and epidermis and contains various receptors scattered throughout these layers. Hairy skin contains un-encapsulated (free) nerve endings and Ruffini corpuscles. Glabrous skin (hairless skin) contains a more complex mixture of free nerve endings and axons that terminate within specialised end organs. The increased complexity probably reflects the fact that we use the palms of our hands and the inside surfaces of our fingers to explore the environment actively. Other specialised end organs have been shown to be variations of a single form, changing shape as a function of age. Five major types of organised endings include Pacinian corpuscles, which are the largest sensory end organs, the Ruffini corpuscles, found in hairy skin, Meissner corpuscles, found in papillae ("nipples"), Merkel disks which are found at the base of the epidermis, and Krause end bulbs, found in the junctions between mucous membrane and dry skin such as the edge of the lips.'

Taste : 'For a substance to be tasted, molecules of it must dissolve in the saliva and stimulate the taste receptors on the tongue. There are four main qualities of taste which are bitterness, sourness, sweetness and saltiness. Flavour, as opposed to taste, is a composite of olfaction and gustation. Most vertebrates possess gustatory systems that respond to all four taste qualities. Most investigators believe that sweetness receptors are food detectors. Most sweet-tasting foods are safe to eat. The acidity tastes sour and causes an avoidance reaction. The tongue, palate, pharynx and larynx contain approximately ten thousand taste buds. Most of these receptive organs are arranged around papillae, small protuberances of the tongue. Papillae are surrounded by moat like trenches that serve to trap saliva. The taste buds (approximately two-hundred of them, for the larger papillae) surround the trenches, and their pores open into them. The tip of the tongue is most sensitive to sweetness and saltiness, the sides are more sensitive to sourness and the back of the tongue, and throat and soft palate are most sensitive to bitterness. This distribution explains why saccharin, an artificial sweetener that tastes both sweet and bitter to some people, produces a sensation of sweetness on the front of the tongue when it is first tasted, and then a sensation of bitterness in the back of the mouth when it is swallowed. It seems most likely that transduction of taste is similar to the chemical transmission that takes place at synapses, the tasted molecule binds with the receptor and produces changes in membrane permeability that cause receptor potentials. Information from the anterior part of the tongue travels through the chorda tympani, a branch of the seventh cranial nerve (facial nerve). Taste receptors in the posterior part of the tongue send information through the lingual (tongue) branch of the ninth cranial nerve (glossopharyngeal nerve), while the tenth cranial nerve carries information from the receptors of the palate and epiglottis.'

Muscles : 'Skeletal muscles are the ones that move us (our skeletons) around and thus are responsible for our behaviour. Most of them are attached to bones at each end and move the bones when they contract. Skeletal muscles consist of two types of muscle fibres. The extrafusal muscle fibres are served by axons of the alpha motor neurones and the intrafusal muscle fibres are specialized sensory organs that are served by two axons, one sensory and one motor. A single muscle fibre consists of a bundle of myofibrils, each of which consists of overlapping strands of actin and myosin. The regions in which the actin and myosin filaments overlap produce striations, hence, skeletal muscle is often referred to as striated muscle. Our bodies contain two types of smooth muscle. Multiunit smooth muscles are found in large arteries, around hair follicles (where they produce piloerection) and in the eye. In contrast, single-unit smooth muscles normally contract in a rhythmical fashion. Some of these cells spontaneously produce pace-maker potentials, which we can regard as self-initiated excitatory postsynaptic potentials. These slow potentials elicit action potentials, which are propagated by adjacent smooth muscle fibres, causing a wave of muscular contraction. Single-unit smooth muscles are found chiefly in the gastrointestinal system, uterus, and small blood vessels. Cardiac muscle is found in the heart and looks somewhat like striated muscle but acts like single-unit smooth muscle. A group of cells in the pacemaker of the heart are rhythmically active and initiate the contractions of cardiac muscle that constitute the heartbeat.'

Digestion : 'Ingestion of food is affected by many factors. Firstly, the characteristics of available food, characteristics of the environment, including the presence of others who are themselves eating; and characteristics of the organism. The detectors of these signals appear to be located primarily in the liver, but some are also located in the brain. The wall of the stomach contains stretch receptors and chemoreceptors. These receptors respond to the bulk and chemical nature of the contents of the stomach, and their activity plays a role in the control of the digestive processes. The stomach empties into the duodenum, the upper portion of the small intestine. The rate of gastric emptying is controlled by the composition of nutrients received by the duodenum. The duodenal receptors also stimulate secretion of the peptide hormone cholecystokinin (CCK), which causes the gallbladder to contract, releasing bile into the duodenum. The pancreas, which is located below the stomach, communicates with the duodenum by means of the pancreatic tract. Pancreatic enzymes break down proteins, lipids, starch, and nucleic acids. Simple sugars and amino acids are soluble in water and enter the capillaries of the intestinal villi, finger like structures that protrude into the intestine. Hardly any nutrients are absorbed in the large intestine, but water and electrolytes are reabsorbed there. Bacteria in the large intestine live mainly on undigested cellulose. They produce some vitamins (especially vitamin K, important in the clotting of blood) that are absorbed into the body. The metabolic processes cooperate to produce the absorptive phase, which occurs while a meal is being absorbed from the intestine, and the fasting phase, which occurs after the nutrients have been absorbed and usually leads to hunger.'

Olfaction : 'Olfaction helps us identify food and avoid food that has spoiled is unfit to eat. The stimulus for odour consists of volatile substances having a molecular weight in the range of approximately 16 to 300. Almost all odorous compounds are organic in nature. However, many substances that meet these criteria have no odour at all. Our olfactory receptors reside within two patches of olfactory epithelium, each having an area of about one square inch. The olfactory epithelium is located at the top of the nasal cavity. Air that enters the nostrils is swept upward by the action of the turbinate bones that project into the nasal cavity, until it reaches the olfactory receptors. Olfactory receptors are bipolar neurons whose cell bodies lie within the olfactory mucosa that lines the cribriform plate, a bone at the base of the front part of the brain. The receptors send one process toward the surface of the mucosa, which divides into several cilia that penetrate the layer of mucus. Presumably, odorous molecules dissolve in the mucus and stimulate receptor molecules on the olfactory cilia. The olfactory mucosa also contains free nerve endings of trigeminal nerve axons, these nerve endings presumably mediate sensations of pain that can be produced by sniffing some irritating chemicals, such as ammonia. Most mammals have another organ that responds to olfactory stimuli, the vomeronasal organ. It has an important role in animal responses to odours that affect sexual physiology and behaviour. It is believed that odours are coded according to some classification scheme. First, some people are unable to detect certain odours, suggesting that there are various receptor types. Secondly, we are able to agree on similarities in odours. Classifications such as fruity, pine like and musky make sense to most of us.'

Balance : 'The vestibular system, which is involved in our balance and has two components, the vestibular sacs and semi-circular canals. They represent the second and third components of the bony labyrinths. The vestibular sacs respond to the force of gravity and inform the brain about the orientation of the head. The semi-circular canals respond to angular acceleration, which are changes in the rotation of the head. They also respond (but rather weakly) to changes in position or to linear acceleration. The functions of the vestibular system include balance, maintenance of the head in an upright position, and adjustment of eye movement to compensate for head movements. Vestibular stimulation does not produce any readily definable sensation, certain low-frequency stimulation of the vestibular sacs can produce nausea, and stimulation of the semi-circular canals can produce dizziness and rhythmic eye movements (nystagmus).The semi-circular canals approximate the major planes of the head- sagittal, transverse, and horizontal. Receptors in each canal respond maximally to angular acceleration in one plane. The semi-circular canal consists of a membranous canal floating within a bony one. The membranous canal contains endolymph and floats within perilymph. Within this are sensory receptors, which are hair cells similar those found in the cochlea. Their cilia protuberances are embedded in a gelatinous mass called the cupula, which blocks part of the ampulla. The vestibular sacs are roughly circular in shape, and each contains a patch of receptive tissue. The receptive tissue is located on the floor of the utricle and on the wall of the saccule, when the head is in an upright position. The receptive tissue, like that of the semi-circular canals and cochlea, contain hair cells. The cilia of these receptors are embedded in an overlying gelatinous mass, which are small crystals of calcium carbonate. The weight of the crystals cause the gelatinous mass to sift in position as the orientation of the head changes.'

Appendix L - Questions used in Chapter 4. These are multiple choice questions used within the test phases of Chapter 4. Correct answers are in bold.

Balance Qs

The semicircular canals approximate which 3 major planes of the head? 1. Inverse, horizontal and axial 2. Saggital, inverse and transverse 3. **Saggital, transverse and horizontal** 4. Vertical, transverse and inverse
Rhythmic eye movements are also known as what? 1. Sygatulous 2. Mastragous 3. **Nystagmus** 4. Opulatenous
What is the cupula? 1. A liquid reservoir 2. A hard mass 3. Air pockets 4. **Gelatinous mass**
The membrous canal contains what? 1. **Endolympth** 2. Trilactacte 3. Pandolymph 4. Receptors
The vestibular system is important for balance and what else? 1. **Maintenance of the head in an upright position and adjustment of eye movement** 2. To slow eye movement and co-ordination 3. Co-ordination and maintaining the head in an upright position 4. Our co-ordination
What does the semicircular canals respond to? 1. The head tilting 2. **Angular acceleration** 3. Air pressure 4. Force of gravity

Within the vestibular system, what do the vestibular sacs respond to? 1. The head tilting 2. **The force of gravity** 3. Angular acceleration 4. Pockets of air within the cerebellum

<u>Digestion Questions</u>

What are intestinal villi? 1. Folds of the intestinal wall 2. **Protrusions into the intestine** 3. Small pockets of lipids in the intestine 4. Minuscule holes in the lining of the intestine
What is vitamin K important for? 1. Energy uptake 2. Healthy blood flow 3. Fat absorption 4. **Blood clotting**
What does pancreatic enzymes help to break up? 1. **Proteins, lipids, starch and nucleic acids** 2. Proteins, starch, vitamins and fats 3. Sugar, amino acids, starch and lipids 4. Cholesterol, proteins, fats and carbohydrates
When the peptide CCK is released, this prompts the gallbladder to release what? 1. Enzymes 2. Vitamin K 3. **Bile** 4. Amino acids
Where is the duodenum located? 1. In the upper portion of the large intestine 2. In the gallbladder 3. In the lower portion of the small intestine 4. **In the upper portion of the small intestine**
Which 2 organs contain the signals for hunger? 1. Liver and brain 2. Liver and stomach 3. **Stomach and brain** 4. Pancreas and stomach

What 3 factors effect ingestion? 1. Level of hunger, availability of food, the time of day 2. Characteristic of the food, level of hunger related hormones, availability of the food 3. **Characteristics of the foods, the environment and organism** 4. Amount of protein in the food, characteristic of the environment, level of hunger

<u>Ears questions</u>

What happens to the air surrounding an object when it vibrates? 1. **Condense and rarefy (pull apart)** 2. Constrict and rarefy (pull apart) 3. Ripple in a rhythmic fashion 4. Constrict and comply
When an object vibrates, waves travel away from an object at approximately 1. 750 miles per hour 2. 850 miles per hour 3. 500 miles per hour 4. **700 miles per hour**
What is the ossicles? 1. The bone surrounding the anvil 2. The bone of the inner ear 3. The bone surrounding the cochlea 4. **The bone of the middle ear**
Within the ear, what funnels sounds? 1. **The pinna** 2. The ear drum 3. The anvil 4. The lingua
Timbre provides information about what? 1. The depth of the particular sound 2. The volume of the particular sound 3. **The nature of the particular sound** 4. The bass of the particular sound
A muscle in the tympanic membrane (the tensor tympani) can alter the membrane tension. What does this help to control? 1. The frequency of the sounds that are passed to the middle ear 2. The depth of the sounds that are passed to the middle ear 3. The fluidity of the sounds that are passed to the middle ear 4. **The amount of sound that is passed to the middle ear.**

Sounds vary in their ___, loudness and timbre (complete) 1. Vibration 2. **Pitch** 3. Intensity 4. Depth

<u>Eyes Questions</u>

Where is the lens situated? 1. At the front of the eye ball 2. **Immediately behind the iris** 3. Immediately in front of the iris 4. Immediately behind the cornea
The eyes are suspended in the orbits. What are the orbits? 1. A bed of nerves within the eye socket 2. **Bony pockets in the front of the skull** 3. Specially moulded cartridge sockets 4. The skin that surrounds the eye sockets
The eyes are able to move by the muscles attached to the outer coat of the eye. What is this outer coat called? 1. The iris 2. The macular membrane 3. The mucous cornea 4. **The sclera**
The amount of light that enters the eye is regulated. How is this regulated? 1. **Through the size of the pupil** 2. Through the positioning of the pupil 3. Through the subtle closing of micro holes in the cornea 4. Through the endothelium in the cornea
Tense elastic fibres suspend the lens. Because of this, what shape is the lens normally? 1. Slightly curved 2. Very curved 3. **Flat** 4. Flat with slight indentations
The iris is formed of a ring of muscles. What are these muscles called? 1. The dilator and the constrictor 2. **The dilator and the sphincter** 3. The distendor and the sphincter 4. The distendor and the compressor

What is the sphincter innervated by? 1. Alemchronolegic fibres 2. **Acetylecholineric fibres** 3. Betachlonergic fibres 4. Alphachlonergic fibres

Muscles Questions

What initiates cardiac muscle contractions? 1. **Cells in the pacemaker of the heart** 2. Adrenaline 3. Rate of blood flow through the heart 4. Pulses through the motor neurones within the heart
What is the function of single unit smooth muscle? 1. Constriction of blood flow 2. Erection of hair follicles 3. **Rhythmic contraction of muscles** 4. Pupil dilation
Where are multi unit smooth muscle usually found? 1. Small capillaries 2. **Large arteries** 3. In the heart 4. Around joints
What do myosin and actin overlaps cause? 1. Stripped muscle 2. **Striated muscle** 3. Regular muscle 4. It causes the muscle fibres to shrink
Which type of neurons serve extrafusal muscle fibres? 1. Beta motor neurones 2. Latent motor neurones 3. Chained motor neurones 4. **Alpha motor neurones**
Skeletal muscles are formed of 2 types of muscle fibres. What are they? 1. Interlinked and extralinked 2. Intrafused and extrafused 3. **Intrafusal and extrafusal** 4. Interfused and extrafused

A single muscle fibre consists of what?

1. **A bundle of myofibrils**
2. Strains of protein
3. A single myofibril
4. Many groups of motor receptors

<u>Olfaction Questions</u>

Why are we able to suggest there are different olfactory receptors?

1. **Some peoples are unable to detect certain odours**
2. Some people are oversensitive to certain odours
3. Some people cannot smell at all
4. We cannot suggest this

Why is it important that most mammals have an additional organ to respond to olfaction?

1. It helps to process odours too strong for the nasal cavity
2. It helps to detect harmful chemicals
3. **It helps responses to odours involved in sexual physiology**
4. It helps to detect bacteria-ridden food

Most mammals have an additional organ to respond to olfaction. This is called what?

1. **The vomeronasal organ**
2. The succumbous organ
3. The hepinasal organ
4. The ventrionasal organ

Olfactory receptors are ___ neurons whose cell bodies lie within the olfactory ___(complete)

1. Unilevel, mucous
2. Sensory, epithelium
3. Motor, mucousa
4. **Bipolar, mucousa**

Where is the olfactory epithelium located?

1. The bottom of the nasal cavity
2. **The top of the nasal cavity**
3. To the right of the nasal cavity
4. To the left of the nasal cavity

Odour consists of volatile substances with what molecular weight?

1. 100 to 200
2. 10 to 300
3. **16 to 300**

4. 26 to 250

Why is olfaction so useful?

1. So that we can taste what we eat
2. **So that we can identify food**
3. It is not as useful as sight
4. So that we can detect the proximity of people

Skin Questions

The skin participates in processes to regulate its temperature. To cool the body, it sweats, to conserve heat, the skin________? (complete)

1. Traps heat between hair follicles
2. Blocks pores to stop body heat from escaping so quickly
3. R**estricts blood circulation**
4. Increases blood circulation

Why is the skin so important for survival?

1. It folds when we move
2. **It protects our cells from the environment**
3. It allows us to keep warm and/or cool
4. It grows hair important for environmental exploration

The skin consists of what order of layers?

1. **Subcutaneous tissue, dermis and then the epidermis**
2. Subcutaneous tissue, epidermis and then the dermis
3. The dermis, the subcutaneous tissue and then the epidermis
4. The epidermis, the subcutaneous tissue and then the dermis

Specialised end organs within the cutaneous tissue have been organised into five different types. These include Pacinian corpuscles, the Ruffini corpsucles, ________, Merkels disks and _______. What two are missing?

1. Glabrous corpuscles and Heisners corpuscles
2. Meissners corpsucles and Kray round bulbs
3. Heisners corpuscles and Krause end bulbs
4. **Meissners corpuscles and Krause end bulbs**

Hairless skin contains a more complex mixture of nerve endings and axons. What does this reflect?

1. That as the skin is hairless, less room is needed for hair follicles
2. **That this skin is used for environmental exploration**
3. That injuries need to be detected easier in these areas
4. That this skin has deeper layers than other types

The skin senses are also known as what? 1. Dermal senses 2. Encapsulated senses 3. Subcutaneous senses 4. **Cutaneous senses**
What causes feelings of pressure? 1. **Mechanical deformation of the skin** 2. Proximity of another stimulus 3. Increased air pressure on the skin 4. Increase in temperature on the surface of the skin

Taste Questions

The tongue, palate, pharynx and larynx contain approximately how many taste buds? 1. 1,000 2. **10,000** 3. 100,000 4. 110,000
What is the ninth cranial nerve also known as? 1. Laryngepharial nerve 2. Parangealla nerve 3. **Glossopharyngeal nerve** 4. Recterhollingial nerve
Information from the anterior part of the tongue travels through the _____, a branch of the ___ cranial nerve. What two answers are missing? 1. Chorda nerve, sixth 2. **Chorda tympani, seventh** 3. Lingual, seventh 4. Chorda tympani, ninth
What are papillae surrounded by? 1. Other smaller papillae 2. **Trenches** 3. Saliva receptors 4. Other larger papillae
For a substance to be tasted, what must happen to the molecules within it? 1. They must attach to the taste buds on the tongue 2. **They must dissolve in the saliva** 3. They must attach to receptors within the saliva 4. They must mix with other tasting molecules within the saliva

How does flavour differ to taste?

1. It does not
2. It is comprised of just olfaction
3. It is comprised of just gustation
4. **It is comprised of both olfaction and gustation**