AGE DIFFERENCES IN SEARCH DURING SELF-REGULATED LEARNING

BY

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ABSTRACT

While search is increasingly becoming a more central process in learning with the rise of electronic environments, little is known about how learners determine the points at which decide to move from one text to another. The current study aimed at examining how learners studying a domain in a multitext environment regulate their effort among multiple sources. Specifically, the goal was to understand the principles governing when learners discontinue reading about one topic to explore another in that domain. By manipulating the amount of new information and conceptual overlap across texts within a topic, we created three types of text environments to generate different trajectories of two cues to perceived learning, new information (measured by rating of perceived new information) and encoding fluency (measured by ratings of reading ease). We report a series of five studies (in Mechanical Turk and the lab; N=180), showing that learners leave one topic for another when perceived learning decreases. The dominant cue to gauge perceived learning was the perceived amount of new information, while encoding fluency became more important when the study time was limited or among the older adults with poorer verbal ability. Interestingly, older adults were able to take differential advantages of conceptual overlap across texts for learning the text in which was high in the amount of new information. The study extended theories in animal foraging and metacognition, and established a novel paradigm to better investigate adult learning in the wild.

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CHAPTER 1.

INTRODUCTION

Learning, as knowledge building, is a complex cognitive process that requires search for information, selective encoding, monitoring, and integrating new information into coherent knowledge representations. With the development of modern information technologies so that the availability of information sources is exploding, so that learners have to take an active role to manage their learning in contemporary education settings. Unlike in traditional classroom settings, adult learners are exposed to multiple information sources in daily life, such as information on the internet. Since viewing all information is not possible given our limited processing capacity (Simon, 1956), choosing the important information, as well as deciding the amount of effort to allocate to particular sources of information, is necessary for promoting learning. Search serves as the route for adult learners to shape their own cognitive enrichment through the selection and engagement of different information environments. For example, an older patient newly diagnosed with hypertension might gather information about self-care with this illness, such as the recommended diet and exercise. In addition to the professional advice from physicians, he may search for information on health websites (such as American Heart Association) or social network sites to get advice from other patients with the same condition. Through exploration of the internet, the patient actively searches for relevant information, engages with that information, and makes decisions about when to stop searching for more information. This search process influences how much and how well the patient learns about the domain. Therefore, search becomes an inevitable and critical process in the authentic ecology of adult education in both formal and informal settings.

With longer life spans, adults in such ecologies are increasingly older. There is a well-established literature documenting the different trajectories of adult cognitive development through the life span (e.g., Baltes, 1997) that are likely to affect how information is processed and managed in such environments. Age-related constraints in processing capacity and growth in knowledge would both be expected to have an impact. The current series of studies was designed to examine how younger and older adult learners adapt to complex contemporary learning environments through the search process.

The theoretical background in this chapter addresses two aspects of the current research topic, the fundamental mechanisms in self-regulated learning across the literatures in metacognition and foraging theories, and age differences in these mechanisms. In introducing theories in metacognition as well as empirical findings in age-related change in the processes of monitoring and control, I propose an ecological model of learning that bridges foraging and metacognition theories, in which search plays an important role in the self-regulation of cognition. The ecological model of learning is grounded in literature in basic search processes and models of animal foraging, which also motivates the analytic framework. By way of introduction, I will review empirical studies of foraging behavior in cognition, information foraging theory, as well as age-related change in foraging behavior in cognition.

1.1 METACOGNITION AND SELF-REGULATED LEARNING

Research in metacognition has examined the way in which the learner takes an active role to regulate study. Research has suggested that learners allocate their study time according to their perception of how well they are learning the materials. There are two components in metacognition, monitoring and control (Metcalfe, 2009; Thiede, 1999). Monitoring is the process in which learners evaluate the status of their own learning, such as the possibility of successful later recall, which is often measured by judgments of perceived learning. Control is the process of regulating engagement in learning (such as study time allocation) in response to monitoring. Research in metacognition is largely conducted in the laboratory with the associative learning paradigm of word pairs (Metcalfe, 2009; Thiede, 1999).

1.1.1 Monitoring

There are different measures of monitoring for accessing different aspects of the learning experience, such as the ease and accuracy of encoding. Judgments of learning (JOLs) have most typically been used to access how well individuals think that they are going to perform in the criterion memory test. As such, the JOL is often measured after the item is learned and before the memory test is administered (e.g., Dunlosky & Connor, 1997; Metcalfe & Kornell, 2005). The accuracy of monitoring is often measured by the Goodman-Kruskal gamma correlations between recall performance and the JOLs. Koriat (1997) has argued that learners monitor different sorts of cues in accessing their learning to generate the JOLs. Intrinsic cues are the characteristics of the study items, such as inherent difficulty (e.g., word frequency, familiarity, or imageability of the items). Extrinsic cues are the conditions of study (e.g., presentation rate or the encoding process available for the learners). For example, learners will have the opportunity to engage in more deliberative processing of items if they can learn the items multiple times or through manipulation such as “interactive imagery” in which learners need to generate images that connect pairs of items resulting in deliberative processing (e.g., Hertzog, Dunlosky, Robinson & Kidder, 2003). Koriat argued that intrinsic and extrinsic cues are theoretical constructs that can be operationalized through manipulations of the properties of the study items and conditions, although the use of cues may vary based on learners' implicit theory of how the nature of items and learning condition impact learning. Both kinds of cues are thought to impact the generation of JOLs directly via knowledge of how item and task conditions affect learning, as well as indirectly through mnemonic cues.

Mnemonic cue reflects learners' own assessment of learning, such as the assessment of the outcome of previous recall (e.g., JOLs or recall accuracy from the previous round of study) or the assessment of processing (e.g., ease of processing), which is generated from the experience from participants. Both intrinsic and extrinsic cues can influence processing that impacts mnemonic cues, and then JOLs. Unlike the intrinsic and extrinsic cues as such were manipulated by the experimenters, experience-based mnemonic cues are dependent on the processes engaged by the learners. Therefore, the strength of mnemonic cues can be changed through practice.

Processing ease has been studied widely in associative learning and text learning (e.g., Price & Murray, 2012). Learners may rely on intrinsic cues, such as item difficulty, to judge learning. The effects of item difficulty can also be reflected in mnemonic cues, as measured in ratings of ease of processing (EOP), also called ease of learning before they study the items (e.g., Price & Murray, 2012). EOP is often correlated with JOL such that learners tend to rate more difficult items as having a lower likelihood of recall. However, after multiple trials of study, although the intrinsic "difficulty" of the item doesn't change, learners may judge the items being easier to learn and have higher JOLs due to study. This change in JOL reflects strengthen of mnemonic cues (e.g., EOP) during multiple trials of study. Therefore, Koriat argued that mnemonic cues as well as intrinsic and extrinsic cues interactively determine JOL.

Beyond the estimated processing ease, researchers have also studied other cues, reflecting the online judgment of item processing, such as retrieval and encoding fluency. Encoding and retrieval fluency are usually measured during or after the item is learned (e.g., Dunlosky, Baker, Rawson & Hertzog, 2006; Hertzog, Dunlosky, Robinson & Kidder, 2003). For example, Hertzog and his colleagues (2003) asked participants to generate images while learning word pairs (interactive imagery) and to press a button when the image was generated. Latency of image generation is a measurement of encoding fluency, which was negatively correlated with JOL showing that learners would rate the likelihood of recalling a word pair as lower if it took longer to generate the image associated with the word pair. However, the latency of image generation was not correlated with their future recall performance, suggesting that encoding fluency might be a misleading cue for JOL. There is parallel research in using retrieval fluency as a metamemory index in memory test (Benjamin, Bjork & Schwartz, 1998). After a question was presented, participants were asked to press a key when they retrieved the answers from memory. Retrieval fluency was measured by the latency of a key press. Findings showed that retrieval fluency was associated with JOLs such that people took less time to retrieve answers that they believed that they would be better at recall. However, like encoding fluency, retrieval fluency was also poor in projecting their future recall performance (Benjamin et al., 1998), suggesting that the use of retrieval fluency was suboptimal for learners in monitoring their memory. Hence, the use of fluency cues to generate JOL is not always accurate.

1.1.2 Control

Researchers have argued that learners use outcomes of monitoring, such as perceived learning (as JOLs), to control learning. Control has been mostly studied in the selection of items or the study time allocation in associative learning tasks. There are three dominant models explaining how adults control their learning according to the outcome of monitoring.

The discrepancy-reduction model (DRM; Nelson & Leonesio, 1988) suggests that the goal of the learner is to reduce the discrepancy between the current state (of knowledge) and the level of knowledge they want to obtain, such that learners select the least known items first to reduce this discrepancy. The region of proximal learning (RPL) model suggests that learners allocate effort to items they are more likely to learn (i.e., items that are not far from the current level of knowledge) such that they select easier items among those that are unlearned (Metcalfe, 2002; Metcalfe & Kornell, 2005). Other models focus on the values of particular items relative to the learning goal (e.g., operationalized as point values). The agenda-based regulation model (Ariel, Dunlosky & Bailey, 2009) suggests that the value of items (such as the payoff structures) can shift the order of item selection in self-regulated learning. When higher values are assigned to more difficult items and lower values to easier items, adults are likely to shift their initial selection to the high-value items rather than the easier items.

1.2 AGING AND METACOGNITION

Monitoring has often been found to be preserved with aging in associative learning paradigms. For example, Dunlosky and Connor (1997) found that both older and younger adults showed high gamma correlations between judgments of learning (JOLs) and their recall performance. In addition, there is also no age difference in the accuracy of ease of learning (EOLs) judgments of word pairs (e.g., Spanish-English or Chinese-English), such that EOLs made by younger and older adults were both associated with normative difficulty of word pairs

(Price, Hertzog & Dunlosky, 2010; Price & Murray, 2012). Overall, there is no age deficit in monitoring.

The literature on age differences in control is less clear. In a multitrial learning task, Dunlosky and Connor (1997) showed that, consistent with DRM, both age groups spent more study time on the items they rated less likely to be recalled (low JOLs) than the items that they rated more likely to be recalled (high JOLs). This relationship, however, was weaker for older adults, suggesting older adults were less able to use their metacognitive knowledge to regulate study time allocation than younger adults. That is, for the items older adults assigned lower JOLs at the first round, the duration of study time of these items at the following rounds did not increase as much as those of younger adults. Dunlosky and Connor (1997) also found this age difference could not be explained by age-related deficits in memory for the metacognitive judgment. When researchers presented the JOLs that participants had made on the earlier trials before restudying the item, older adults still did not adjust their time allocation as much as younger adults.

Price and her colleagues suggested that older adults select easier items first as guided by a region of proximal learning heuristic (Price et al., 2010; Price & Murray, 2012). In two studies, participants rated the ease of processing (EOP) for foreign cue words (e.g., Spanish or Chinese words) before being presented the English translations. Both age groups chose easier items first suggesting that older adults use their EOP in a similar way as younger adults. However, older adults spent most of their study time on the easy items, and less study time on complex items than younger adults. Thus, older adults avoided learning more complex items. This was especially true for those with low working memory capacity and low memory self-efficacy.

Hence, older adult may adaptively control study to accommodate the constraint of memory capacity.

Some studies have shown that older adults have equivalent, or even better, control processes relative to the young when point values are given (Castel, Benjamin, Craik & Watkins, 2002; Castel, Farb & Craik, 2007; Castel, Murayama, Friedman, McGillivray & Link, 2013). Castel and his colleagues (2002) showed how adult learners control their learning depending on the "value" of information. In Castel's study, participants were given a grid of point values associated with the items they were to learn. They showed that older adults demonstrated better selectivity in allocating more time to and recalling high valued words than younger adults. During recall, older adults would retain a few more high valued words in their primary memory and recalled the high valued words first, and followed by a few low valued words. While younger adults also recalled a few high valued words first, and followed by a greater number of low valued words. Therefore, older adults showed greater selectivity because they avoid selecting or recalling low valued items. Older adults allocated more time learning and rehearsing high valued words and retaining the high valued words in their primary memory. This value-based remembering echoed Koriat's (1997) notion that learners may regulate their study according to the extrinsic cues (point values).

Castel and his colleagues (2007) assigned a wider range of point values to words in several lists, ranging from high positive values to high negative values. Participants studied these lists of words with their associated point values, and then did two memory tests, free recall of the words and a value recognition test. Results showed that older adults, like younger adults, selectively learned the high valued information and showed comparable recall performance of high valued words. Although, older adults were less able to recall the specific value points associated with each word than younger adults, there was no age difference in recognizing the items with negative values. Therefore, older adults did not neglect low-value words, but still maintained a gist representation of them as suggested by the comparable recognition performance of negative items. Castel et al. (2007) concluded evidence showing that older adults show great control in recalling high valued words and not recalling negative valued words.

Castel and his colleagues (2013) studied how younger and older adults allocate study time on words with different point values. While the values of words were available, both younger and older adults selected and spent more time on the high valued words than the low valued ones. In addition, although older adults overall selected fewer items to learn, they allocated disproportional more time on the on the high valued items than younger adults. As a result, the recall performance of the high valued items showed minimum age differences, however, age differences in recall performance increased as the point values of items decreased. Older adults also strategically studied or restudied the high valued items immediately before the memory test to compensate for their poor memory. The investigators argued that older adults showed adaptive control in study time allocation and item selection in favor of high valued items.

Thus, older adults showed equivalent and even greater control in regulating study time allocation with metacognitive knowledge (Castel et al., 2002, 2007, 2013). Older adults have preserved monitoring process and can use their metacognitive knowledge to control study time allocation and selection of items to some extents in learning simple information, such as word pairs or word-point pairs.

Summing up, monitoring remains intact with aging for learning word pairs. Evidence about age deficits in control are inconsistent. Older adults are able to use point values, an extrinsic cue, as a cue to regulate study time allocation or item selection but may be less sensitive to the mnemonic cue (such as the JOLs made in the previous round of study) in regulating study time than younger adults.

1.3 METACOGNITION AND METACOMPREHENSION IN TEXT LEARNING

Monitoring for text learning has usually been found to be less accurate than word-pair learning (e.g., Dunlosky, Baker, Rawson & Hertzog, 2006). Most research has focused on the accuracy of the judgments in accessing comprehension performance (e.g., Maki & Berry, 1984; Thiede, Anderson & Therriault, 2003); rarely studied is metacomprehension as a process involving the control of study in relation to metacognitive cues. One sort of metacognitive knowledge that readers often rely on to make judgments about their comprehension performance is processing ease, suggesting that readers who perceive a more fluent reading experience tend to believe that they have better comprehension (e.g., Dunlosky, Baker, Rawson & Hertzog, 2006; Hertzog, Dunlosky, Robinson & Kidder, 2003; Maki, 1998; Rawson, Dunlosky & McDonald, 2002). Processing ease has often been studied as the amount of disruptions in reading. The amount of disruptions, reading latency, along with the ratings of processing ease all can be used to measure encoding fluency. In addition, Rawson, Dunlosky and Thiede (2000) found that learners usually made more accurate judgments of learning during rereading. They interpreted this finding as a result of the use of appropriate cues of encoding fluency (Dunlosky & Rawson, 2005). During rereading, learners usually shift their attention to the level of situation model processing (e.g., Stine-Morrow et al., 2004). Since comprehension outcome was associated more with the situation model processing (Dunlosky & Rawson, 2005), the fluency cue derived from this level of processing should be more accurate in terms of judging the perceived learning. Contrary to evidence that neither retrieval fluency nor encoding fluency are associated with actual memory performance in associative learning paradigm (Benjamin, Bjork & Schwartz, 1998; Hertzog, Dunlosky, Robinson & Kidder, 2003), Dunlosky and his colleagues (2006) found that processing ease is one of the major cues for readers to judge their subsequent performance on recall or comprehension. They manipulated the coherence between sentence pairs and longer texts to examine the relationship between processing ease and later recall performance. In order to understand the sentence pair, individuals needed to generate an inference; the success and latency of generation were the indicators of processing ease. In their experiments, individuals reported their JOLs after reading the sentence pairs, and were later tested with cued recall performance. Results showed that the positive associations between processing ease and JOLs and between processing ease and later recall performance, were weaker for older adults than for younger ones, showing that processing ease was not as good of a metacomprehension index for older adults to evaluate learning, and they did not use it as much as younger adults. However, there was no age difference in the correlation between JOLs and later recall, such that older adults showed equivalent degrees of accuracy in making judgments of sentence learning. In the paragraphs learning task, individuals saw one sentence at a time. During reading, they could press a key when they had difficulty understanding the information, such that the key press was a measure of processing ease. Interestingly, both younger and older adults showed a high correlation between processing ease and JOLs, suggesting that encoding fluency, as manipulated by the coherence of texts, was used as a proximal cue to make the judgment about comprehension performance. However, for both younger and older adults, the accuracy of JOLs in comprehension was low, and the use of encoding fluency was not reliable for monitoring their comprehension performance. Hence, processing ease was a misleading cue for metacomprehension, and older adults used it as much as younger adults to make JOLs in learning longer text.

The metacognition literature has shown evidence that learners can regulate their study according to their perception of projected learning performance, however, there are still gaps in the current literature explaining how people regulate their study across *multiple texts*. There have been few empirical studies in metacognition investigating how individuals self-regulate learning when multiple texts are available for learners. Son and Metcalfe (2000) examined how adults allocated their time to multiple texts under a limit of time with two different goals, free reading and reading for a test. Results suggested that when time was very short, adults allocated more time to the easier articles than the more difficult ones; however, this difference was less for the participants who studied for a test. With the goal of studying for a test, readers still read more difficult articles under the time limit. When time became sufficient, as predicted in the discrepancy-reduction model, adults allocated more time to study the more difficult articles. Son and Metcalfe argued that adults are sensitive to the task demands in order to actively regulate their learning in a meaningful way. Although JOL was not measured in the study, from the recall performance, processing ease still showed a weak relationship with learning performance (gamma correlation around 0.20), suggesting that processing ease influenced self-regulation in text learning regardless of its weak prediction of learning performance.

While this research examined selection and study time allocation across multiple texts, there is a lack of empirical study investigating what motivates learners' decisions to leave one text for another. Although some associative learning studies examine the self-regulation of study time across multiple learning materials, there are limitations in terms of generalizing the findings using word pairs to complex text learning (Dunlosky et al., 2006). Metcalfe and Kornell (2005) suggested that learners stop studying an item when its rate of change in JOLs decreases, this only was empirically demonstrated in showing that learners would not go back to *restudy* an item when the JOLs increased over multiple times of study. There is no empirical evidence to address whether learners stop learning based on the change in JOLs *within* a trial. Given the limitation in terms of explaining and examining self-regulation in multiple texts learning from the existing theories in metacognition, a different theoretical paradigm, information foraging theory, is required to answer this question.

1.4 AN ECOLOGICAL MODEL OF LEARNING

With the rise of the internet, a learner can be faced with access to an overwhelming amount of information. As a consequence, search has become an important cognitive process to study for understanding how humans regulate their effort across different resources to achieve their goals, such as learning. Search has been studied in a number of arenas, such as simulated foraging tasks (e.g., Hutchinson, Wilke & Todd, 2008; Mata, Wilke & Czienskowski, 2009), memory search (Hills, Jones & Todd, 2012), word search (e.g., Chin, Fu & Stine-Morrow, 2011; Hills, Todd & Goldstone, 2008; 2010; Payne Duggan & Neth, 2007) and internet search (Fu & Pirolli, 2007). Although there has been little attention on studying the search process as a means to adapt to text environments for the purpose of learning, Pirolli and Card (1999) used “knowledge crystallization” to frame information search through multiple resources. In addition to theories in metacognition, the current study will adopt foraging theories to make predictions and study how learners regulate their study with multiple texts.

1.4.1 Basics of Search Processes

Search is ubiquitous. Search may happen in our minds or in the environment. For example, people retrieve the names of their friends from their memories, try to recall the best restaurant from their past experience, look for a building as a guide for following directions while driving, skim the newspaper to get information of interest, browse the latest news by clicking links on a website, navigate through online shopping sites to purchase a new computer, or check the definition of a technical term by looking through notes or using Wikipedia when a piece of information cannot be retrieved from their own knowledge. Thus, we can search internally through memory or externally through various information media to obtain resources.

We can think of search as entailing two phases, exploration and exploitation. Exploration involves navigation through the environment (internal or external) to locate resources. Exploitation involves gaining or using the resource that was discovered during exploration. During search, people make decisions about when to stop exploiting (or using) the current resource and to explore for other resources. For example, in apartment hunting, people encounter various options for potential apartments. However, they have limited time and effort, so they are unable to visit all the available apartments. After visiting each apartment, an individual will need to decide whether to make a choice now or to delay this choice so as to search more apartments. If the process goes longer, other people may rent the previously visited apartments. If people stop searching too early (i.e., make decisions too soon), they might lose the opportunity to visit a better apartment. Therefore, during the search process, people have to make decisions about when to stop searching and to take advantage of what they have found. This tradeoff between exploration and exploitation also occurs in searching through memory. For example, one would like to hold a party and invite friends to his/her house. To list the people to invite, one might start thinking of the friends from work. After retrieving several names, one may be less able recall any more friends from work, and so may decide to recall friends from high school, college, and so forth. Hence, in searching memory, people also need to decide when they want to stop searching in one cluster of information and move to another. Hence, search requires that one balance the resources allocated to exploitation (i.e., consuming the current resource) and to exploration (i.e., finding a new, and perhaps better, resource).

Recent research in search adopts the principles of animal foraging model to explain and predict how people adapt to the environments through search. According to foraging theory (e.g., Pirolli & Card, 1999), in both internal and external search, the decision to shift from exploration to exploitation (or vice versa) follows certain universal principles. The similarities and differences of decision rules in animal foraging models and human search process are discussed.

1.4.2 Early Models of Animal Foraging

Charnov (1976) proposed the marginal value theorem using a patch model to explain how animals optimize the tradeoff between exploration and exploitation with change in the rate of gain (as defined by the amount of food gained as a function of time) and properties of the ecology. It is assumed that food is located in patches or clumps in the wild, which can be depleted over time; therefore, animals need to travel between patches to forage food. Charnov (1976) assumed that foragers sequentially visit patches of random profitability (as defined by the amount of energy return per unit of time) in an environment. Since food can be depleted in a patch, foragers encounter a diminishing return with time (i.e., a reduced rate of gain). Hence, Charnov suggested the optimal time to depart a patch was when the marginal rate of gain (i.e., the derivative of the gain function) falls equal to the overall rate of gain in the entire habitat.

However, the marginal value theorem only provides the theoretical optimal policy, Important empirical questions inspired by this approach include the extent to which foragers adopt patch-departure policies that optimize gain, and how they monitor the change in rate of gain in order to guide the implementation of these policies. Optimal policies are difficult to apply in the real world, because foragers do not have perfect knowledge of the patch profitability and are often limited in computational abilities that would be needed to make optimal decisions (e.g., Simon, 1956). Thus, foragers must rely on heuristics.

Studies showed that animals adopt a number of rules of thumb (i.e., heuristics) to make patch-departure decision (Stephens & Krebs, 1986) under different conditions. One is the cumulative time, or so called time-based, rule, in which animals leave a patch when the time in the patch exceeds a certain threshold. Another one was the cumulative number of prey, or so called item-based, rule, in which animals leave a patch when the number of prey they encounter exceeds a certain threshold. These two heuristics are really simple and can only be used in some situations (Iwasa, Higashi & Yamamura, 1981). If the prey distribution among patches is a Poisson distribution, such that prey rarely appear (i.e., the prey is extremely unevenly distributed in a patch), animals are better off adopting the time-based rules departing the patch when the cumulative time exceeds a threshold. On the other hand, if the prey distribution among patches is an even distribution, in which the likelihood of encountering a prey is equal across patches, animals are better off departing a patch when the cumulative number of prey exceeds a threshold.

Another rule is the give-up time rule (Charnov, 1976; Green, 1984; Stephens & Krebs, 1986). Give-up time is the time between the last encounter of a prey and the time to depart a patch The give-up time rule assumes that encountering a prey become increasingly less likely as the time since the last prey was encountered increases. The give-up time rule suggests that the forager should leave the patch when the give-up time exceeds a threshold. Give-up time also represents the time that the animal is willing to persist without finding a prey. The give-up time rule favors the patchy environments where the quality of patches significantly varies (Iwasa et al., 1981).

Finally, the rate rule (Stephens & Krebs, 1986), related to Green's assessment rule (Green, 1984) and the incremental rule (Iwasa et al., 1981), suggests that animals leave a patch based on the decrease in rate of gain. The incremental rule suggests that animals have an initial tendency to depart a patch and then track the rate of gain during the entire visit in the patch. The model assumes that the tendency to remain in a patch increased with the number of prey encountered and decreased as the time elapsed. In other words, the tendency to depart a patch will be jointly adjusted by the gain (number of prey) and time spent in the patch. When the tendency reaches a threshold, the forager will depart the patch. Green's assessment rule (1984) suggests that animals assess the patch quality during foraging, such that the decisions to depart are influenced by the number of prey caught up to a given time. Therefore, the assessment rule is relatively more flexible and sensitive to the environments than give-up time rule, item-based and time-based rules (Green, 1984).

Information foraging theory attempts to explain how people manage the acquisition of information in text environments, such as from the internet, libraries, or piles of documents in an office (Pirolli & Card, 1999). Decisions about when to stop searching were predicted by the patch model, which suggests that animals forage for food in patchy environments by adapting to the payoff structures through exploration and exploitation. Payoff structures in search are analyzed with information value and two types of costs, the resource cost that was incurred with the chosen behavior (i.e., cost to uptake information in the current information source), and the opportunity cost that was the potential benefits from engaging in other behaviors (i.e., expected gain in other information source). Hence, there are two enrichment activities for optimizing foraging performance, to reduce the costs in exploration or to increase the return in exploitation. For example, in internet search, individuals face patch-departure decisions of when to stop browsing the current website to explore new websites, or to return to the search engine to search for new information. To obtain relevant information effectively, individuals can use search engines with more accurate algorithms to yield better return of information value from the WWW or rely on the link recommendations suggested by the previous search history to reduce the search costs in navigating between pages.

Selection of information was predicted by the diet model. In animal foraging, the diet model suggests that the forager chooses more profitable prey for maximizing gain, in which profitability is defined as the energy returned per unit of handling time. On the other hand, information value is estimated by “information scent” representing a proximal cue of profitability of information patch (Pirolli & Card, 1999). For example, in the web search, information scent is defined as the semantic relevance between a proximal cue (such as the hyperlinks, titles of the website, or the text snippets of a webpage) and the distal information (such as the linked website). Individuals would expect higher return of information gain from the website with highly relevant title, hyperlink or text snippets returned from the search engine.

1.4.3 Empirical Evidence of Foraging Models in Cognition

Recent research in cognitive science has used foraging models to explain the search process in different activities. However, the extent to which people use optimal strategies in foraging (marginal value theorem; Charnov, 1976) or simple heuristics (Stephens & Krebs,

1986) to allocate resources for maximizing search outcomes is inconsistent.

Hills and his colleagues (Hills, Johnes & Todd, 2012) have suggested that individuals follow marginal value theorem in memory search. They defined a semantic patch using the semantic similarity between the word pairs. When reviewing the semantic similarities of successive pairs of words, if the similarity of one pair was lower than the previous pair and the following pair, it implied a patch-departing behavior. Similar to marginal value theorem (Charnov, 1976), results showed that people departed a semantic patch when the similarity of current pair of words was equal to the mean similarity of pairs of words a participant recalled in the trial. Hence, Hills suggested that individuals optimally allocate their time in memory search.

Hills and Pachur (2012) replicated the patterns in a social memory search task, in which individuals were asked to recall the names of individuals from their social networks. The clusters were created based on the self-rated frequency about how often individuals met the recalled individuals and their self-perceived social proximities of the recalled individuals. Research showed the similar findings that individuals would switch between the local search (social proximity) and global search (frequency).

Except findings in memory search (Hills, Johnes & Todd, 2012; Hills & Pachur, 2012), most of the research in cognitive search has found that individuals rely on heuristics in making the decisions to depart a patch. Payne, Duggan and Neth (2007) used a series of cognitive search tasks, including an anagram task and a word search puzzle task to examine how young adults interleave their time to two resources of each task. Results showed that adults tended to adaptively allocate more time to the richer resource and shorten their give-up time in the richer resource, suggesting that people are sensitive to the properties of the patch. In terms of making the patch-departure decisions, the simple heuristics alone (such as the number of words generated or found in a puzzle and the give up time) could not predict the number of switches people made. Payne found that a combination of the rate rule (to stay longer if the individual continued finding words) and the tendency to leave a patch when completing a subgoal could better explain the variation in staying time. The reason to consider the completion of the subgoal was because the give-up time showed a bimodal distribution suggesting that there may be a dual process of switching, in which decisions may be triggered by the drop in the rate of gain or the completion of a subgoal (finding a word).

Hutchinson, Wilke and Todd (2008) developed a simulated fish foraging task to examine how young adults forage within environments with different properties. Results showed that adults made more switches when the switch cost was low than when the switch cost was high, suggesting that foragers adapt to the cost structure in patchy environment. They used a Cox proportional hazards regression to show that simple heuristics (such as the number of fish captured in a pond or the cumulative time in a pond) alone did not explain the likelihood of departing a patch. Instead, the interval since last uptake (i.e., the duration from catching the last fish), and the interval of previous uptake (i.e., the time spent to catch the last fish) contributed to the likelihood of depart a patch, suggesting that adults were using some form of a rate rule to decide when to stop exploitation to find a new patch. Wilke and his colleagues (2009) found the similar patterns in an anagram task; the interval since the last item found (i.e., the time after generating the last word from the letter set) and the time to retrieve the previous item contributed to the likelihood of departing a letter set (Wilke, Hutchinson, Todd & Czienskowsk, 2009). Hence, regardless of the tasks, adults used the same rules to depart a patch.

Previous research has studied search in different paradigms, such as searching for words in puzzles (Payne, Duggan & Neth, 2007), generating words from letter sets (anagram; Hills, Todd & Goldstone, 2008, 2010; Mata, Wilke & Czienskowski, 2013; Payne et al., 2007; Wilke et al., 2009), simulated fishing task (Hutchinson, Wilke & Todd, 2008; Mata, Wilke & Czienskowski, 2009; 2013), generating words under a semantic category or social contexts (Hills, Jones & Todd, 2012; Hills, Mata, Wilke & Samanez-Larkin, 2013; Hills & Pachur, 2012). All these tasks require individuals to achieve the goal of maximizing gains under a time limit. The amount of gain can be operationalized as the number of words/ fish individuals find in the puzzles/ponds, the number of words individuals generated from an anagram puzzle or from their semantic memory. Therefore, there are discrete gains for all these task demands, that the foraging theories can explain the patch-departure decisions according the change in their rates of gains in varying extents across tasks. However, when the search goal is more complex such as to gather information for some purpose, such as learning new information, can foraging theories be used to explain the individual differences in search process?

Fu and Pirolli (2007) implemented a computational model, SNIF-ACT (Scent-based Navigation and Information Foraging in the ACT cognitive architecture), to model how individuals attend and leave a webpage during internet search. Profitability of a webpage was measured by the information scent, the semantic relevance between ones information goal and the linked texts. Webpages of high profitability were assigned higher ranks whereas the distribution of ranks of webpages showed a long-tailed function. Individuals would visit the webpages with higher ranks earlier than the pages with lower ranks. In addition, there were three major productions, attend-to-link, click-link and back-a-page, in the model. The probability of administering the production varied with the ranks of links. The utility of attend-to-link and click-link decreased as the ranks of links increased; the utility of back-a-page increased as the ranks of links decreased. Hence, individuals would tend to click links in the earlier stage of search, and likely stop browsing and return to previous page when the profitability of information went down in the later search. In addition to the ranks of webpages, SNIF-ACT better modeled search decisions by suggesting that individuals did not review all the links before selecting the one with the highest ranks, individuals would satisfice with a good enough links presented earlier on the page, which echoed that information seekers might satisfice with local goals and result in suboptimal performance (Fu & Gray, 2006). Besides the influence of link positions and satisficing strategy, as suggested by the marginal value theorem (Charnov, 1976) and information foraging model (Pirolli & Card, 1999), SNIF-ACT implemented that the probability of site-leaving would increase when the information scent of the current page drops below the mean information scent of the previous page, which well predicted the site-leaving behavior in two empirical web search studies. Overall, information foraging theory can explain how people search information in a large-scale text environment, such as the internet.

While the task goal in studies of web search is often to locate information (Fu & Pirolli, 2007), Payne and his colleagues examined how people reading for comprehension allocate time to multiple texts varying in difficulty and time constraints (Reader & Payne, 2007). Unlike previous studies in metacomprehension, the texts used in the study were too long to be studied thoroughly under the time limit. Therefore, the challenge for individuals was to select the right texts to read for better comprehension performance. Findings suggested that readers with more knowledge adaptively allocated time so as to spend less time on the easier texts regardless of the time pressure. In addition, the researchers categorized two kinds of search patterns, sampling and satisficing. Sampling was operationalized as a strategy in which readers visited all the paragraphs of texts early on, suggesting that readers evaluated all the texts before engaging some subsets of texts. Satisficing was operationalized as a strategy in which the longest reading time on a paragraph was on the first visit to the paragraph, suggesting that readers engaged in texts before evaluating other options. Reader and Payne (2007) found that most of the readers were satisficers; however, there were more samplers when an outline for all the texts was provided. Their explanation was that the outline reduced the cost of adopting sampling strategies; therefore, readers are able to adjust their strategies in selecting texts according to the cost-benefit structures of the task.

In another study, Duggan and Payne (2009) further suggested that readers adaptively skimmed the longer texts under time pressure. They hypothesized that skimming happened because individuals may experience drop in rates of information gain during reading (Pirolli & Card, 1999). For example, readers usually faced repeated ideas in the second half of the texts; therefore, they tended to adaptively allocate less and less time through the texts. However, the paradigm used in the previous studies (Duggan & Payne, 2009; Reader & Payne, 2007) was not able to examine the change in rates of information gain due to the lack of measurement of information gain. Whether readers were sensitive to the change in rates of information gain in learning longer texts also required further examination.

In sum, empirical studies have suggested that time-based and item-based heuristics alone cannot explain patch-departure decisions (e.g., Payne et al., 2007; WIlke et al., 2009). Instead, the patch-departure decisions are influenced by the change in the rate of gain, either following the optimal foraging theory (e.g., Fu & Pirolli, 2007; Hills et al., 2012) or other forms of the rate rules (e.g., Hutchinson et al., 2008; Payne et al., 2007; Wilke et al., 2009). Similar to the findings in Metcalfe and Kornell (2005), learners also stop restudying an item when the change in the rate of JOLs decreased. Thus, the change in the rate of gain should be a crucial rule for learners to determine when to stop learning.

1.5 AGING AND FORAGING

As alluded to earlier, cognitive development across the life span is multidimensional and multidirectional. While "mechanics," or fluid intelligence (including processing speed, working memory and executive control), declines with age, crystallized intelligence (e.g., verbal ability) is sustained (e.g., Baltes, 1997; Beier & Ackerman, 2005). Age-graded declines in mechanics contribute to age difference in text learning (Stine-Morrow, Miller, Gagne & Hertzog, 2006), especially with respect to encoding the particular content from text. However, age differences in text learning can be reduced if learning is self-paced (Johnson, 2003). In other words, when adults have the opportunity to self-regulate learning from texts, the effects of age differences in cognitive abilities can be mitigated. Therefore, search, as a mean for readers to shape their own enrichment, may provide older learners an opportunity to preserve their ability to learn from text.

There is a modest literature examining age differences in foraging, which has shown that older adults tend to be less explorative in terms of searching for less information in decision making and web information search (e.g., Chin, Fu & Kannampallil, 2009; Chin & Fu, 2010, 2012; Johnson, 1993; Mata & Nune, 2010; Meyer, Russo & Talbot, 1995; Meyer, Talbot, Ranalllil, 2007; Sharit et al., 2008). Mata and his colleagues (Mata, Schooler & Rieskamp, 2007; Mata, von Helverson & Rieskamp, 2010) have found that older adults are more likely to use the non-compensatory information frugal strategy (i.e., reviewing less information) in decision-making regardless of the tasks. This age difference in strategy use can be explained by individual differences in fluid abilities, such that older adults with better fluid ability were more likely to look up more information before making decisions. Similarly, Meyer and her colleagues (1995, 2007) have found that older patients tend to make quicker treatment decisions than younger ones because they tend to look up less treatment information before making decisions. Furthermore, regardless of treatment knowledge, older patients with higher levels of fluid ability tended to search for more information and delay their treatment decisions. To the contrary, older adults with limited fluid ability, but more treatment knowledge, tended to make immediate treatment decisions. Hence, among older adults, fluid ability is associated with the flexibility in adopting different information search strategies in decision-making.

Evidence from studies in web search has also shown the same pattern that older adults search for less information (i.e., browse fewer websites) and spend more time on a page in the internet (Chin et al., 2009; Chin & Fu, 2010, 2012; Sharit, Hernadez, Czaja & Pirolli, 2008). These age differences in search strategies can be explained to some extent by the variance in fluid ability and domain-specific knowledge (Chin et al., 2009). Older adults with more knowledge and poorer fluid ability viewed less information and spending longer time to information integration; younger adults gathered more information (with lower relevance to the tasks) and gave up browsing a page quickly.

Thus, there is well-documented evidence that the reduced level of exploration for information among older adults is associated with decline in fluid ability (also see a review in Mata & Nune, 2010). However, the mechanisms underlying this relationship are not well understood. Whether age differences in performance can be attributed to age differences in timing or cues used to make tradeoff between exploration and exploitation is unknown. Few studies used foraging models to test age differences in search process in different tasks, such as semantic fluency (i.e., memory search, Hills, Mata, Wilke & Samanez-Larkin, 2013), anagram (Mata, Wilke & Czienskowski, 2013), fish foraging (Mata, Wilke & Czienskowski, 2009, 2013) and word search puzzle tasks (Chin, Fu & Stine-Morrow, 2011; Chin et al., 2012).

There are diametrically opposite results in which some studies showed that older adults did less exploration (made fewer switches) during memory search (Troyer, Moscovitch & Winocur, 1997), and the other showing that older adults did more exploration than younger ones (Hills, Mata, Wilke & Samanez-Larkin, 2013). There are differences in the ways researchers defining patches and switches, and these differences may result in the difference in the results. Troyer et al. (1997) and Hills et al. (2013) both used animal naming task to examine age differences in memory search. Troyer studied memory search in terms of two components, clustering and switches. Clustering implies the consecutive production of words within a subcategory, and switching implies the ability to initiate a new search in other clusters (subcategories) while individuals cannot think of any new solutions in the current subcategory, in which an animal subcategory is operationalized using a norm of animal names. Troyer (1997) suggested that both clustering (i.e., the size of verbal storage) and switching (i.e., the ability to search for new subcategory) were positively associated with the performance. Results showed that older adults tended to switch less often than younger ones, and that this tendency reflected age-related deficits in cognitive control in terms of initiating a new search (Troyer et al., 1997).

Hills and his colleagues (2013) examined age differences in memory search and operationalized switch behavior as the “number of switches per item” to adjust for age-related the effects of slowing on number of switches (Mayr, 2002). Hills and colleagues (2013) tested three hypotheses, the general slowing hypothesis (Mayr, 2002), the clustering-switching hypothesis (Troyer et al., 1997) and the cue maintenance hypothesis (Hills et al., 2013) to explain age differences in memory search. They explored two kinds of cues adults may use to help recall the word under the category of animal, one being the semantic relevance of between consecutive word pairs (local cue); the other being the word frequency of the current word (global cue) (Hills et al, 2012). If the general slowing hypothesis was true, there should not be age differences in the use of cues, and older adults should make fewer switches than younger adults because of their slower processing speed. If the clustering-switching hypothesis was true, there should be age differences in the use of cues in making switches, and older adults should also make fewer switches than younger adults because older adults had deficits in executive control function in terms of the ability to initiate a new search (i.e., switch to a different cluster). However, the results confirmed the cue maintenance hypothesis, in which there was an age difference in the use of cues, such that older adults made more switches per item than younger adults. Hills suggested that older adults made more switches because of deficits in executive control function that would compromise their ability to maintain the use of current cues and to inhibit the use of other cues. In other words, individuals with poor executive control had difficulty maintaining the local cue during memory search, and tended to switch to the global cue more often (Hills et al., 2013; Hills & Pachur, 2012). This assumption was further supported by the evidence that the span of working memory was negatively correlated with the number of switches per items regardless of age (Hills et al., 2013). The association between working memory and number of switches per item was independent of the association between age and number of switches per item. In other words, older adults or adults with smaller working memory spans were not able to keep using the local cue in memory search (or having the smaller clusters) that led to earlier give-up in the local clusters and more transitions to global search.

Although there have been mixed results in age differences in memory search, there were consistent results in cognitive foraging tasks involving external search showing that older adults have a tendency to do less exploration (looking up less items) and more exploitation (spending longer time in a patch) (e.g., Chin, Fu & Stine-Morrow, 2010; Chin et al., 2012; Mata, Wilke &

Czienskowski, 2009, 2013). Mata and his colleagues examined age differences in give-up time and staying tendency using fish foraging and anagram tasks (Mata, Wilke & Czienskowski, 2009, 2013). Mata and his colleagues (2009) used linear regressions to model the time people stayed in a patch (the "pond") as a function of number of prey (fish), with the intercept being the initial staying time, and the slope being the rate of uptake. Although both younger and older adults showed longer initial staying time when the travel cost was high, older adults still stayed longer than younger ones before encountering the first fish in a pond, suggesting that older adults tended to persist in the patch.. However, Mata et al. (2009) did not find age differences in the incremental rate suggesting the unit of time older adults delayed their patch-departure decisions after catching a fish was roughly the same with the unit of time younger adults did. In addition, older adults reduced their initial staying time when they were given explicit instructions to estimate their time allocation during fish foraging. Hence, both younger and older adults were adaptive foragers in terms of adjusting the initial staying time to the varying travel time cost. Similarly, Chin et al. (2010, 2012) used a word search puzzle paradigm (Payne et al., 2007) to examine age differences in switch among puzzles. Results showed that older adults made fewer switches than younger ones regardless of the search cost. In addition, both younger and older adults switched less often and had longer give up time when the search cost was high, suggesting that individuals were adaptive to the search costs in adjusting their search behavior (Chin, Fu & Stine-Morrow, 2011). Mata et al. (2013) also showed that older adults had longer give-up times regardless of the tasks (fish foraging and anagram), suggesting that older adults set higher thresholds for switching from exploitation to exploration than younger ones. These studies confirmed that older adults tended to stay longer and did less exploration in both internal (anagram) and external search task (word search puzzle and fishing).

The fact that older adults persist longer and delay their decisions to depart a patch has been found in multiple studies (using external search tasks), and the delay in decisions to depart a patch ultimately lead to less exploration among older adults relative to the younger (Chin et al., 2011; Mata et al., 2009, 2013). To explain the decrease in exploration of older adults, Chin et al. (2012; 2015) tested two possible hypotheses. One was that there was no age difference in the rules used to make patch-departure decisions, but that older adults stayed longer in a patch because it took longer time for them to reach the point of diminishing return than younger ones due to general slowing. In other words, older adults persisted longer in order to reach the diminishing return in the current patch, and then delayed their decisions to switch to a new patch, which resulted in less exploration. If this hypothesis were true, older adults who reached the point of diminishing return earlier should switch earlier. The other explanation was that there was age difference in the rules used to make patch-departure decisions (such as using different cues or setting different thresholds for making a switch). If the later hypothesis were true, older adults should tolerate a bigger drop in rates of gain in a patch, which made them delay their patch-departure decisions and led to less exploration.

To test these hypotheses, Chin et al. (2012; 2015) analyzed the link between patch-departure behavior and the changes in the rate of information gain (RIG) in both macro (by-subject) and micro (by-item) levels. In the macro analysis, younger adults showed a higher RIG as well as a bigger change in RIG than older adults, such that younger adults tended to reach the point of diminishing return earlier than older ones. In addition, younger adults whose change in RIG was bigger tended to switch more often than the ones whose change in RIG were smaller; however, older adults consistently switched less often regardless of their change in the rate of gain. Thus, regardless of the time course of reaching the point of diminishing return, older adults tended to stay longer and made fewer switches, which ruled out the former explanation that older adults delayed their departure only because they were slow.

A micro analysis examined the effect of the amount of change in the RIG on the likelihood of departing a patch across time (Chin et al., 2015). Results have shown that the variance in when individuals give up exploiting the current puzzle to explore a new one can be explained by individual differences in the cues used to determine the change in RIG, which supported the latter hypothesis that older adults persisted longer in a patch not only because they had slower uptake rates, but also they relied on different cues to make the decisions. The patch-departure decisions of younger adults were more dependent on the long-term incremental change in RIG; the patch-departure decisions of older ones were more dependent on the local change in RIG. Age-related differences in the use of different cues from RIG to make patch-departure decisions may be explained by the individual differences in executive control functions. Older adults who had better executive control functions, more like younger adults, also adjusted their departure time according to the long-term change in RIG. However, older adults with poor executive control functions were not able to rely on the long-term change in RIG for making patch-departure decisions.

In sum, there are age differences in the mechanisms underlying the control of search, which might be related to executive control functions. Furthermore, older adults do less exploration because they use different cues to determine the points to stop exploiting the current resource for exploring a new one.

CHAPTER 2.

RESEARCH RATIONALE AND HYPOTHESES

Both metacognitive and information foraging theories try to account for how people regulate their time and effort in order to learn new information. Metcalfe and Jacobs (2010) drew parallels between metacognition and animal foraging theory, and suggested that there are some commonalities between the general principles of both theories. For example, learners do not go back to fully learned items, at least in the short run, which is similar to the fact that animals do not go back to a depleted patch immediately. Also, learners choose the easily learned and unknown items first instead of the difficult or learned items (as suggested by RPL theory). Similarly, animal foragers choose the just-right-size food to minimize the cost of consumption. Bigger prey induces higher handling cost, and smaller prey induces the cost of multiple searches. For example, some seabirds pick just the right size of oysters to maximize their food gain. Furthermore, learners stop studying items when their perceived rates of learning decrease (Metcalfe & Kornell, 2005), which is analogous to the rate rule (Stephens & Krebs, 1986), the assessment rule (Green, 1984) and the marginal value theorem (Charnov, 1976), all of which suggest that animals leave a patch when the rate of gain decreases. Thus, although animals and learners use different mechanisms to regulate their search or resource allocation process, there are common principles that govern these mechanisms.

Little is known about how learners decide to discontinue study of one text to search for other sources. The comparison of animal foraging and metacognition suggests new ways of examining these processes in learning. Thus, the current study was to fill the gap in the literature by examining how readers engage multiple texts for the purpose of learning. Three major research questions were addressed in this study: (1) how does perceived rate of gain influence decisions to discontinue reading? (2) what sort of cues do text foragers use in assessing the rate of information gain? (3) Are there age differences in these processes?

Although common principles between metacognition and animal foraging have been developed to some extent, the application of foraging theory to text learning has not heretofore been well developed theoretically. There are a number of ways in which comprehension/learning in multitext environments present challenges for classic foraging theory.

First, although information foraging has been regarded as a "knowledge crystallization" activity (Pirolli & Card, 1999), this has primarily been studied in terms of finding information sources. There is lack of empirical study to examine actual leaning or knowledge building. In fact, previous models in information foraging (ACT-IF, Pirolli & Card, 1999; SNIF-ACT, Fu & Pirolli, 2007) have defined the goal of search as whether users find the target information without consideration of how this information is consumed, or how exploitation processes interact with search processes. In other words, psychological processes engaged for learning information have not been examined in the context of information foraging. Therefore, whether the decision rules of patch-departure can predict when people stop learning one text to move on to other text remained to be studied.

Second, the nature of resources in information foraging differs from that of resources in classic foraging (e.g., animals finding and consuming food) in important ways that need to be taken into account in theory development. For example, in the context of classic foraging, resources can be depleted; whereas in information foraging, resources cannot be depleted and cannot be taken away by competitive foragers. This difference in the concept of "depletion" of resources has implications for application to the context of learning. In characterizing this analogy, Metcalfe and Jacob (2010) noted that animal foragers do not return to depleted patches just as learners do not choose “learned” items to restudy. However, their analysis focused primarily on memory paradigms in which the to-be-learned material consisted of discrete items (e.g., word pairs). Defining whether a text resource is learned or not is more complex. Another conceptual challenge of applying foraging processes to explain learning processes in text is that resources can be re-consumed in learning. For example, the same concepts learned in different contexts may be regarded as “new” information since they may create new knowledge by virtue of the fact that they are related to other concepts in the texts. Or, even if individuals learn the same concepts in the same context repeatedly, they may still gain a new representation or deeper understanding from the texts since the learner may elaborate these concepts and make inferences while reading the texts. Therefore, it is interesting and important to understand information foraging behavior under the constraints that information may not be depleted and can be re-consumed.

Third, the consumption (or uptake) of resources in classic foraging is particularly different from learning from texts (Pirolli & Card, 1999; Fu & Pirolli, 2007). In learning, individuals cannot uptake all the information to which they are exposed. In other words, even if readers find fruitful and profitable information resources, the ability to consume the information that is found depends, in part, on a range of abilities. Foraging models assume that foragers will obtain the resource once locating it, and this is often assumed in web search model. However, the ability of learners to obtain the resource from text varies with the cognitive processes, goals, and task demands. Unlike animal foraging, the rate of information gain of learners may not reflect the uptake functions of the text environments alone. Studies of mechanism underlying search often neglect individual differences that contribute to variation in uptake rate, and rather regard uptake rate as a property of the environment. Uptake rate is jointly determined by the profitability (i.e., the yield from a patch) of environment and the ability of individuals. Hence, it may not be valid to assume that learners will have higher rates of information gain from sources that have more information.

Finally, since finding the information is not the same as learning the information, what makes foragers or learners continue exploiting the current resource creates other complexities to study the topic of patch-departure decisions. In foraging models, animals may use heuristics, such as the number of prey they get, or the time they stay in a patch to determine if exploiting the current patch has higher gains relative to the costs of exploring a new patch (Stephens & Krebs, 1986). On the other hand, the goal of learning is to gain knowledge through comprehending the information from texts. Comprehension involves the generation of representations at multiple levels through different processes (Kintsch, 1988). Beyond decoding the surface from, comprehenders activate features of meaning for individual words so as to access meanings. Within this perspective, then, the function of text can be thought of as conveying information about collections of *concepts* – roughly equivalent to the semantic representations for particular words. These concepts are bound together into ideas (i.e., propositions), which are integrated into a coherent representation, called the *textbase*. Finally, the representation of events and the implied situation, the *situation model,* involves more deliberate processing of the discourse by drawing inferences, deploying prior knowledge, etc. in order to create a representation of the situation conveyed by the text (e.g., Zwaan & Radvansky, 1998). In foraging, animals are likely to stay in a patch if they are able to continue obtaining food from the patch (Stephens & Krebs, 1986). According to the same analogy, in text learning, if learners feel that they are able to generate new representations (i.e., knowledge), from one text, they should continue studying it.

If learners feel that they are not able to gain new knowledge from text, they should stop reading it and turn to explore new text. As discussed earlier, unlike food in a patch, information cannot be depleted. Thus, instead of using heuristics to determine profitability of a patch (such as number of words found in a puzzle or number of prey caught in a patch), how learners determine if they can gain new knowledge from the text is relatively ambiguous.

In the current project, the theoretical scope of foraging theory is extended to incorporate language comprehension mechanism and techniques used in self-regulated learning research. A novel text foraging task was developed in which participants learned about a domain by selecting a series of topics and then reading a series of texts about the selected topic. There was a series of articles about each topic. By selecting a topic to read, learners were exploiting a text patch. Learners could decide to exploit the patch by continuing to read more articles about this topic, or to explore other patches by leaving this topic and reading articles about another topic. In other words, participants searched among text topics (which operationalized individual patches) and made decisions to discontinue reading each topic in order to optimize their learning of the whole domain.

As discussed above, based on foraging theory, learners should leave a topic if their rates of perceived information gain (perceived learning) decreased. Perceived learning was measured after reading each article as a JOL rating. By examining the relationship between the change in perceived learning across articles within a topic and the number of articles learners engaged in that topic, this text foraging task allowed us to explore the metacognitive cues that the learners used to discontinue reading about a topic (“leave a patch”).

A related question was how learners generate these estimates of perceived learning in the first place. Following Koriat (1997), learners were expected to rely on proximal cues from the materials, the task, and the experience of study to judge their perceived information gain (i.e., how well they were learning from a text about a topic). Two kinds of proximal cues were examined (see Table 1 for a comparison). First, like information scent of a site (Fu & Pirolli, 2007) or number of words in a puzzle (Chin et al., 2012, 2015; Payne et al., 2007), people may rely on the amount of new information (i.e., new ideas) in the text patch to determine the amount of knowledge they are able to gain from a text. Accordingly, when individuals perceive that there is more to learn from the texts (an intrinsic cue) and use this as a cue to perceived information gain, this would lead to longer perseverance in the text patch. Alternatively, as demonstrated in the literature in metacognition (Dunlosky et al., 2006), people may rely on encoding fluency (i.e., ease of processing, a mnemonic cue) to determine the amount of knowledge they are able to acquire from a text. Individuals who perceive that they have less difficulty learning information from the texts will have higher perceived rates of information gain, which lead to longer perseverance in the text patch. Either one or both of the cues, the perceived amount of new information and perceived encoding fluency may contribute to the perceived rate of information gain. Hence, the current study used three kinds of text patches to operationalize the availability of these proximal cues in determining the time to stop learning.

Specifically, the manipulation focused on the relationship across articles on a topic (which operationalized the "patch") to induce different trajectories of fluency and availability of new information to examine their relative contributions to perceived information gain. To create three patch types varying in the amount of new information and the stimulation of perceived encoding fluency, the current study followed Kintsch's theory on how information is encoded from texts (Kintsch, 1988; Kintsch 1994). Kintsch and his colleagues (1975) suggested that although introducing new concepts in a sentence creates demands for comprehending, introducing new propositions (i.e., ideas) about the same concepts is less effortful relative to introducing new ideas that contain new concepts. In other words, while introducing more new ideas (propositions), there was a way to mitigate the effort of encoding by using the same concepts to build up new relationships among old concepts. They demonstrated this empirically by showing that while controlling the number of propositions and sentence length in the short sentences, learners spent longer time and recalled less for the items with more new concepts than the items with fewer new concepts. This finding suggested a way to differentially foster encoding fluency while increasing the equivalent amount of new information (ideas) in text, through the repeated usage of concepts across articles, called *conceptual overlap*. By manipulating the amount of new information and conceptual overlap across articles, three conditions of text patches were designed (Table 2).

In the HI-LCO condition (high information and low conceptual overlap), there were more and more new ideas and more new concepts introduced as participants read the articles in a topic. As shown in Figure 1a, participants would be expected to experience an increasing amount of new information if they continued to exploit this text patch. In addition, because the conceptual overlap among articles was low in this condition, participants would be expected to experience low encoding fluency across articles (as in Figure 1b). In the HI-HCO condition (high information and high conceptual overlap), there were more and more new ideas but few new concepts introduced as participants read the articles in a patch. The conceptual overlap among articles would be expected to increase coherence across articles even though the information load was high. Therefore, as shown in Figure 1a and 1b, participants would be expected to experience high information gain, but also high encoding fluency over the articles in this condition. In the LI-HCO condition (low information and high conceptual overlap), texts introduced virtually no new information and were, of course, high in conceptual overlap. As shown in Figure 1a, participants would be expected to perceive little new information because the content of articles was repetitive. At the same time, because of the use of paraphrase, participants would have high encoding fluency (Figure 1b).

The differential patterns of change in these cues across the articles in three conditions allowed us to test how these cues affect perceived learning in three conditions (Figure 1c and 1d). If learners use the perceived amount of new information as the cue to judge perceived learning, the rates of perceived learning should be the highest in the HI-LCO condition, HI-HCO condition, and the lowest in the LI-HCO condition. On the contrary, if learners use encoding fluency as the cue to judge perceived learning, the rates of perceived learning should be the highest in the LI-HCO condition, followed by the HI-HCO condition, and with the HI-LCO condition being the lowest. By investigating the rates of perceived learning in the three conditions, we were able to differentiate the cues learners use to estimate their perceived information gain, and examine whether adults leave a topic when the rate of perceived learning decreased.

CHAPTER 3.

MATERIAL DESIGN

In the study, adults were asked to learn about "Transplantation and Donation" by reading a set of short articles about three topics, Bone Grafts, Blood Donation and Corneal Transplants. These text materials were adapted from articles extracted from dozens of health information websites with good credibility, such as MedlinePlus, WebMD, Mayo Clinic and others. For each topic, three sets of six sequential articles were created, with the three sets constituting the primary manipulation of the experiments, such that sets varied in the amount of new information and degree of conceptual overlap across articles (i.e., repeated use of the same concepts in multiple articles). New information in an article was operationalized as the ideas (propositions) that had not appeared in any of the previous articles under the same topic. Conceptual overlap was operationalized as the proportion of the same content words that were appeared in the consecutive articles. This measure was obtained from Coh-Metrix, a text analysis database developed by Grasser and his colleagues (Graesser, McNamara, Louwerse & Cai, 2004). The complete set of stimulus materials is presented in Appendix 2.

The first article for each topic was always an introductory article to provide an overview of the topic and was the same across the three sets. Subsequent articles in each set were constructed as follows.

The HI-LCO condition was the *high information - low conceptual overlap* condition. Following the introduction, the subsequent articles were constructed so that each subsequent article Article_N contained relatively more new information (i.e., propositions) and new concepts than Article_{N-1}. This was accomplished by elaborating on five different areas (subtopics) of the topic to create the five subsequent articles. In this condition, new ideas as well as new concepts were consistently introduced across the six articles in a topic.

The HI-HCO condition was the *high information - high conceptual overlap* condition. Subsequent articles were created by introducing new ideas using about the concepts that had been introduced in prior articles within the same topic. There was always more new information but few new concepts in Article$_N$ relative to Article$_{N-1}$ in this condition. In this condition, the subtopics were developed across subsequent articles that met two criteria. One criterion was that the main concepts had been introduced in the first (introductory) article of the topic, and the second was that this theme had enough breadth that it could be further elaborated for five more articles. Subsequent articles were constructed by elaborating on existing concepts with new ideas. For example, for the topic of "bone graft," the first article briefly introduced concepts such as allografts and autografts, as well as more basic concepts related to donors, locations of grafts (hips, spines), tissue banks, materials, procedures, and so forth; subsequent articles elaborated, for example, on allografts and autografts, in part by grounding the explanation in these more basic concepts. In "blood donation," successive articles introduced different kinds of blood donations varying in the blood components being donated as well as the recipients. In the topic "corneal transplants," successive articles introduced different kinds of surgeries used in corneal transplants depending on the number of layers and the kinds of layers being transplanted.

The LI-HCO condition was the *low information - high conceptual overlap* condition. This was a paraphrase condition that introduced minimal new ideas or concepts across the five subsequent articles. There was almost no new information or new concepts in Article$_N$ relative to Article$_{N-1}$. In this condition, the information in the first article was paraphrased in the five subsequent articles without adding new concepts or new ideas.

To verify the differences in conceptual overlap across conditions, CohMetrix (Graesser et al., 2004) was used to calculate two indices, global conceptual overlap and local conceptual overlap. Global conceptual overlap was defined as the proportion of content words that occurred in the current article and any of the previous articles on the same topic ($M_{Condition1}=0.28$, $SE_{Condition1}=0.01$; $M_{Condition2}=0.47$, $SE_{Condition2}=0.01$, $M_{Condition3}=0.70$, $SE_{Condition3}=0.01$). Local conceptual overlap was defined as the proportion of content words that occurred in both the current article and the immediately prior one ($M_{Condition1}=0.23$, $SE_{Condition1}=0.02$; $M_{Condition2}=0.44$, $SE_{Condition2}=0.02$, $M_{Condition3}=0.68$, $SE_{Condition3}=0.02$). Figure 2 showed the indices of global and local conceptual overlap across articles. MANOVA was conducted to examine the effects of condition on global and local conceptual overlap. There was a significant effect of condition on global conceptual overlap ($F(2,42)=367.20$, $p<.0001$). Post-hoc tests further confirmed that global conceptual overlap in the HI-LCO condition was lower than the HI-HCO condition ($d=-0.18$, $p<.001$) and the LI-HCO condition ($d=-0.42$, $p<.001$) and the conceptual overlap in the HI-HCO condition was lower than the LI-HCO condition ($d=-0.23$, $p<.001$). Similarly, there was also a significant effect of condition on local conceptual overlap ($F(2,42)=208.46$, $p<.0001$) showing the same patterns of results that local conceptual overlap in the HI-LCO condition was lower than the HI-HCO condition ($d=-0.21$, $p<.001$) and the LI-HCO condition ($d=-0.45$, $p<.001$) and local conceptual overlap in the HI-HCO condition was lower than the LI-HCO condition ($d=-0.24$, $p<.001$).

Despite the fact that conceptual overlap was different across conditions, all other linguistic properties of the texts in three conditions were carefully controlled, including the number of words, number of sentences, sentence length, word frequency (Balota, et al., 2007) and readability (descriptive statistics in Table 3). MANOVA was used to examine the effects of condition on the number of words, number of sentences, sentence length, word frequency (log word frequency of all words, log word frequency of all content words and minimum log word frequency) and Flesch-Kincaid grade levels. There were no differences in the number of words ($F(2,51)=0.003$, $p=0.99$), number of sentences ($F(2,51)=0.93$, $p=0.40$), sentence length ($F(2,51)=1.27$, $p=0.29$), average log word frequency ($F(2,51)=0.23$, $p=0.80$), log word frequency of all content words ($F(2,51)=0.50$, $p=0.61$), minimum log word frequency ($\mathrm{F}(2,51)=0.53$, $p=0.59$) and Flesch-Kincaid grade levels ($F(2,51)=2.95$, $p=0.6$) across three conditions. Therefore, except the differences in new propositions and conceptual overlap, the texts used in three conditions were largely equivalent.

All five studies that are reported used these materials. See a summary of the studies in Table 5.

CHAPTER 4.

TEXT LEARNING STUDY (STUDY 1)

The first study was a pilot study to examine how adults monitor their learning performance across three conditions of text patches. Participants were asked to learn health information at their own pace. After reading each article, participants were asked to judge how much new information they thought was in the article, how easy was the article for them to read and how much information they learned. These ratings were used to (1) validate the manipulation of the three conditions and (2) examine how adults used the cues (encoding fluency and amounts of new information) to judge their perceived learning. Unlike in the foraging task, participants were asked to read all the articles and did not need to make selections on the topics or to make the decisions to stop reading. Therefore, the study aimed at understanding how adults monitored their learning in the multiple-text environments when they were allowed to read all the articles in a patch (topic) without time pressure.

4.1 METHOD

4.1.1 Participants

Seventy-nine participants were recruited from Amazon Mechanical Turk. Data from 27 people were excluded due to technical problems. Data from the remaining fifty-two participants (Mean age =38.9, *SD*=10.9, age range=23-69; 46% female) were used in the analysis. Most (60%) of the participants completed college (Mean years of education =15.3, *SD*=1.9, range=12-20) (See descriptive statistics in Table 4).

4.1.2 Measures

Participants were administered pattern comparison (Salthouse, 1991) and ETS Advanced Vocabulary task (Ekstrom et al., 1976) to measure their processing speed and verbal ability.

4.1.3 Experimental Design

The study followed a within-subject design with condition being the within-subject variable (The HI-LCO condition, HI-HCO condition and LI-HCO condition).

4.1.4 Procedures

When a participant logged into Mechanical Turk, s/he was presented with a consent form, and then completed a demographic questionnaire. For the main task, participants were asked to learn health information from multiple texts, with the goal to learn as much as possible about topics related to Donation and Medical Transplants by reading a series of articles (instructions that participants received are presented in Appendix 3). All participants were asked to read 18 articles, six articles in each of the three conditions. The assignment of condition to each topic was counterbalanced.

To begin, participants viewed a button corresponding to one of the topics, Bone Grafts, Blood Donation or Corneal Transplants (Figure 3b). Once clicking on the topic button, the first article was presented (Figure 3c). After reading each article, participants pressed a button, which initiated the presentation of three rating scales (Figure 3d, 3e, 3f) to operationalize perceived encoding fluency, the perceived amount of new information and perceived learning. The perceived amount of new information was assessed with the item, “Taking into account the other articles that you have read today about this topic, how much new information was in this article?” which participants rated on a scale of 0 to 100, where 0 meant that this article did not have any new information, and 100 meant that this article had completely new information. Encoding fluency was assessed with the item, “How easy was it for you to understand this article?” which participants rated on a scale of 0 to 100, where 0 meant that it was very difficult to learn from this article, and 100 meant that it was very easy to learn from this article. In addition to the hypothesized proximal cues used to determine information gain, perceived learning was assessed by the item, “Taking in to account the other articles that you have read today about this topic, how much new information did you learn from this article?” which participants rated on a scale of 0 to 100, where 0 meant that they did not learn anything new from this article, and 100 meant that they learned everything from this article.

After providing these ratings for the article, participants pressed the “NEXT” button to read the subsequent article (Figure 3c). After reading all six articles about one topic, participants were directed to a new topic (Figure 3b) and continued in the same way. Articles within a topic were presented sequentially. After reading one topic, participants answered three multiple-choice questions to test their comprehension. Lastly, participants completed two cognitive tasks. Reading time on each page was recorded.

4.2 RESULTS

The analysis focused on answering two questions; (a) whether participant’s ratings of new information and ease of processing varied across conditions as predicted, and (b) to what extent did learners use these cues to judge their perceived learning across the articles.

4.2.1 The Effects of Condition on Monitoring and Performance

Table 6 summarizes the descriptive statistics for ratings of perceived ease of processing, the perceived amount of new information, and perceived learning; and for accuracy scores of the comprehension questions in the three conditions. Repeated measures ANOVA was used to examine the effects of condition on encoding fluency showing a significant main effect of condition ($F(2,51)=3.88$, $p<.05$). Post-hoc tests suggested that adults thought articles in the HI-LCO condition were more difficult than articles in the HI-HCO condition ($d=-2.25$, $SE=1.15$, $p=0.05$) and the LI-HCO condition ($d=-4.69$, $SE=1.92$, $p<.05$). However, articles in the HI-HCO condition were equivalent with articles in the LI-HCO condition in terms of encoding fluency ($d=2.44$, $SE=1.87$, $p=0.20$). There was also a significant effect of condition on the perceived amount of new information ($F(2,51)=123.45$, $p<.001$). Post-hoc tests further showed that participants thought there was more new information in the HI-LCO condition than the HI-HCO condition ($d=7.44$, $SE=2.00$, $p<.001$) and the LI-HCO condition ($d=49.36$, $SE=4.12$, $p<.001$). Adults also rated that there was more new information in the HI-HCO condition than the LI-HCO condition ($d=41.92$, $SE=3.66$, $p<.001$). Condition also had an effect on perceived learning ($F(2,51)=96.69$, $p<.001$). Post-hoc tests further showed that participants thought that they learned more in the HI-LCO condition than the HI-HCO condition ($d=5.59$, $SE=1.96$, $p<.01$) and the LI-HCO condition ($d=42.84$, $SE=4.10$, $p<.001$), and adults thought that they learned more in the HI-HCO condition than the LI-HCO condition ($d=37.25$, $SE=3.61$, $p<.001$).

Finally, there was a significant effect of condition on comprehension performance ($F(2,36)=3.66$, $p<.05$). Adults tended to perform better in the LI-HCO condition than the HI-

HCO condition (*d*=0.12, *SE*=0.05, *p*<.05) and the HI-LCO condition (*d*=0.11, *SE*=0.04, *p*<.01). There was no difference in performance between the HI-LCO condition and the HI-HCO condition (*d*=0.01, *SE*=0.05, *p*=0.87).

The next set of analyses was to examine whether age moderated the effect of condition on the three ratings using the mixed effects models (PROC MIXED in SAS). Contrast coding was used to examine the differences between conditions. The first contrast (Con 1) was to examine the difference between high-information conditions (averaging the HI-LCO and HI-HCO) and low-information condition, and the second contrast (Con 2) was to examine the effect of conceptual overlap between the two high-information conditions (the HI-LCO vs HI-HCO condition). Overall, there were no age x condition interactions on encoding fluency (Con 1 x age: *Est*=-1.14, *SE*=0.90, *t*=-1.26, *p*=0.21; Con 2 x age: *Est*=0.20. *SE*=0.79, *t*=0.26, *p*=0.80) and the perceived amount of new information (Con 1x age: *Est*=1.94, *SE*=2.22, *t*=0.87, *p*=0.39; Con 2 x age: *Est*=-0.13, *SE*=1.94, *t*=-0.07, *p*=0.95) and perceived learning (Con 1 x age: *Est*=4.01, *SE*=2.16, *t*=1.86, *p*=0.07; Con 2 x age: *Est*=0.12, *SE*=1.89, *t*=0.06, *p*=0.95). There were no age differences in the condition effects on ratings of proximal cues or perceived learning.

4.2.2 The Effects of Condition on the Changes in Monitoring

Mixed effects models (PROC MIXED in SAS) were used to analyze how the ratings changed across articles in three conditions article by article (Estimates of parameters are in Table 7). The same contrast coding was used to examine the effects of condition.

Results showed that reading ease increased across articles in the LI-HCO condition more than in the other two conditions (*t*=-3.05, *p*<.01). However, there was no difference in the changes in reading ease between the HI-LCO and HI-HCO conditions (*t*=-0.44, *p*=0.66) (See

Figure 4a for the average ratings of encoding fluency as a function of articles in three conditions). On the other hand, the perceived amount of new information decreased across articles more in the LI-HCO condition than the other two conditions (*t*=8.56, *p*<.001). There was also no difference in the changes of the perceived amount of new information between the HI-LCO condition and HI-HCO condition (*t*=-0.25, *p*=0.80) (See Figure 5a for the average ratings of the perceived amount of new information with progression through the articles in the three conditions). Similarly, perceived learning also decreased across the articles more in the LI-HCO condition than the other two conditions (*t*=7.62, *p*<.001). The changes in perceived learning did not differ in the HI-LCO condition and HI-HCO condition (*t*=0.72, *p*-0.47) (See Figure 6a for the average ratings of perceived learning as a function of articles in three conditions). So generally it appeared that perceived learning tracked the changes in new information and not fluency (as measured by reading ease).

4.2.3 The Cues used in Perceived Learning

To further investigate the cues used to judge perceived learning, an analysis was done to test how changes reading ease and the perceived amount of new information predicted the changes in perceived learning article-by-article using the linear mixed effects models. Results showed that the perceived amount of new information was the dominant cue used to judge perceived learning (*Est*=0.78, *SE*=0.01, *t*=61.48, *p*<.0001), but that reading ease was not (*Est*=-0.04, *SE*=0.03, *t*=-1.24, *p*=0.21).

Mixed effects models were used to examine whether age moderated the effects of encoding fluency and the perceived amount of new information on perceived learning (Estimates of parameters were summarized in Table 8). Standardized age was entered in the model to reduce the collinearity issue. There was a significant interaction of age and encoding fluency on perceived learning (t=2.00, p<.05). As shown in Figure 7, as reading ease increased, perceived learning decreased for adults who were younger, and increased for older (Noted that the analysis of age was based on the continuous variable, and the figure plotted two points representing the participants one standard deviation younger and older from the mean age). These findings suggest that younger adults thought that they learned less if they perceived the articles to be easier to read, but older adults did not.

There was also a significant interaction of age and the perceived amount of new information (t=2.65, p<.01). As shown in Figure 7, when the perceived amount of new information increased, perceived learning increased more for older than younger adults. In other words, older adults relied slightly more on the perceived amount of new information to judge perceived learning than the adults at younger ages.

4.3 CONCLUSION

Results from Study 1 successfully validated the text manipulation in three conditions such that adults perceived that the LI-HCO condition had less new information than the HI-HCO and HI-LCO conditions did. Also, averaging ratings from six articles in one condition, adults tended to perceive that the LI-HCO and HI-HCO conditions were easier than the HI-LCO condition. Interestingly, averaging six articles, adults even rated articles in the HI-HCO condition overall as easy as those in the LI-HCO condition. Even if there was much more new information in the HI-HCO condition than the LI-HCO condition, conceptual overlap induced encoding fluency for learners to comprehend information in the HI-HCO condition and the LI-HCO condition equivalently. Therefore, as expected, when manipulating the amount of new information and conceptual overlap across articles, adults perceived more new information and lower encoding fluency in the HI-LCO condition; more new information and higher encoding fluency in the HI-HCO condition, and less new information and higher encoding fluency in the LI-HCO condition.

In addition, adults perceived that they learned more in the HI-LCO and HI-HCO conditions than in the LI-HCO condition. The performance on comprehension questions, however, showed the reverse pattern, such that accuracy was higher in the LI-HCO condition than the two other conditions. However, the comprehension questions were not able to fully estimate the amount of information participants learned in each topic; rather, this procedure was just a manipulation check to confirm that adults understood the basic information. Therefore, although adults perceived that they learned more in the high-information conditions, their accuracy in comprehension was not as good as one in the LI-HCO condition. Paraphrase (LI-HCO) helped adults to learn the information.

Also, adults used the perceived amount of new information as the cue to judge perceived learning, especially for adults at older ages. The findings from reading ease suggest that adults at older age tend to relate encoding fluency to perceived learning relatively more. However, younger adults tended to rate perceived learning as lower when the articles were easier to read. Thus, the results from Study 1 suggested that amount of new information was more central for learners to judge how much they were learning than fluency. I will return to this issue in the Discussion.

In the following chapter, a series of text foraging studies were conducted to examine the relationship among perceived learning, cues for learning, resource allocation, actual learning performance and individual differences, in which adults needed to optimize their learning by making the decisions about how much they would like to learn for each topic under a limit of time.

CHAPTER 5.

TEXT FORAGING STUDIES (STUDY 2-5)

The text foraging task was designed to examine how adults regulate their learning by searching multiple texts. In the study, participants were asked to learn information about a health domain under *a time limit*. Their goal was to learn as many “facts” about a topic as possible instead of memorizing details. To create an analogue of the patchy environment in foraging, a topic (composed of a series of articles) was used to operationalize the information patch. Once a topic was chosen, a series of articles varying in the amounts of new information and conceptual overlap were available for learning. Articles were presented one at a time and in a fixed order. After reading one article, participants made the decision to keep reading the next article under the current topic (exploitation), or go to other topics to read (exploration).

A series of studies was conducted across consecutive weeks on the Amazon Mechanical Turk website as well as in the lab (See Table 5 for a summary of studies). There have been more and more behavioral studies conducted on the platform of Amazon Mechanical Turk (e.g., Buhrmester, Kwang & Gosling, 2011; Mason & Suri, 2012). The advantages of Amazon Mechanical Turk include the inclusion of a large and heterogeneous sample (relative to the college students), lower cost and quick iteration for testing and developing new paradigms. Researchers have found that the data quality and reliability from Mechanical Turk are not inferior to the data collected in the lab (Buhrmester, Kwang & Gosling, 2011; Mason & Suri, 2012). Participants on Mechanical Turk have been found, for the most part, to be conscientious and honest in generating their responses. Given the variability in the sample, researchers have suggested that the use of careful screening methods can enhance data quality and reliability

(Paolacci & Chandler, 2014). In our studies, participants were restricted to be residents of the United States and native speakers of English , who also had achieved good reputations from their past work records (over 95% acceptance rates on Amazon Mechanical Turk and completing more than 500 hits).

All the studies followed similar procedures but varied primarily in the limits on study time. In Study 1, in which participants read all the articles, the average reading time for an article was about 50 seconds ($M_{HI\text{-}LCO}$ = 57.65, *SE* = 3.38; $M_{HI\text{-}HCO}$ = 54.43, *SE* = 3.11; $M_{LO\text{-}HCO}$ = 47.46, *SE* = 3.18). Therefore, to allow participants to read about two-thirds of the articles (12 out of 18 articles), Study 2 was first administered with the study time of 10 minutes. However, in Study 2, participants read much fewer than the anticipated two-thirds of the articles in the study, suggesting that they spent more time reading each article when the task demands changed. Therefore, the study time was extended in Study 3, 4 and 5. The instructions were also modified in Study 3 in an attempt to better motivate the participants to pay more attention to the task and their learning performance. Study 3 was conducted on Amazon Mechanical Turk with the study time of 15 minutes, and Study 4 was later conducted on Amazon Mechanical Turk with the study time of 12 minutes. For Study 5, groups of younger and older adults were recruited to the lab for the 15-minute task. The procedures of Study 3 and Study 5 were the same except that one was conducted through Amazon Mechanical Turk and the other was conducted in the lab. All versions of the instructions (one used in Study 2 and the other used in Study 3~5) were included in the Appendix 3.

5.1 METHOD

5.1.1 Participants

Eighty-four participants were recruited for Study 2, but 48 were excluded because they did not pay attention to the task (reading time per article <15 seconds) or they did not follow the instructions (did not read the articles for 10 minutes). Among the remaining 37 participants (M_{Age}=38.05, SD_{Age}=11.17, $Range_{Age}$= 21-63 years old; 59.5% female), most (73%) of them had completed college (Mean years of education: 15.56 years, SD=1.91). Forty-eight participants were recruited for Study 3, but 10 were excluded because they did not pay attention to the study (reading time per article< 15 seconds) or did not follow the instructions (did not read the articles). Among the 38 participants (M_{Age}=37.45, SD_{Age}=12.61, $Range_{Age}$= 21-69 years old; 57.9% female), 65% of the participants had completed college (Mean years of education: 15.40 years, SD=2.46). Thirty participants were recruited for Study 4, but 13 were excluded from the analysis because they did not pay attention to the study (reading time per article < 15 seconds) or did not follow the instructions (did not read the articles). Among the 17 participants (M_{Age}=40.00, SD_{Age}=11.06, $Range_{Age}$= 19-64 years old; 70.6% female), 66% of the participants had completed college (Mean years of education: 15.29 years old, SD=2.14). For Study 5, 18 younger and 20 older adults were recruited. but 1 younger and 1 older adult were excluded because they did not pay attention to the tasks and did not follow the instructions. Data from 17 younger adults (M_{Age}=21.47, SD_{Age}=2.58, $Range_{Age}$= 18-27 years old; 76.5% female; Mean years of education: 14.97 years) and 19 older adults (M_{Age}=71.63, SD_{Age}=4.5, $Range_{Age}$= 64-80 years old; 73.7% female; Mean years of education: 16.24, SD=2.43) were used in the analysis. All descriptive statistics of participants are in Table 4.

5.1.2 Measures

For Study 2, Study 3 and Study 4, the letter comparison test (Salthause, 1991) was used to measure processing speed and ETS Advanced Vocabulary task (Ekstrom et al., 1976) was used to measure verbal ability. Given the affordance of the online testing, letter comparison test was modified by measuring the time adults spent to complete a test. Participants needed to do the test twice with two versions of the stimuli. Performance was measured by averaging the time adults took to complete the letter comparison tests. Therefore, longer times represent worse performance.

For the Study 5, which was conducted in the lab, in addition to the above measures, two measures were added, including the pattern comparison test (Salthouse, 1991) to assess processing speed and the reading span task (Stine & Hindman, 1994) to assess working memory.

5.1.3 Materials

The materials used in the formal task were the same as the materials in the Study 1. Details of the text materials were described in Chapter 3.

In the practice task, there were 15 shorter articles about animal (length about 80 to 90 words). There were three topics, Big Cats, Wild Horses and Great Apes, with five articles in each topic. Wild Horses was designed to replicate the manipulation of the LI-HCO condition (low information high conceptual overlap) with ideas being introduced repeatedly over articles. There were no specific manipulations on the other two topics except to introduce different ideas in each article.

5.1.4 Experimental Design

The within-subject variable was the Condition of patch types (The HI-LCO condition, HI-HCO condition and LI-HCO condition). Although participants were not required to read all the topics, the presentation of topics in the three patch types was balanced. Given the selection order, one of the three conditions was assigned accordingly. There were six sequences of assignments of patch types to topic (See Table 9). Participants were assigned to one of the six sequences in a counterbalanced order. This assignment was to assure that participants would be exposed to three conditions equivalently regardless of the topics they selected.

5.1.5 Procedure

When a participant logged into Mechanical Turk, s/he was presented with a consent form, and then completed a demographic questionnaire. For the main task, the goal was to learn as much information as possible under a limit of time. Participants started with a practice task with the topic of "animal" (Figure 8a) under a limit of time (3 minutes for Study 2, 4 minutes for Study 4, and 5 minutes for Study 3, 5). Participants could select the topic to read (Figure 8b), and read each article at their own pace. Articles within each topic were presented sequentially and in the same order across all the participants. After reading an article, participants could decide whether to stay on the same topic and continue reading, or to switch to a different topic (Figure 8c). Once participants switched to a different topic, they could not go back to the visited topics. Participants were told that there were probably more articles than they could completely read within in the limit of time so they should choose carefully so that they could learn as much information as possible.

After reading each article within a topic, participants rated how easy was it for them to read, how much new information they thought was in the article, and how much they had learned. Participants made three ratings on a scale from 0 to 100 (Figure 8d, 8e, 8f):

1. How easy was this article to read? (0: very difficult; 100: very easy)
2. Including the other articles that you have read today, how much new information was in this article? (0: no new information; 100: completely new information)
3. How much did you learn from this particular article? (0: didn't learn anything at all; 100: learned a lot)

These three ratings were used to estimate encoding fluency, perceived amount of new information, and perceived learning, respectively.

At the end of the practice, participants were administered a cued recall task on the information they had learned from the articles. After the practice, participants followed the same procedures as in the practice, and then completed the experimental task under a limit of time (Study 2: 10 minutes; Study 4: 12 minutes; Study 3 and 5:15 minutes). Participants selected the health topics to read (Figure 8i). After selecting the topic, the first article appeared (Figure 8j). Similar to the practice task, the participant made ratings after reading each article, and then made the decisions to either continue reading by moving to the next article about the same topic, or to go to another topic. At the end of the task, participants were administered a cued recall on the information they had learned from all the articles in the domain, with cues being titles of the three topics. In order to motivate participants to optimize their learning outcome, they received bonus money based on the amount of information they recalled at the end of the study. After the text foraging task, participants completed letter comparison tests and the verbal task. In the Study 5, participants were also administered pattern comparison and reading span tasks at the end.

5.2 RESULTS

To present the results more coherently, the analyses of the four studies are organized by research questions: (1) What are the effects of condition and individual difference variables (such as age, cognitive ability measures) on monitoring (encoding fluency, amount of new information and perceived learning)? (2) What are the effects of condition and individual difference variables on resource allocation (the number of articles read in each topic)? (3) What are the individual differences in the cues used to judge perceived learning? (4) When to stop reading articles in a topic as a function of perceived learning? and (5) What are the effects of condition and individual difference variables on actual learning performance? Each section of analyses would start with the analysis of the major effects. For nested analyses, I only report moderation effects without repeating the lower order effects. The data from Study 2 to Study 5 were used to answer the first four questions. For the last question, only data from Study 5 was used given that not all the participants completed the recall test on Amazon Mechanical Turk. The linear mixed effects models (PROC MIXED in SAS) and the generalized linear mixed effects models (logistic mixed effects models, PROC GLIMMIX in SAS) were mainly used in the analyses.

In the analysis including all four studies (Study 2, 3, 4 and 5), speed of processing was computed by averaging the response time of two letter comparison tests ($\alpha = 0.88$). In the analysis based on data only from Study 5, mechanics was computed by averaging the standardized scores of the pattern comparison tests (processing speed) and the reading span test (working memory). To reduce collinearity, measures of age, speed, mechanics and verbal ability were standardized.

For the analyses below, contrast coding was adopted to test the effects of categorical variables, condition and study time. To test the differences among the three conditions, two contrasts were examined. The first contrast, *Con 1* tested the effect of information by examining the difference between the high-information conditions (averaging data from the HI-LCO and HI-HCO conditions) and the low-information condition (LI-HCO). The second contrast, *Con 2*, examined the effect of conceptual overlap between high-information conditions by examining the difference between the HI-LCO and HI-HCO conditions. To test the differences among the three study times, two contrasts were examined. The first contrast, *Time 1*, tested the difference between shorter study time (averaging data from Study 2 with a 10-minute limit and Study 4 with a 12-minute) and longer study time (averaging data from Studies 3 and 5 with a 15-minute limit). The second contrast, *Time 2*, tested the difference between the two short study times (10-minute limit vs.12-minute limit).

5.2.1 Effects of Conditions on Monitoring

Collapsing across all four studies, participants perceived that articles in the LI-HCO condition were easier than the other two conditions (the HI-LCO and HI-HCO conditions) (Con 1: t=-4.77, p<.05). There was also a marginal significant effect suggesting that learners tended to rate the HI-HCO condition as easier than the HI-LCO condition (Con 2: t=1.71, p=0.08; Table 10). With the analysis separated by different study times (Table 10), each of the studies showed the similar pattern.

Participants accurately perceived that there was more new information in the objectively high-information conditions (HI-LCO and HI-HCO) condition than in the low-information condition (LI-HCO) (See Table 11, Con 1: t=19.19, p<.05). Between the two high-information conditions, participants judged that there was more new information in the HI-LCO condition than HI-HCO condition (Con 2: t= -2.45, p<.05). Similar patterns of results were found in the individual analysis for each of the studies (Table 11 summarized all the estimates of parameters).

Finally, the effects of condition on the judgments of perceived learning were examined. Results showed that participants perceived that they learned more in the high-information conditions (HI-LCO and HI-HCO) than in the low-information condition (LI-HCO) (Con 1: t=16.4, p<.05). However, in this case, there was no difference in the judgments of perceived learning between the HI-LCO and HI-HCO conditions (Con 2: t=-0.82=0.41). Similar patterns of results were also found in the individual analyses on the studies with different study times (Table 12 summarized all the estimates of parameters).

5.2.1.1 Effects of study time

The next analyses examined the effects of study time and condition on the three ratings (Table 13 summarizes all the estimates of parameters). First, learners rated LI-HCO condition as being easier to read than the other two conditions, and the HI-HCO condition as being easier to read than the HI-LCO condition. There was no interaction with study time suggesting that the effects of condition on ease of processing were robust (Con 1 x Time 1: t=-0.06, p=0.95; Con 2 x Time 1: t=0.77, p=0.44; Con 1 x Time 2: t=0.85, p=0.40; Con 2 x Time 2: t=0.57, p=0.57).

Participants perceived that there was the most new information in the HI-LCO condition, followed by the HI-HCO condition, and the least new information in the LI-HCO condition. However, when time was longer, the difference between the high- and low-information conditions was larger (Con 1 x Time 1, t=-2.44, p<.05), suggesting that adults were more sensitive to the difference in the amount of new information when the study time was ample.

Similar to the findings of the perceived amount of new information, participants perceived that they learned more in the high-information conditions than in the low-information condition (*t*=14.17, *p*<.05), but the difference was bigger when study time was larger (Con 1 x Time 1: *t*=-2.34, *p*<.05).

5.2.1.2 Individual Differences

There was a marginal age x condition interaction for ease of processing, suggesting that between the two high-information conditions, adults at older ages rated articles with high conceptual overlap as easier than those with low conceptual overlap (i.e., HI-HCO > HI-LCO). However, there was no age difference in rating the low-information condition as the easiest among the three conditions (Con 1: *t*=-5.22, *p*<.001; Con 2: *t*=1.79, *p*=0.07; Con 1 x Age: *t*=-1.27, *p*=0.21; Con 2 x Age: *t*=1.87, *p*=0.06). As shown in Figure 9, participants perceived that articles in the low-information condition were easier than the other conditions regardless of age. However, between the high-information conditions, adults at younger age perceived that articles with high conceptual overlap were as difficult as ones with low-conceptual overlap. Thus, adults at older age may experience more benefit on encoding fluency from conceptual overlap.

None of the Age x Condition interactions on the perceived amount of new information were significant, suggesting that adults rated perceived new information similarly regardless of ages (Con 1: *t*=-19.1, *p*<.001; Con 2: *t*=-2.43, *p*<.05; Con 1 x Age: *t*=0.25, *p*=0.80; Con 2 x Age: *t*=0.6, *p*=0.55). There were also no age x condition interactions on perceived learning, suggesting that adults rated perceived learning similarly regardless of age (Con 1: *t*=16.49, *p*<.001; Con 2: *t*=-0.64, *p*=0.52; Con 1 x Age: *t*=1.06, *p*=0.29; Con 2 x Age: *t*=0.96, *p*=0.34).

5.2.1.3 Changes in ratings with Progression through the Articles

The changes in ratings of ease of processing, the perceived amount of new information and perceived learning over the sequence of articles (i.e., order) were examined (Estimates of parameters were summarized in Table 14). While ease of processing increased over articles (t=3.79, p<.05), the perceived amount of new information and perceived learning decreased (t=-20.8, t=-18.12 respectively, p's<.05). Further, as expected, ease of processing increased more in the low-information condition than in the high-information conditions (t=-3.79, p<.05). The perceived amount of new information and perceived learning showed the opposite pattern, decreasing more in the low-information condition than in the high-information conditions (t=16.05, t=13.33 respectively, p's <.05) (See Figure 4, 5 and 6). The relationship among these three ratings over articles will be discussed in the later sections. Similar to the findings from Study 1, perceived learning seemed to track the changes of the perceived amount of new information over articles rather than ease of processing.

5.2.2 Effects of Condition on Resource Allocation

Similar to Son and Metcalfe (2000), resource allocation was operationalized as the number of articles learners read in each topic. Linear mixed effects models were used to examine how adults allocated their resources to the three conditions under a limit of time. Collapsing across the four studies, the first analysis examined the effects of condition on the number of articles read in each topic (Table 15). As shown in Figure 10, adults tended to read more articles in the high-information conditions than in the low-information condition (Est=0.25, SE=0.10, t=2.36, p<.05), but there was no difference in the number of articles read between the two high-information conditions (Est=-0.01, SE=0.09. t =-0.06, p=0.95).

5.2.2.1 Effects of study time

The next analysis examined the effects of condition, study time and their interaction terms on the number of articles read in each topic (Table 13, Figure 11). Results showed a main effect of study time such that participants read more articles per topic in Studies 3 and 5 (15 minutes) than in Studies 2 and 4 (10 and 12 minutes, respectively). There was a nonsignificant trend for participants to read more articles in in the high-information conditions than in the low-information condition regardless of the study time (Con 1 x time 1: t=-0.9, p=0.37; Con 1 x time 2: t=0.29, p=0.77). There was another marginally significant interaction of Condition x Study Time suggesting that when time was short, participants read more of the high-information articles when conceptual overlap was high (i.e., HI-HCO > HI-LCO) only under extreme time pressure (Con 2 x time 2: t=-1.87, p=0.06). Thus, as shown in Figure 11, learners generally persevered with a topic when the information content was high, but when time was really short, they tended to favor the condition with higher conceptual overlap.

5.2.2.2 Individual Differences

First, speed and verbal ability did not moderate the effects of condition on the number of articles participants read (Con 1 x Speed: Est=-0.10, SE=0.10, t=-0.99, p=0.32; Con 2 x Speed: Est=0.04, SE=0.09, t=0.44, p=0.66; Con 1 x Verbal: Est=-0.01, SE=0.10, t=-0.07, p=0.95; Con 2 x Verbal: Est=-0.01, SE=0.09, t=-0.14, p=0.89). For the moderation effect of age, there was a marginal Age x Condition interaction suggesting that between the high-information conditions, adults with older ages tended to read more articles when there was high conceptual overlap (i.e., HI-HCO>HI-LCO) (Age x Con 2: t=1.63, p=0.10) (Model 1 in Table 16). Then the interaction of Age x Speed x Condition was tested in the model, there was a trend showing that between the high-information conditions, older adults with lower speed tended to read more articles when conceptual overlap was high (Age x Speed x Con 2: *t*=1.7, *p*=0.09) (Model 2 in Table 16). However, there was no Age x Verbal x Condition interaction in the model (Model 3 in Table 16).

The next analysis examined how study time moderated the effects of age, speed and condition on the number of articles read in each topic (Table 17 summarizes the estimates of parameters; given that verbal ability was not moderating the effect of condition, only age and speed were entered in the model). There was a significant Age x Speed x Condition x Study time interaction on the number of articles read per topic (*t*=-3.51, *p*<.001). To decompose the interaction, the analysis examining the effects of condition, age and speed was conducted in separate models that differed in study time (Table 17).

The Age x Speed x Condition interactions were significant in the intermediate timing study (*t*=-2.89, *p*<.05) (12 minutes) and longer timing study (*t*=2.79, *p*<.05) (15 minutes). In the intermediate timing study, only older high-speed adults selectively persisted when conceptual overlap was high and information was high (Figure 12a and Figure 12b). When the time was longer, older low-speed adults would also persist when conceptual overlap was high (Figure 12d), but not for adults with high speed of processing.

5.2.3 Cues for Perceived Learning

To examine how ease of processing and perceived new information were used as cues in the judgments of perceived learning, mixed effects models were used. The first analysis examined the effects of ease of processing and perceived new information on perceived learning of each article (Model 1 in Table 19). Both the perceived amount of new information and ease of processing predicted ratings of perceived learning (*t*=69.31, *p*<.001; *t*=7.31, *p*<.001 respectively), with the perceived amount of new information accounting for more variance than encoding fluency.

5.2.3.1 Effects of study time

Learners also made differential use of cues to judge perceived learning, depending on the study time available. The analysis examined the effects of study time, cues and the interactions of Cue x Study time on the ratings of perceived learning (Model 2 in Table 19). The importance of cues on perceived learning varied with study time. There was a marginal interaction of ease of processing and study time suggesting that encoding fluency was relatively more important as a cue to perceived learning when learning under more time pressure (Time 1 x Ease, t=1.68. p=0.09). However, there were no differences in the relationships between encoding fluency and perceived learning in the 10-minute and 12-minute study. Therefore, when the learning time was not sufficient, adults would weigh encoding fluency more when they made the judgments of learning. There was a Study time x Perceived amount of new information interaction on perceived learning. While perceived new information was the more important cue for judging perceived learning, between the shorter studies (10 and 12 minutes), participants weighed perceived new information more when there was a 12-minute limit relative to a 10-minute limit (t=3.32, p<.001). As shown in Figure 13, with a unit increase in ease of processing, perceived learning increased about 0.1 units. With a unit increase in perceived new information, perceived learning increased about 0.8 units, on average, but this effect was larger for the intermediate time limit. Therefore, adults would rely more on encoding fluency when they were under time pressure. Although there was no difference on the use of perceived new information between sufficient time and shorter time, adults would weigh more on the perceived new formation during the intermediate time.

5.2.3.2 Individual Differences

The next set of analyses was to examine the individual differences in the use of cues for perceived learning. First, there was no moderation effect of age on the use of cues for perceived learning (Model 1 in Table 20). However, after entering verbal ability in the model (Model 2 in Table 20), there was a significant interaction of Age x Verbal ability x Perceived reading ease on the ratings of perceived learning (*Est*=-0.05, *SE*=0.02, *t*=-2.2, *p*<.05). As shown in Figure 14, beyond the fact that adults with lower verbal ability relied on the cue of encoding fluency more to judge perceived learning than the adults with higher verbal ability, among adults with lower verbal ability, older adults tended to rely on the cue of encoding fluency more in judging perceived learning than younger adults. In other words, for adults who were older and with poorer verbal ability, when their perceived encoding fluency increased, their perceived learning increased, but this was not the case for younger adults. However, for adults with higher verbal ability, the reliance of cue of encoding fluency did not change across age. Further, there was a significant interaction of Verbal x Perceived New Information (*Est*=4.53, *SE*=2.28, *t*=1.98, *p*<.05) suggesting that adults with higher verbal ability tended to rely on the cue of the perceived amount of new information more to judge perceived learning than the adults with lower verbal ability (Figure 15).

An analogous analysis with speed entered into the model (Model 3 in Table 20) revealed a marginally significant Age x Speed x Perceived New Information interactions on perceived learning (*Est*=0.03, *SE*=0.01, *t*=-1.94, *p*=0.05). As shown in Figure 16, the finding suggested that among adults with better processing speed, younger adults use the cue of perceived new information more than the older adults to judge their perceived learning. As the perceived amount of new information increased, perceived learning of younger adults increased more than older adults. On the contrary, among adults with lower processing speed, adults used the cue of perceived new information to judge perceived learning similarly across the lifespan.

5.2.4 Leaving a Topic

To answer the question of whether adults stop reading when the rate of perceived learning (information gain) decreases, logistic mixed effects models were used to model the effects of the rates of perceived learning on the likelihood to leave a condition using PROC GLMMIX in SAS. The analysis was based on article-level data. The dependent variable was binary, whether adults continued or stopped reading in one topic. Before doing the analysis, all the last "leaving" decisions in the task were excluded because participants did not choose to leave a topic. Participants were forced to leave a topic because they did not have time to continue reading. Then, among all the last articles in each condition, the data in which the last article was the sixth article in a condition was also excluded. In this situation, participants left the condition because there were no more articles available (32.8% overall; 36.7% in HI-LCO condition, 35.4% in HI-HCO condition; 26.7% in LI-HCO condition). Therefore, more than one-third of the participants read through all the articles in HI-LCO condition and HI-HCO condition, and about a quarter of participants read through all the articles in LI-HCO condition. For the remaining voluntary leaving decisions, logistic mixed effects models were used to model the likelihood to leave a condition as a function of the change in the rate of perceived learning.

5.2.4.1 Different rules

To test the use of different heuristics for discontinuing study of a topic, different rules were defined. The first rule was the “local-one” rule, to represent the hypothesis that adults would be increasingly likely to leave a topic as the perceived learning of the current article relative to the most recent one decreased. The local-one rule was operationalized as the difference in perceived learning between the most recent consecutive pairs of articles (i.e., perceived learning of Article$_N$ – perceived learning of Article$_{N-1}$). The second rule was the “local-two” rule, representing the hypothesis that adults would have an increasing probability of leaving a topic as perceived learning of the two most recent articles decreases relative to the prior two. The local-two rule was operationalized by averaging the differences in perceived learning between Article$_N$ and Article$_{N-1}$ and between Article$_{N-1}$ and Article$_{N-2}$. The third rule was the “global rule,” representing the hypothesis that adults would leave a topic when they consider the change between pairs of consecutive articles from the beginning of the topic (the average difference between Article$_1$ and Article$_2$,…, Article$_{N-2}$ and Article$_{N-1-,}$ Article$_{N-1}$ and Article$_N$).

The first set of analyses was to examine the likelihood of leaving a topic as a function of the change in the rates of perceived learning (using three rules). The three rules were examined separately, with Table 21 summarizing the estimates of parameters and model fits of each model. From the model fit, the local-two rule had the highest model fits relative to the other two rules suggesting that the local-two rule better explained how adults leave a topic based on the reduction in rates of gain (t=-4.76, p<.0001). Local-one rule showed the lowest model fit with a marginal effect (t=-1.85, p=0.06). Results suggested that adults tended to leave a topic after the reduction in perceived learning from two consecutive articles.

5.2.4.2 Effects of condition

The next analysis was to examine whether adults used the local-two rule to stop learning differently across conditions. Results showed that there were no interactions between condition and local-two rule on the likelihood of leaving a topic suggesting that adults followed the same rule across three conditions (Con 1 x local-two rule: *Est*=-0.02, *SE*=0.01, *t*=-1.73, *p*=0.08; Con 2 x local-two rule: *Est*=0.002, *SE*=0.01, *t*=0.13, *p*=0.90). The models were further conducted by condition and showed that local-two rule well explained the text-leaving behavior in three conditions (as shown in Figure 17; Estimates of parameters of local-two rule in three conditions, HI-LCO condition: *Est*=-0.06, *SE*=0.02, *t*=-2.62, *p*<.01; HI-HCO condition: *Est*=-0.05, *SE*=0.02, *t*=-2.97, *p*<.01; LI-HCO condition: *Est*=-0.02, *SE*=0.01, *t*=-2.1, *p*<.05).

5.2.4.3 Individual differences

The analysis then focused on individual differences in the likelihood of leaving a condition as a function of change in the rate of perceived learning, such as age, speed of processing and verbal ability (Table 21). There was no interaction between age and the use of the local-two rule on the likelihood to leave a topic, suggesting that the use of local-two rule did not differ across the lifespan (age x local-two rule: *t*=0.05, *p*=0.96). There was a marginal interaction between speed of processing and the local-two rule on the likelihood to leave a topic (speed x local-two rule: *t*=-1.89, *p*=0.06). As shown in Figure 18, adults with lower speed tended to leave the condition as long as the perceived learning of the recent two articles decreased. Adults with better speed were more likely to stay in a topic even if their perceived learning decreased. The verbal x local-two rule interaction was not significant (*t*=0.21, *p*=0.84), suggesting that the use of local-two rules did not vary with adults with different levels of verbal ability.

5.2.5 Actual Learning Performance

Given that not all participants completed the recall task in the Amazon Mechanical Turk studies (Study 2 to Study 4), the following analyses of actual learning performance were based on the recall performance in the Study 5 (N= 36). First, participants generated on average 369 overall words in recall (SD=208; 72 - 1119 words) at the end of the study. Depending on the condition participants had an opportunity to learn a total of 330 to 355 concepts from the three topics. Depending on the order of the topics participants selected and the counterbalance order to which they had been assigned, there were minor differences in the number of concepts available in each condition (172 to 190 unique concepts in the HI-LCO condition; 100 to 106, in the HI-HCO condition; and 56 to 80 concepts, in the LI-HCO condition. Conditional on the topics they selected, the texts in the recall task were first sorted by topics, and then the number of concepts recalled that were contained in the articles was calculated. Since the goal of the task was to learn as much as possible, the raw number of correct concepts recalled was the measure of actual learning performance (*M*=50; *SD*=22.26; *Range:* 13~99). Table 22 summarized the descriptive statistics of the indicators of actual learning performance in each condition for younger and older adults.

Mixed effects models were used to test the effects of condition on the number of correct concepts recalled. Adults tended to recall more correct concepts in the high-information conditions than in the low-information condition (*Est*=3.75, *SE*=1.07, *t*=3.51, *p*<.001). There was no difference between the two high-information conditions (*Est*=0.69, *SE*=0.92, *t*=0.75, *p*=0.46). This pattern was also found when recall was adjusted for the actual number of articles participants read (*Est*=0.83, *SE*=0.27, *t*=3.04, *p*<.01; *Est*=0.16, *SE*=0.24, *t*=0.69, *p*=0.49, for Con 1 and 2, respectively).

5.2.5.1 Memory accuracy

Different from the learning performance (amount of information learned), this analysis examined how well participants learned each topic in terms of the accuracy scores (% concepts recalled per topic). Given the different numbers of concepts available in each condition, for the proportion of correct concepts learned in each condition (i.e., number of correct concepts recalled divided by the number of concepts available in each corresponding condition) and the proportion of correct concepts learned per article in each condition (i.e., the proportion of correct concepts learned divided by the number of articles read in each corresponding condition), both showed significant differences among conditions. When the amount of information was controlled across conditions, participants tended to learn better in LI-HCO condition than in HI-HCO condition, and with the HI-LCO condition being the worst (Proportion of correct concepts in each condition: Con 1 (comparing difference between LI-HCO condition and two other conditions): *Est*=-0.04, *SE*=0.01, *t*=-4.46, *p*<.001; Con 2 (comparing difference between HI-LCO condition and HI-HCO condition): *Est*=0.04, *SE*=0.01, *t*=5.22, *p*<.001; Proportion of correct concepts learned per article: Con 1 (comparing difference between LI-HCO condition and two other conditions): *Est*=-0.01, *SE*=0.003, *t*=-4.25, *p*<.001; Con 2 (comparing difference between HI-LCO condition and HI-HCO condition): *Est*=0.01, *SE*=0.002, *t*=4.4, *p*<.001). These results suggested that conceptual overlap helped adults to learn from texts.

5.2.5.2 Individual Differences

The effects of age and condition on the number of correct concepts recalled in each topic were further examined (Model 1 in Table 18). Results showed that learners recalled more information (learned more) in the HI-LCO condition and the HI-HCO condition than LI-HCO condition (*t*=2.55, *p*<.05). Furthermore, between two high-information conditions (HI-LCO and HI-HCO), an Age x Condition interaction showed that older adults tended to recall more concepts in the HI-HCO condition than the HI-LCO condition suggesting that older adults took more advantage of the conceptual overlap in the HI-HCO condition (*t*=2.06, *p*<.05). Mechanics (speed and working memory) moderated the effects of age and condition (Model 2 in Table 18). First, adults with better mechanics recalled more concepts from the articles (*t*=2.02, *p*<.05), but this was moderated by condition in an Age x Mechanics x Condition interaction (*t*=-2.68. *p*<.05). As shown in Figure 19, among the high-information conditions (the HI-LCO condition and the HI-HCO condition), older adults with poorer mechanics recalled more concepts in the HI-HCO condition than younger adults; on the contrary, younger adults with poorer mechanics recalled more concepts in the HI-LCO condition than older adults. Therefore, older adults took more advantage of conceptual overlap recalling more concepts in the HI-HCO condition than in the HI-LCO condition. There was no Age x Verbal x Condition interaction on the number of correct concepts recalled in each topic (Age x Verbal x Con 1: *Est*=0.005, *SE*=0.04, *t*=-0.1. *p*=0.92; Age x Verbal x Con 2: *Est*=-0.01, *SE*=0.04, *t*=-0.28. *p*=0.78).

5.2.5.3 Relating Perceived Learning to Actual Learning Performance

The next analysis was to examine whether adults were able to generate accurate judgments of their learning performance. Mixed effects models examined the relationship between perceived learning and the actual number of correct concepts recalled per article. In fact, the ratings of perceived learning predicted the actual learning performance (*Est* =0.14, *SE*=0.04, *t*=4.00, *p*<.001). With the effects of condition added to the model, the association between perceived learning and actual learning was shown not to vary across conditions (perceived learning x Con 1: *Est*= 0.02, *SE*=0.06, *t*=0.34, *p*=0.74; perceived learning x Con 2: *Est*=0.03, *SE*=0.05, *t*=0.61, *p*=0.54). In the next model, individual differences in the accuracy of perceived learning, mechanics, verbal ability and age were entered in the model in addition to the effect of perceived learning on the actual learning performance respectively. The accuracy of perceived learning was not different across younger and older adults (age x perceived learning interaction: *Est*=-0.02, *SE*=0.04, *t*=-0.6, *p*=0.55) or for adults with different levels of verbal ability (verbal x perceived learning interaction: *Est*=-0.03, *SE*=0.03, *t*=-0.89, *p*=0.38). There was a marginally significant trend for participants with better mechanics to show stronger associations between perceived learning and actual learning performance compared to adults with lower mechanics (mechanics x perceived learning interaction: *Est*=0.08, *SE*=0.05, *t*=1.77, *p*=0.08). Note that this finding was based on "relative accuracy" instead of "absolute accuracy," given that actual learning performance was not measured after each article (Hertzog, Kidder, Powell-Moman & Dunlosky, 2002). Therefore, it remains unclear to what extent adults would be able to make accurate predictions on the percentages of information they had learned from an article from these analyses.

5.3 CONCLUSIONS

5.3.1 What are the effects of condition on monitoring (encoding fluency, amount of new information and perceived learning)?

Similar to the findings from Study 1, learners perceived that there was more new information in the high information conditions than in the low information condition. Among the high-information conditions, learners also perceived that there was more new information in the condition with low conceptual overlap, and these perceptions were veridical. Learners' ease of processing ratings also patterned mostly as expected. They rated the passages with the least new information as the easiest to process, but on the other hand, they did not generally distinguish between high- and low-conceptual overlap in the high-information conditions as predicted. Learners perceived that they learned more in the high-information conditions than in the low-information one. However, as with encoding fluency, learners did not distinguish between the high and low conceptual overlap conditions. Therefore, results showed that perceived learning tracked mostly with perceived new information. There was no age difference in the perceived amount of new information and perceived learning. Hence, monitoring was preserved with age.

5.3.2 What are the effects of condition on resource allocation (the number of articles read in each topic)?

For resource allocation, learners read more articles in the high-information conditions than the low-information condition suggesting that persistence among readers is largely driven by perceived information uptake. However, when time was extremely limited, there was a trend for learners to allocate differentially more effort to the series of high information texts with high conceptual overlap that enhanced reading fluency (may be easier to read) (e.g., Reader & Payne, 2007; Son & Metcalfe, 2000; Wilkinson, Reader & Payne, 2012). Furthermore, with more time available, similar pattern of differential allocation to high-information conditions with higher conceptual overlap (relative to one with lower conceptual-overlap) was found for adults with older ages and poorer speed of processing. However, when time was relatively limited, the ability to take more advantage of this differential allocation to the HI-HCO condition among adults with older ages was positively associated with speed of processing.

5.3.3 What are the individual differences in the cues used to judge perceived learning?

While the perceived amount of new information was the dominant cue and encoding fluency was a supplementary cue to perceived learning overall, the importance of the cues varied with individual difference variables. The association between perceived learning and perceived amount of new information was stronger for adults with better verbal ability. On the contrary, encoding fluency was weighted more heavily by adults with poorer verbal ability, especially for older adults. Following the agenda-based regulation model (Ariel, Dunlosky & Bailey, 2009), the results also showed that encoding fluency became a more important cue when the study time was more limited beyond the fact that the perceived amount of new information was the more important cue to perceived learning. This finding echoes several previous studies suggesting that adults allocate more effort to learning easier items when the time is limited (e.g., Reader & Payne, 2007; Son & Metclafe, 2000).

5.3.4 When to stop reading articles in a topic as a function of perceived learning?

The likelihood of leaving a topic was influenced by the change in the rate of perceived learning (e.g., Charnov, 1976; Pirolli & Card, 1999). Specifically, participants tended to leave a topic when the rate of perceived learning decreased across two consecutive articles. This did not vary with age.

5.3.5 What are the effects of condition on actual learning performance?

Similar to the patterns of resource allocation, adults recalled more concepts in the high-information conditions relative to the low-information condition. Importantly, when information load was high, older adults tended to show better recall performance when there was high conceptual overlap among passages, especially those with poorer mechanics, even if they did not perceive that they learned more in the high- than low-conceptual overlap high information condition. The results suggested that with the goal to optimize the learning outcome, adult learners appropriately allocated more resources to the high-information conditions in order to maximize the amount of information they learned. This finding that learners selective allocate resource to maximize the information gain was consistent with the previous finding that learners selected more items with higher points in order to maximize the performance (Castel et al., 2002, 2007, 2013). This ability was also preserved with age.

CHAPTER 6.

GENERAL DISCUSSION

This research was motivated by the question, when do learners of different ages discontinue learning in multitext environments. Both theories in animal foraging and metacognition suggested that the mechanism of stop uptaking was associated with the change in the rate of gain. For example, animals would leave a patch when the rate of gain decreased (Charnov, 1976); learners would not restudy an item when the change in the rate of JOLs decreased (Metcalfe, 2002). In this study, by investigating the topic-leaving decision as a function of the rate of perceived learning over sequence of articles, results also showed an interesting parallel that adult learners leave a topic when they perceived that the rate of information gain decreased, especially after they found that they cannot learn much from the most recent two texts. Therefore, this finding suggested the commonalities of the mechanisms of satiety in learning and food foraging. That is, the decision to stop reading when learners felt that they have learned enough from this topic, to some extent, is similar to the decision to stop finding food in the patch when animals have found enough food (cannot find anymore easily) from this patch. Although resources in learning are different from resource in food foraging, models in foraging theory largely account for the relationship between the topic-leaving behavior in learning and the change in the rate of information gain.

6.1 Perceived and actual learning

Such a comparison between topic-leaving decisions for learners and patch-leaving decisions for animals may raise an argument as to whether the perceived rate of information gain used in learning was sufficient to represent the actual rate of information gain. While the literature in text comprehension has suggested that accuracy of judgments of learning is relatively low (30%) in text comprehension relative to word pairs learning (see Maki, 1998, for a review), there is evidence that perceived learning in text comprehension may not veridically reflect actual learning (in terms of the percentage of ideas learners would be able to recall after reading a text). However, a more interesting question is, whether using the rate of actual information gain would be more accurate than using the rate of perceived information gain in understanding topic-leaving behavior in learning. Although the rate of actual information gain was not measured directly in the study, I would argue that the answer is NO. Given that learners are poor at estimating the amount of information they have learned from a text, it would be difficult to argue that they leave a topic based on the actual learning performance. In addition to the fact that the likelihood of leaving a topic was a function of the rate of perceived learning, there was also some indirect evidence from the recall performance at the end of the study suggesting that some adults did not read more articles in the condition which they actually learned better (HI-HCO condition) than the condition they actually learned less but perceived that they learned as much (HI-LCO condition). Therefore, results may suggest that perceived information gain is more important than actual information gain for predicting the decision to discontinue learning. Thus, what made learners continue reading may not be the actual amount of information they gained (which they are really poor at estimating), but how much they perceived they gained.

A recent study in associative learning also considered the role of stopping in learning (Murayama, Blake, Kerr & Castel, 2015). Murayama and his colleagues (2015) examined when learners stop learning from a word list. With the goal to remember as many words as possible, all the participants stopped learning the word list before reaching the end, even though they performed better if they went through the whole list. Murayama and his colleagues (2015) suggested that learners might stop because they felt that they couldn't learn any more, although there was no measure of perceived learning in this study. Their results suggested that learners were using suboptimal strategies in stopping the list earlier. Therefore, instead of actual learning performance, learners may rely on their perceived learning to decide when to stop studying.

6.2 Encoding Fluency vs. the Perceived Amount of New Information

Beyond the hallmark finding in this study that learners discontinue reading when perceived learning decreases, the cues used to gauge perceived learning were also investigated. Some previous studies have shown that learners relate encoding fluency to their judgments of learning, although encoding fluency is a misleading cue for estimating actual learning performance (Dunlosky et al., 2006; Rawson et al., 2002). Interestingly, in our study, although some learners did relate encoding fluency to their learning to a modest degree, the dominant cue to perceived learning was not encoding fluency. Encoding fluency did not contribute to perceived learning alone. Note that the small contribution of encoding fluency to perceived learning was also found in the first study in which participants were not required to actively regulate their learning through selection. Hence, it appears that encoding fluency is only a meaningful cue for adult learners to gauge their learning when they also perceive new information is available.

The dominant cue for judging perceived learning in this study, which has been neglected in the previous literature, is the perceived amount of new information available. Evidence showed that the perceived amount of new information has accounted for most of the variance in perceived learning relative to encoding fluency. Noted that this effect was not due to the order of the prompts for learners to provide their ratings. No matter whether learners provided their judgments of learning after the ratings of encoding fluency (Study 1) or the perceived amount of new information (Study 2~5), perceived learning tracked the perceived amount of new information in all the studies. However, this finding does not mean that learners would perceive that they are learning as long as there is new information in the text. Evidence showed that learners perceived that there was more new information in low- than high-conceptual overlap high information condition; however, there was no difference in their perceived learning between these two conditions suggesting that learners may reach their asymptote to uptake more new information in the condition in which they need to integrate many new ideas with new concepts. Thus, to some extent fluency experience in reading may let learners perceive that they can learn more from the texts.

Further, with perceived new information being the dominant cue and encoding fluency being the secondary cue, the weights of these two proximal cues on perceived learning varied with the task demands and individual differences. The reliance on encoding fluency increased when learners were poor in both cognitive resource (older and with poor verbal ability) and external resource (time pressure), which then resulted in the differential allocation to high-information conditions with more conceptual overlap. Hence, the findings from the current study do not argue that encoding fluency is not important in the monitoring of learning, but rather point to the idea that there are more cues the learners use to gauge their perceived learning.

6.3 The role of age in the decisions to stop learning

First, consistent with previous findings (e.g., Dunsloky et al., 2006), we found that monitoring was preserved with age. There was no age difference in the association between the judgments of perceived learning and actual learning performance.

Further, regarding stopping rules, we found there was no age difference in the use of decision rules to monitor the perceived learning. Like younger adults, older adults left a topic when the perceived learning decreased in the recent two articles.

There were two major findings about age differences in topic-leaving decisions in this study. One was that older adults took more advantages of the conceptual overlap when the information load was high. Despite the fact that adult learners generally favored the high-information conditions over the low-information condition, the benefit of conceptual overlap did not differentiate the learning outcome or resource allocation among younger adults. On the contrary, although older adults perceived that they learned as much in the low conceptual overlap high information condition as they did in the high conceptual overlap high information condition, older adults (especially those with poorer mechanics) read more articles and recalled more concepts in the condition with higher conceptual overlap. The differential advantages of conceptual overlap for older adults to learn in informationally rich texts might be explained by the fact that older readers better utilized the rich contexts and derived benefits from the situation model in text comprehension relative to younger readers (e.g. Shake, Noh & Stine-Morrow, 2009; Stine-Morrow et al., 2004).

The reliance on the situation model processing among older learners may also contribute to their use of encoding fluency as a cue for perceived learning. That is, encoding fluency was a more important cue for perceived learning among older adults with poorer verbal ability than among younger ones. Encoding fluency was likely enhanced by conceptual overlap across texts, in helping readers build more elaborated representations of the situation from a text. Importantly, Dunlosky and Rawson (2005) argued that encoding fluency that arises from situation model processing (as engendered during rereading) is a more accurate cue to perceived learning than encoding fluency that arises from other levels of text comprehension. Although we were not able to differentiate the source of fluency from the ratings, based on the manipulation, encoding fluency was likely influenced by the situation model processing developed from the conceptual overlap across texts. Thus, although similar to the younger, older adults discontinued learning when the rate of perceived learning decreased, some older adults put different weights on the cues to gauge perceived learning.

6.4 Limitations

One limitation of of the study was that the text manipulation might underestimate the effect of encoding fluency on learning. The generation of encoding fluency was manipulated by the conceptual overlap across articles. Although both indices of local and global conceptual overlap (see definitions in Chapter 3, obtained from CohMetrix) showed significant differences across conditions during manipulation, learners should benefit from the coherence between texts more and more as they go over the articles. When participants were required to read all six articles in each topic, encoding fluency was found to be associated with conceptual overlap regardless of the major difference in the amount of new information (HI-HCO and LI-HCO). However, when participants were required to select articles and make decisions to stop learning a topic for another, the difference in encoding fluency between these two conditions appeared. This may because learners did not read through all six articles in one condition in the text foraging study in order to get the most benefits from the conceptual overlap across articles, or because the difference in task demands (reading articles with a learning goal vs. optimizing the amount of information learned by actively selecting articles to read) mitigated the experience of encoding fluency while more attention was paying to the new information. However, this design should not weaken the contribution of the study given that the perceived amount of new information remaining the dominant cue of perceived learning in both norming and text foraging studies.

The second limitation was the prompt used for measuring perceived learning. Although learners discontinued learning when their perceived learning of two consecutive articles decreased, there was a trend that this effect was weaker in the condition in which there was minimum new information and high conceptual overlap. It was surprising that learners continued reading articles in the condition, in which the text was paraphrased repeatedly, even when they put a lower rating on perceived learning. Some participants mentioned that although there was nothing new in that condition, reading more helped them learn more. Indeed adults had the best memory accuracy (i.e., % concepts recalled) in the condition with low information high conceptual overlap than the other two conditions. Therefore, “learning something from this particular article” and “learning something” could be different for readers. The prompt of perceived learning used in the study was “How much did you learn from this particular article” in which learners were asked to relate what they have learned from this article to the previous ones. However, adults may be learning in a topic without learning anything new. Therefore, different prompts of perceived learning will be examined in the future study.

Overall, the findings were consistent with the predictions in foraging models and metacognition and extending the theories by suggesting that learners discontinue reading a topic when perceived learning decreases, such that perceived learning is largely determined by the perceived amount of new information. Given that the assignment of study time was not randomized in the current study, future studies should provide a systematic investigation about the effect of study time on the decisions to stop learning. Further, it would be interesting to explore the effect of different learning goals on the self-regulated learning, such as learning information for a problem-solving or decision-making scenario instead of to optimize the memory for content. The current study established a new paradigm for studying learners' decisions to stop learning, and more research is needed to test the generalizability of these findings.

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TABLES

Table 1.

Comparison of different theoretical models

	Animal foraging paradigm	Metacognition paradigm	Current study (Text/information foraging)
Goal	To gain food	To learn word pairs	To accumulate knowledge (ideas)
Value of resource relative to the goal	Profitability (amount of prey or food return in a patch)	Point values assigned (Castel et al., 2002, 2007, 2013)	Amount of new information (ideas) in a text
Cues (for regulating behavior to reach the goal)	Rate of gain (number of prey as a function of time)	Ease of processing (e.g., Dunlosky, Baker, Rawson & Hertzog, 2006)	Rate of gain (number of ideas uptake as a function of time), encoding fluency.

Table 2.

Three types of patches

	New Information	Encoding Fluency
The HI-LCO condition. High information and low conceptual overlap	High	Low
The HI-HCO condition. High information and high conceptual overlap	High	High
The LI-HCO condition. Low information and high conceptual overlap	Low	Very High

Table 3.

Descriptive statistics of the text properties among three conditions

	HI-LCO condition	HI-HCO condition	LI-HCO condition
Number of words	220.28 (3.06)	220.56 (3.06)	220.28 (3.06)
Number of sentences	13.22 (0.43)	13.39 (0.43)	12.61 (0.43)
Sentence length	16.91 (0.50)	16.69 (0.50)	17.75 (0.50)
Log word frequency (WF)	2.88 (0.03)	2.90 (0.03)	2.91 (0.03)
WF of the content words	2.01 (0.03)	2.03 (0.03)	1.99 (0.03)
Minimum WF	0.79 (0.10)	0.85 (0.10)	0.70 (0.10)
Flesch-Kincaid grade level	10.07 (0.22)	10.19 (0.22)	9.50 (0.22)
Number of new concepts in first article (Same)	43.33 (11.06)	43.33 (11.06)	43.33 (11.06)
Number of unique concepts in all the articles	172~190	100~106	56~80

Table 4.

Descriptive statistics of the participants

	Study 1	Study 2	Study 3	Study 4	Study 5	
	N=52	N=37	N=38	N=17	Young (N=17)	Old (N=19)
Age	38.88 (10.89)	38.05 (11.17)	37.45 (12.61)	40 (11.06)	21.47 (2.58)	71.63 (4.5)
Age Range	23-69	21-63	21-69	19-64	18-27	64-80
Female	46.3%	59.5%	57.9%	70.6%	76.5%	73.7%
Education (yrs)	15.26 (1.88)	15.56 (1.91)	15.40 (2.46)	15.29 (2.14)	14.97 (1.41)	16.24 (2.43)
Verbal	7.98 (3.73)	9.32 (3.21)	9.90 (2.86)	10.19 (2.29)	8.93 (1.66)	10.61 (2.04)
Speed	40.38 (10.34)	41.64 (10.73)	39.54 (10.16)	38.62 (10.15)	34.65 (7.20)	48.42 (10.00)

Table 5.

Summary of the studies

	Goal	Instructions	Study time	Method
Study 1	With the goal of learning, reading and rating 18 articles	Version 1	Unlimited	Amazon Mechanical Turk
Study 2	With the goal to optimize learning outcome, reading articles from three topics under a limit of time	Version 2	10 minutes	Amazon Mechanical Turk
Study 3	With the goal to optimize learning outcome, reading articles from three topics under a limit of time	Version 3	15 minutes	Amazon Mechanical Turk
Study 4	With the goal to optimize learning outcome, reading articles from three topics under a limit of time	Version 3	12 minutes	Amazon Mechanical Turk
Study 5	With the goal to optimize learning outcome, reading articles from three topics under a limit of time	Version 3	15 minutes	Lab

Note. There were minor differences in the instructions of version 2 and version 3. Version 3 emphasized that participants should optimize their learning and pay attention to their reading explicitly. Appendix shows the versions of Instructions.

Table 6.

Study 1: Descriptive statistics for ratings of perceived reading ease, the perceived amount of new information, perceived learning and for comprehension across three conditions

	HI-LCO condition	HI-HCO condition	LI-HCO condition
Reading Ease	79.64 (2.75)	81.89 (2.40)	84.33 (2.13)
The perceived amount of New Information	84.29 (1.97)	76.85 (1.92)	34.93 (2.96)
Perceived Learning	81.35 (2.01)	75.76 (1.84)	38.51 (3.38)
Comprehension (Accuracy scores)	0.83 (0.04)	0.82 (0.04)	0.94 (0.03)

Table 7.

Study 1: Estimates of parameters of the mixed effects models - effects of condition on ratings (reading ease, perceived amount of new information, perceived learning) across order of articles

	Reading Ease		New Information		Perceived Learning	
	Estimate (*SE*)	*t*	Estimate (*SE*)	*t*	Estimate (*SE*)	*t*
Intercept	78.72 (2.50)	31.51*	72.35 (3.05)	23.71*	69.56 (2.95)	23.62*
Order	0.91 (0.34)	2.65*	-8.95 (0.72)	-12.5*	-7.20 (0.65)	-11.01*
Con 1	1.10 (1.09)	1.01	7.33 (2.27)	3.23*	7.24 (2.07)	3.49*
Con 2	1.37 (0.97)	1.41	-2.46 (2.01)	-1.22	-3.42 (1.84)	-1.86†
Con 1 x Order	-0.86 (0.28)	-3.05*	4.99 (0.58)	8.56*	4.06 (0.53)	7.62*
Con 2 x Order	-0.11 (0.25)	-0.44	-0.13 (0.52)	-0.25	0.34 (0.47)	0.72

Note. Contrast coding was used to test the effects of conditions on ratings across the order of articles. Con 1 was to examine the differences between high information (averaging HI-LCO and HI-HCO) and low information (LI-HCO); Con 2 was to examine the effects of conceptual overlap in high-information conditions (HI-LCO and HI-HCO).

* $p<.05$; † $p<0.10$

Table 8.

Study 1: Effects of age on the cues used for perceived learning

	Perceived Learning	
	Estimate (*SE*)	*t*
Intercept	19.88 (4.53)	4.39*
Reading Ease	-0.07 (0.05)	-1.39
New Information	0.78 (0.02)	50.48*
Age	-12.85 (5.73)	-2.24*
Age x Reading Ease	0.12 (0.06)	2.00*
Age x New Information	0.04 (0.02)	2.65*

* *p*<.05; † *p*<0.10

Table 9.

Six sequences of patch types

	1st Topic	2nd Topic	3rd Topic
Sequence 1	HI-LCO	HI-HCO	LI-HCO
Sequence 2	HI-HCO	LI-HCO	HI-LCO
Sequence 3	LI-HCO	HI-LCO	HI-HCO
Sequence 4	HI-LCO	LI-HCO	HI-HCO
Sequence 5	HI-HCO	HI-LCO	LI-HCO
Sequence 6	LI-HCO	HI-HCO	HI-LCO

Table 10.

Estimates of parameters in the mixed effects models by studies– effects of condition on reading ease

		Estimate (*SE*)	*t*
All	Con 1	-4.70(0.99)	-4.77*
	Con 2	1.49 (0.87)	1.71†
Study 2 (10 mins)	Con 1	-5.82 (2.12)	-2.74*
	Con 2	1.56 (1.91)	0.81
Study 4 (12 mins)	Con 1	-3.29 (1.82)	-1.81†
	Con 2	3.28 (1.61)	2.03*
Study 3 & 5 (15 mins)	Con 1	-4.44 (1.25)	-3.54*
	Con 2	1.00 (1.10)	0.91

Note. Contrast coding was used to test the effects of condition. Con 1 was to examine the differences between high information (averaging HI-LCO and HI-HCO) and low information (LI-HCO); Con 2 was to examine the effects of conceptual overlap in high-information conditions (HI-LCO and HI-HCO).

* p<.05; † p<0.10

Table 11.

Estimates of parameters in the mixed effects models by studies– effects of condition on the perceived amount of new information

		Estimate (*SE*)	*t*
All	Con 1	21.61 (1.13)	19.19*
	Con 2	-2.44 (1.00)	-2.45*
Study 2 (10 mins)	Con 1	18.48 (2.17)	8.52*
	Con 2	-2.56 (1.94)	-1.32
Study 4 (12 mins)	Con 1	18.76 (2.12)	8.84*
	Con 2	-2.14 (1.88)	-1.14
Study 3 & 5 (15 mins)	Con 1	24.21 (1.52)	15.89*
	Con 2	-2.48 (1.34)	-1.86†

Note. Contrast coding was used to test the effects of condition. Con 1 was to examine the differences between high information (averaging HI-LCO, HI-HCO) and low information (LI-HCO); Con 2 was to examine the effects of conceptual overlap in high-information conditions (HI-LCO and HI-HCO).

* p<.05; † p<0.10

Table 12.

Estimates of parameters in the mixed effects models by studies– effects of condition on perceived learning

		Estimate (*SE*)	*t*
All	Con 1	18.08 (1.10)	16.4*
	Con 2	-0.80 (0.97)	-0.82
Study 2 (10 mins)	Con 1	12.58 (2.24)	5.63*
	Con 2	0.12 (2.00)	0.06
Study 4 (12 mins)	Con 1	19.08 (2.13)	8.97*
	Con 2	-2.57 (1.88)	-1.36
Study 3 & 5 (15 mins)	Con 1	21.01 (1.39)	15.08*
	Con 2	-0.82 (1.22)	-0.67

Note. Contrast coding was used to test the effects of condition. Con 1 was to examine the differences between high information (averaging HI-LCO, HI-HCO) and low information (LI-HCO); Con 2 was to examine the effects of conceptual overlap in high-information conditions (HI-LCO and HI-HCO).

* p<.05; † p<0.10

Table 13.

Estimates of parameters in the mixed effects models –effects of study time and condition on reading ease, the perceived amount of new information, perceived learning and the number of articles

	Reading Ease		New Information		Perceived Learning		Number of Articles	
	Estimate (*SE*)	*t*	Estimate (*SE*)	*t*	Estimate (*SE*)	*t*	Estimate (*SE*)	*t*
Intercept	77.09 (2.41)	32.03*	44.22 (2.19)	20.23*	44.76 (2.19)	20.39*	4.23 (0.18)	23.32*
Con 1	-4.51 (1.13)	-3.99*	20.44 (1.28)	15.92*	17.52 (1.24)	14.17*	0.20 (0.12)	1.71†
Con 2	1.93 (1.01)	1.91†	-2.36 (1.14)	-2.07*	-1.12 (1.10)	-1.02	-0.05 (0.11)	-0.48
Time 1	2.24 (2.06)	1.09	0.99 (1.62)	0.61	0.24 (1.69)	0.14	-0.59 (0.12)	-5.02*
Time 2	2.13 (2.40)	0.89	-3.58 (1.89)	-1.90†	-3.46 (1.96)	-1.76†	0.13 (0.14)	0.97
Con 1 x Time 1	-0.08 (1.37)	-0.06	-3.78 (1.55)	-2.44*	-3.49 (1.49)	-2.34*	-0.13 (0.14)	-0.9
Con 2 x Time 1	0.92 (1.20)	0.77	0.13 (1.36)	0.1	-0.30 (1.31)	-0.23	-0.03 (0.13)	-0.2
Con 1 x Time 2	1.32 (1.56)	0.85	0.12 (1.77)	0.07	3.35 (1.71)	1.96*	0.05 (0.17)	0.29
Con 2 x Time 2	0.79 (1.39)	0.57	0.29 (1.58)	0.18	-1.37 (1.52)	-0.9	-0.28 (0.15)	-1.87†

Note. Contrast coding was used to test the effects of condition and study time on reading ease, the perceived amount of new information, perceived learning and the number of articles in each condition. Con 1 was to examine the differences between high information (averaging HI-LCO and HI-HCO) and low information (LI-HCO); Con 2 was to examine the effects of conceptual overlap in high-information conditions (HI-LCO and HI-HCO). Time 1 was to examine the difference between shorter times (10 and 12 minutes; averaging Study 2 and Study 4) and longer time (15 minutes; Study 3 and 5); Time 2 was to examine the difference between two short times (10 minutes: Study 2 vs 12 minutes: Study 4).

* p<.05; † p<0.10

Table 14.

Effects of condition on the ratings (reading ease, the perceived amount of new information, perceived learning) across order of articles

	Reading Ease		New Information		Perceived Learning	
	Estimate (*SE*)	*t*	Estimate (*SE*)	*t*	Estimate (*SE*)	*t*
Intercept	74.41 (2.04)	36.43*	79.59 (2.20)	36.26*	75.97 (2.20)	34.54*
Order	1.70 (0.49)	3.79*	-13.69 (0.66)	-20.8*	-11.68 (0.64)	-18.12*
Con 1	-0.81 (1.15)	-0.7	2.89 (1.57)	1.85†	2.93 (1.53)	1.91†
Con 2	0.92 (0.99)	0.93	-1.13 (1.35)	-0.83	-0.80 (1.32)	-0.8
Con 1 x Order	-1.44 (0.38)	-3.79*	8.28 (0.52)	16.05*	6.73 (0.50)	13.33*
Con 2 x Order	-0.01 (0.32)	-0.04	-0.55 (0.43)	-1.28	-0.24 (0.42)	-0.56

Note. Contrast coding was used to test the effects of condition on ratings across the sequence of articles. Con 1 was to examine the differences between high information (averaging HI-LCO and HI-HCO) and low information (LI-HCO); Con 2 was to examine the effects of conceptual overlap in high-information conditions (HI-LCO and HI-HCO).

* $p<.05$; † $p<0.10$

Table 15.

Estimates of parameters in the mixed effects models by studies – effects of condition on the number of articles

		Estimate (*SE*)	*t*
All	Con 1	0.25 (0.10)	2.36*
	Con 2	-0.01 (0.09)	-0.06
Study 2 (10 mins)	Con 1	0.09 (0.20)	0.45
	Con 2	0.22 (0.18)	1.19
Study 4 (12 mins)	Con 1	0.19 (0.26)	0.72
	Con 2	-0.34 (0.23)	-1.48
Study 3 & 5 (15 mins)	Con 1	0.34 (0.13)	2.67*
	Con 2	-0.02 (0.11)	-0.22

Note. Contrast coding was used to test the effects of condition on the number of articles read in each topic. Con 1 was to examine the differences between high information (averaging HI-LCO and HI-HCO) and low information (LI-HCO); Con 2 was to examine the effects of conceptual overlap in high-information conditions (HI-LCO and HI-HCO).

* $p<.05$; † $p<0.10$

Table 16.

Estimates of parameters in the mixed effects models - effects of age, speed, verbal ability and condition on the number of articles

	Model 1		Model 2 (Cog=Speed)		Model 3 (Cog=Verbal)	
	Estimate (*SE*)	*t*	Estimate (*SE*)	*t*	Estimate (*SE*)	*t*
Intercept	3.89 (0.14)	27.54*	3.79 (0.15)	24.91*	3.85 (0.15)	26.33*
Age	-0.02(0.14)	-0.13	0.04 (0.16)	0.27	-0.04 (0.15)	-0.26
Cog			-0.29 (0.16)	-1.9†	0.08 (0.15)	0.56
Age x Cog			0.19 (0.14)	1.37	0.12 (0.16)	0.77
Con 1	0.26(0.10)	2.55*	0.29 (0.11)	2.63*	0.26 (0.10)	2.52*
Con 2	0.004 0.09)	0.05	-0.06 (0.10)	-0.6	0.02 (0.09)	0.27
Age x Con 1	-0.11(0.10)	-1.08	-0.04 (0.12)	-0.34	-0.10 (0.10)	-0.98
Age x Con 2	0.14 (0.09)	1.63†	0.11 (0.10)	1.08	0.16 (0.09)	1.75†
Cog x Con 1			-0.07 (0.11)	-0.63	0.02 (0.11)	0.15
Cog x Con 2			-0.02 (0.10)	-0.21	-0.04 (0.09)	-0.43
Age x Cog x Con 1			-0.11 (0.10)	-1.08	-0.07 (0.11)	-0.63
Age x Cog x Con 2			0.16 (0.09)	1.7†	-0.10 (0.10)	-1.04

Note. Contrast coding was used to test the effects of condition on the number of articles read. Con 1 was to examine the differences between high information (averaging HI-LCO and HI-HCO) and low information (LI-HCO); Con 2 was to examine the effects of conceptual overlap in high-information conditions (HI-LCO and HI-HCO).

**p*<.05; † *p*<0.10

Table 17.

Estimates of parameters in the mixed effects models - Effects of age, speed, study time and condition on the number of articles

	10 Mins		12 Mins		15 Mins		All	
	Estimate (*SE*)	*t*	Estimate (*SE*)	*t*	Estimate (*SE*)	*t*	Estimate (*SE*)	*t*
Intercept	3.28(0.29)	11.19*	3.81 (0.27)	14.06*	4.11 (0.19)	21.37*	4.11(0.19)	21.74*
Subject-Level								
Age	0.38(0.47)	0.82	-0.11 (0.47)	-0.23	-0.003(0.17)	-0.02	-0.003(0.16)	-0.02
Speed (Sp)	-0.14(0.28)	-0.5	0.59 (0.30)	2.00 *	-0.56 (0.20)	-2.76*	-0.56(0.20)	-2.84*
Age x speed	0.25(0.38)	0.67	0.35 (0.44)	0.8	0.19 (0.15)	1.26	0.20(0.15)	1.31
Item-Level								
Con 1	0.21(0.23)	0.88	-0.01 (0.20)	-0.05	0.42 (0.14)	3.01*	0.20(0.12)	1.66†
Con 2	0.39(0.20)	1.91†	-0.28 (0.18)	-1.59	-0.16 (0.12)	-1.32	-0.02(0.11)	-0.15
Time 1							-0.59(0.13)	-4.66*
Time 2							0.15(0.15)	1.05
Con 1 x Time 1							-0.22(0.15)	-1.46
Con 2 x Time 1							0.14(0.13)	1.1
Con 1 x Time 2							-0.11(0.17)	-0.62
Con 2 x Time 2							-0.34(0.15)	-2.29*
Cross-Level Interaction								
Age x Con 1	-0.09(0.37)	-0.23	-0.06 (0.35)	-0.16	-0.06 (0.12)	-0.52	-0.07(0.19)	-0.39
Age x Con 2	0.44(0.32)	1.37	1.04 (0.31)	3.41*	0.02 (0.11)	0.2	0.50(0.17)	2.95*
Speed x Con 1	-0.09(0.23)	-0.4	-0.69 (0.22)	-3.07*	0.07 (0.15)	0.47	-0.23(0.13)	-1.8†
Speed x Con 2	-0.44(0.21)	-2.13*	-0.43 (0.20)	-2.2*	0.14 (0.13)	1.02	-0.24(0.11)	-2.13*
Age x Sp x Con 1	-0.10(0.31)	-0.31	-0.48 (0.33)	-1.45	-0.18 (0.11)	-1.58	-0.25(0.18)	-1.45
Age x Sp x Con 2	-0.36(0.28)	-1.25	-0.83 (0.29)	-2.89*	0.28 (0.10)	2.79*	-0.31(0.16)	-1.99*
Age x Time 1							0.09(0.18)	0.49
Age x Time 2							-0.23(0.25)	-0.94
Sp x Time 1							0.21(0.13)	1.58
Sp x Time 2							0.07(0.16)	0.43
Age x Sp x Time 1							-0.01(0.16)	-0.04
Age x Sp x Time 2							-0.14(0.22)	-0.62
Age x Con 1 x Time 1							-0.01(0.21)	-0.06
Age x Con 2 x Time 1							0.47(0.18)	2.65*
Age x Con 1 x Time 2							0.03(0.28)	0.09
Age x Con 2 x Time 2							0.31(0.25)	1.23
Sp x Con 1 x Time 1							-0.31(0.16)	-1.98*
Sp x Con 2 x Time 1							-0.37(0.14)	-2.72*
Sp x Con 1 x Time2							-0.30(0.18)	-1.66†
Sp x Con 2 x Time 2							0.002(0.16)	0.01
Age x Sp x Con 1 x Time 1							-0.08(0.19)	-0.41
Age x Sp x Con 2 x Time 1							-0.58(0.16)	-3.51*
Age x Sp x Con 1 x Time 2							-0.19(0.26)	-0.72
Age x Sp x Con 2 x Time 2							-0.23(0.23)	-1.01

Note. Contrast coding was used to test the effects of condition and study time. Con 1 was to examine the differences between high information (averaging HI-LCO and HI-HCO) and low information (LI-HCO); Con 2 was to examine the effects of conceptual overlap in high-information conditions (HI-LCO and HI-HCO). Time 1 was to examine the difference between shorter times (10 and 12 minutes; averaging Study 2 and 4) and longer time (15 minutes; Study 3 and 5); Time 2 was to examine the difference between 10-minute and 12-minute study.
* *p*<.05; † *p*<0.10

Table 18.

Study 5: Estimates of parameters in the mixed effects models - effects of age, mechanics and condition on the number of correct concepts

	Model 1 Number of Correct Concepts		Model 2 Number of Correct Concepts	
	Estimate (*SE*)	*t*	Estimate (*SE*)	*t*
Intercept	15.11 (3.41)	4.42*	11.23 (3.63)	3.1*
Age	-0.03 (0.06)	-0.56	0.02 (0.07)	0.29
Mechanics			9.24 (4.57)	2.02*
Age x Mechanics			-0.12 (0.09)	-1.35
Con 1	5.73 (2.24)	2.55*	5.37 (2.44)	2.2*
Con 2	-2.71 (1.87)	-1.44	-5.01 (2.04)	-2.46*
Age x Con 1	-0.04 (0.04)	-1.03	-0.01 (0.05)	-0.32
Age x Con 2	0.07 (0.04)	2.06*	0.09 (0.04)	2.33*
Mechanics x Con 1			-2.67 (3.08)	-0.87
Mechanics x Con 2			7.87 (2.64)	2.98*
Age x Mechanics x Con 1			0.10 (0.06)	1.54
Age x Mechanics x Con 2			-0.14 (0.05)	-2.68*

Note. Contrast coding was used to test the effects of condition on the number of correct concepts recalled in each topic. Con 1 was to examine the differences between high information (averaging HI-LCO and HI-HCO) and low information (LI-HCO); Con 2 was to examine the effects of conceptual overlap in high-information conditions (HI-LCO and HI-HCO).

* $p<.05$

Table 19.

Estimates of parameters in the mixed effects models – cues for perceived learning

	Model 1		Model 2	
	Estimate (*SE*)	*t*	Estimate (*SE*)	*t*
Intercept	-0.66 (1.91)	-0.35	1.54 (2.50)	0.62
Ease	0.14 (0.02)	7.31*	0.12 (0.03)	4.83*
New Info	0.82 (0.01)	69.31*	0.81 (0.01)	54.72*
Time 1			-6.30 (2.80)	-2.25*
Time 2			-9.00 (3.43)	-2.63*
Time 1 x Ease			0.05 (0.03)	1.68†
Time 2 x Ease			0.04 (0.04)	1.16
Time 1 x New Info			0.03 (0.02)	1.49
Time 2 x New Info			0.07 (0.02)	3.32*

Note. Contrast coding was used to examine the effects of study time on perceived learning. Time 1 was to examine the difference between shorter times (10 and 12 minutes; averaging Study 2 and Study 4) and longer time (15 minutes; Study 3 and 5); Time 2 was to examine the difference between two short times (10 minutes: Study 2 vs 12 minutes: Study 4). Ease = encoding fluency. New Info=the perceived amount of new information.

* p<.05; † p<0.10

Table 20.

Estimates of parameters in the mixed effects models – individual differences in the cues for perceived learning

	Model 1		Model 2		Model 3	
	Estimate (*SE*)	*t*	Estimate (*SE*)	*t*	Estimate (*SE*)	*t*
Intercept	-0.001 (1.96)	0	1.32 (2.06)	0.64	1.71 (2.27)	0.75
Subject-Level						
Age	-1.04 (1.86)	-0.56	-0.57 (1.94)	-0.29	-1.09 (2.26)	-0.48
Speed					-0.67 (2.51)	-0.27
Verbal			-2.88 (1.98)	-1.45		
Age x Speed					-1.82 (2.07)	-0.88
Age x Verbal			4.53 (2.28)	1.98*		
Item-Level						
Ease	0.14 (0.02)	6.72*	0.14 (0.02)	6.35*	0.13 (0.02)	5.67*
New Info	0.82 (0.01)	68.14*	0.80 (0.01)	60.7*	0.80 (0.01)	58.62*
Cross-Level Interaction						
Age x Ease	-0.01 (0.02)	0.53	0.02 (0.02)	0.94	0.005 (0.02)	0.2
Age x New Info	-0.01 (0.01)	-0.6	-0.02 (0.01)	-1.6	0.001 (0.01)	0.09
Speed x Ease					0.02 (0.03)	0.99
Speed x New Info					-0.02 (0.01)	-1.47
Verbal x Ease			-0.02 (0.02)	-0.84		
Verbal x New Info			0.05 (0.01)	3.55*		
Age x Speed x Ease					0.0003 (0.02)	0.01
Age x Speed x New Info					0.03 (0.01)	1.94†
Age x Verbal x Ease			-0.05 (0.02)	-2.2*		
Age x Verbal x New Info			0.01 (0.01)	0.65		

* $p<.05$; † $p<0.10$

Table 21.

Estimates of parameters in the mixed effects models – Change in the rate of perceived learning on the likelihood to leave a topic

	Local-one		Local-two		Global	
-2 Log Likelihood	863.61		615.97		861.95	
BIC	869.61		630.57		876.67	
	Estimate (*SE*)	*t*	Estimate (*SE*)	*t*	Estimate (*SE*)	*t*
Intercept	-1.74 (0.10)	-17.73*	-1.71 (0.14)	-12.44*	-1.82 (0.11)	-17.3*
Change in RG	-0.01 (0.004)	-1.85†	-0.03 (0.01)	-4.76*	-0.01 (0.004)	-3.12*
Age			0.15 (0.13)	1.22		
Change			-0.03 (0.01)	-4.74*		
Age x Change			0.0004 (0.01)	0.05		
Speed			-0.11 (0.16)	-0.68		
Change			-0.04 (0.01)	-4.87*		
Speed x Change			-0.02 (0.01)	-1.89†		
Verbal			0.03 (0.14)	0.25		
Change			-0.03 (0.01)	-4.54*		
Verbal x Change			0.002 (0.01)	0.21		

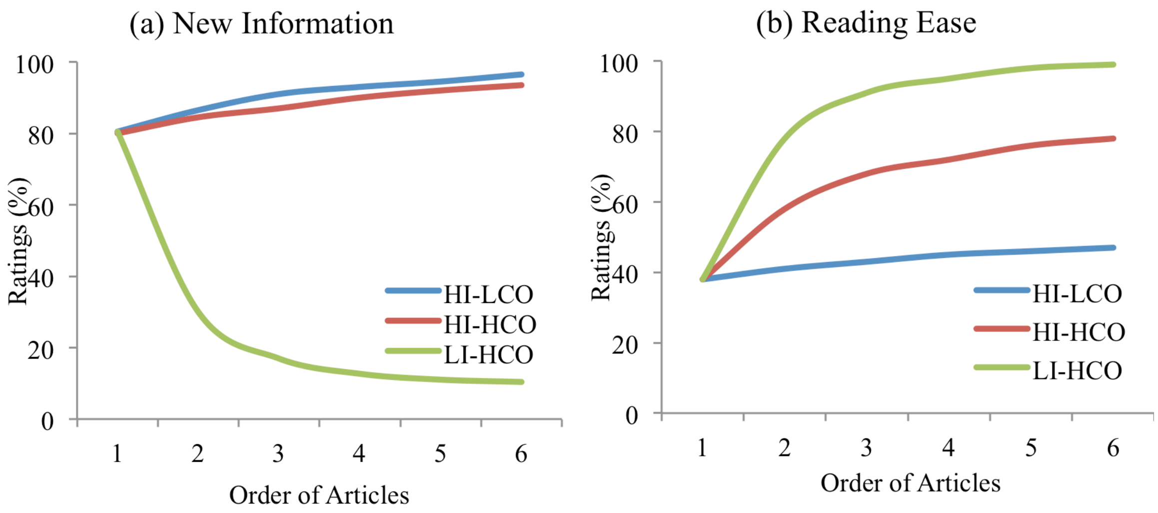
* *p*<.05; † *p*<0.10

Table 22.

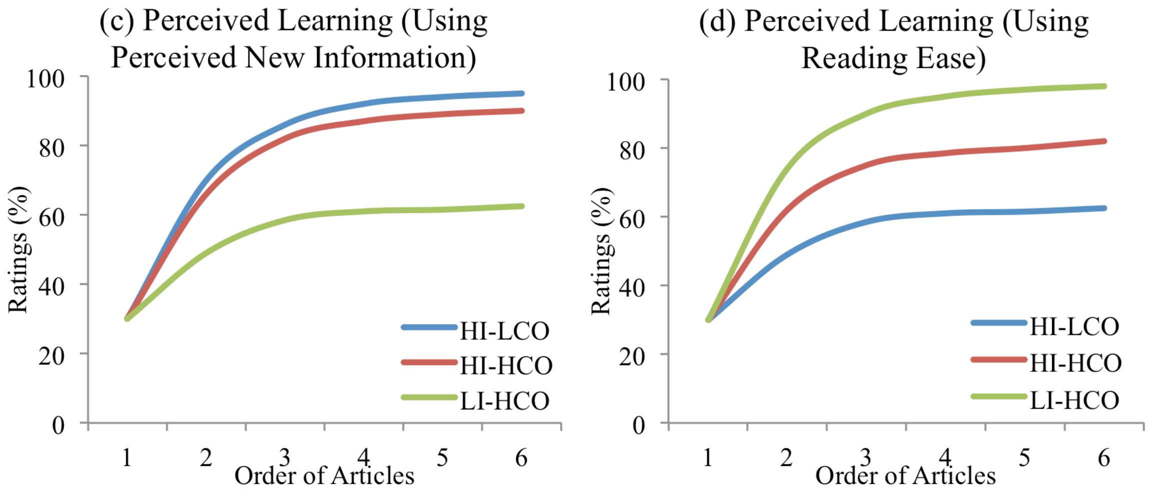
Descriptive statistics of the actual learning performance in Study 5

	Conditions	Young M (SD)	Old M (SD)	All M (SD)
Number of correct concepts recalled	HI-LCO	22.65 (13.13)	14.56 (10.19)	18.49 (12.24)
	HI-HCO	20.65 (10.44)	19.11 (8.36)	19.86 (9.32)
	LI-HCO	14.40 (7.30)	12.74 (5.69)	13.47 (6.40)
% Correct concepts recalled (out of all available in this condition)	HI-LCO	12.83 (7.39)	8.17 (5.83)	10.44 (6.95)
	HI-HCO	20.07 (10.31)	18.67 (8.38)	19.35 (9.25)
	LI-HCO	22.00 (10.93)	21.13 (10.48)	21.52 (10.53)
% Correct concepts recalled per article	HI-LCO	2.58 (1.67)	2.29 (1.73)	2.43 (1.68)
	HI-HCO	4.52 (1.96)	4.54 (2.11)	4.53 (2.01)
	LI-HCO	4.99 (2.80)	5.44 (3.14)	5.24 (2.96)
Total number of words recalled	HI-LCO	175.47 (118.39)	101.56 (80.26)	137.46 (105.93)
	HI-HCO	179.94 (130.71)	135.44 (70.38)	157.06 (105.00)
	LI-HCO	95.73 (45.26)	81.74 (47.85)	87.91 (46.56)
% Words recalled in this condition (out of all recalled)	HI-LCO	41.16 (20.25)	30.30 (19.25)	35.57 (20.21)
	HI-HCO	39.19 (13.89)	44.52 (18.14)	41.93 (16.20)
	LI-HCO	22.28 (8.94)	29.12 (16.01)	26.10 (13.62)

FIGURES


(a) New Information

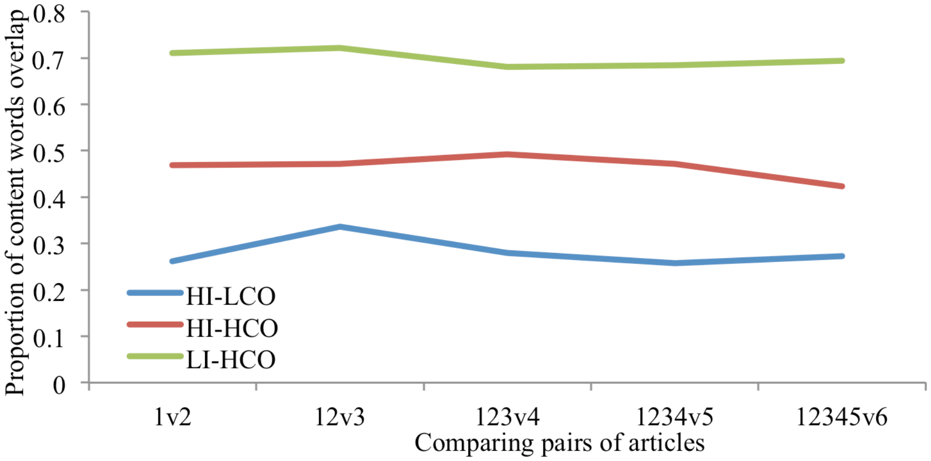
(b) Reading Ease


(c) Perceived Learning (Using Perceived New Information)

(d) Perceived Learning (Using Reading Ease)

Figure 1. (a) The expected perceived amount of new inforamtion, and (b) expected reading ease as a function of the sequence of articles in each condition; (c) Expected rates of perceived learning if adults adopt the cue of the perceived amount of new information in each condition; (d) Expcted rates of perceived learning if adults adopt the cue of reading ease as a function of the sequence of articles in each condition

(a) Global Conceptual Overlap



(b) Local Conceptual Overlap

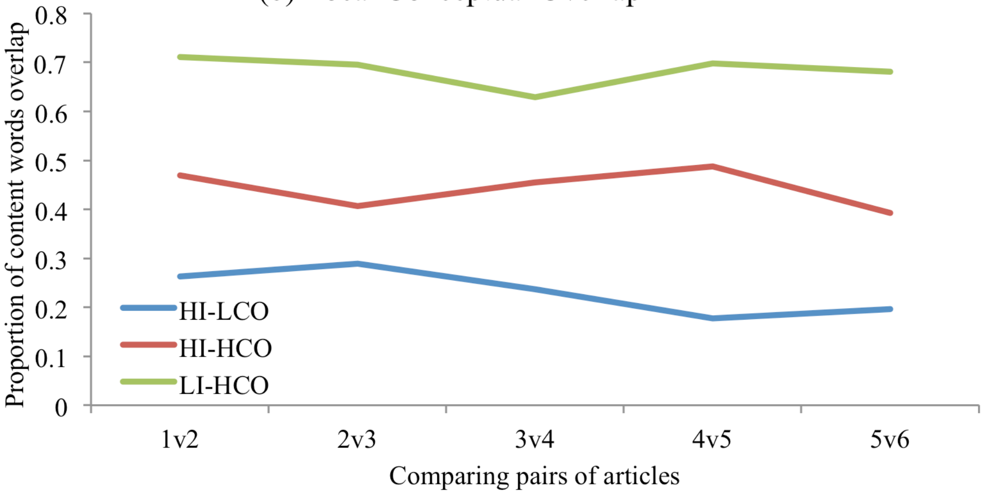
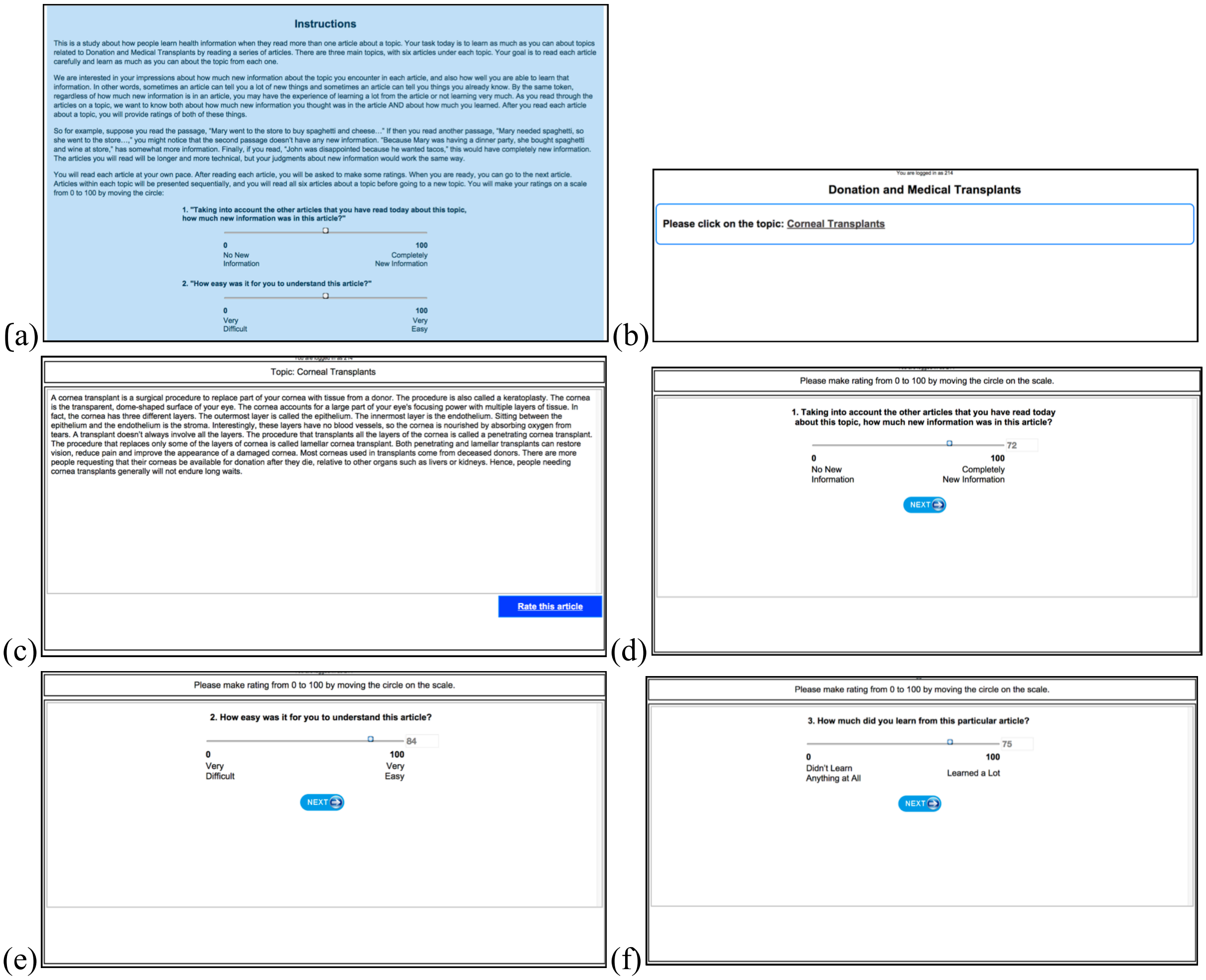


Figure 2. Conceptual overlap across articles. (a) Global conceptual overlap; (b) Local conceptual overlap



(a)

Instructions

This is a study about how people learn health information when they read more than one article about a topic. Your task today is to learn as much as you can about topics related to Donation and Medical Transplants by reading a series of articles. There are three main topics, with six articles under each topic. Your goal is to read each article carefully and learn as much as you can about the topic from each one.

We are interested in your impressions about how much new information about the topic you encounter in each article, and also how well you are able to learn that information. In other words, sometimes an article can tell you a lot of new things and sometimes an article can tell you things you already know. By the same token, regardless of how much new information is in an article, you may have the experience of learning a lot from the article or not learning very much. As you read through the articles on a topic, we want to know both about how much new information you thought was in the article AND about how much you learned. After you read each article about a topic, you will provide ratings of both of these things.

So for example, suppose you read the passage, "Mary went to the store to buy spaghetti and cheese…" If then you read another passage, "Mary needed spaghetti, so she went to the store…," you might notice that the second passage doesn't have any new information. "Because Mary was having a dinner party, she bought spaghetti and wine at store," has somewhat more information. Finally, if you read, "John was disappointed because he wanted tacos," this would have completely new information. The articles you will read will be longer and more technical, but your judgments about new information would work the same way.

You will read each article at your own pace. After reading each article, you will be asked to make some ratings. When you are ready, you can go to the next article. Articles within each topic will be presented sequentially, and you will read all six articles about a topic before going to a new topic. You will make your ratings on a scale from 0 to 100 by moving the circle:

1. "Taking into account the other articles that you have read today about this topic, how much new information was in this article?"

2. "How easy was it for you to understand this article?"

(b)

Donation and Medical Transplants

Please click on the topic: Corneal Transplants

(c)

Topic: Corneal Transplants

A cornea transplant is a surgical procedure to replace part of your cornea with tissue from a donor. The procedure is also called a keratoplasty. The cornea is the transparent, dome-shaped surface of your eye. The cornea accounts for a large part of your eye's focusing power with multiple layers of tissue. In fact, the cornea has three different layers. The outermost layer is called the epithelium. The innermost layer is the endothelium. Sitting between the epithelium and the endothelium is the stroma. Interestingly, these layers have no blood vessels, so the cornea is nourished by absorbing oxygen from tears. A transplant doesn't always involve all the layers. The procedure that transplants all the layers of the cornea is called a penetrating cornea transplant. The procedure that replaces only some of the layers of cornea is called lamellar cornea transplant. Both penetrating and lamellar transplants can restore vision, reduce pain and improve the appearance of a damaged cornea. Most corneas used in transplants come from deceased donors. There are more people requesting that their corneas be available for donation after they die, relative to other organs such as livers or kidneys. Hence, people needing cornea transplants generally will not endure long waits.

(d)

Please make rating from 0 to 100 by moving the circle on the scale.

1. Taking into account the other articles that you have read today about this topic, how much new information was in this article?

72

(e)

Please make rating from 0 to 100 by moving the circle on the scale.

2. How easy was it for you to understand this article?

84

(f)

Please make rating from 0 to 100 by moving the circle on the scale.

3. How much did you learn from this particular article?

75

Figure 3. Layouts of the Study 1

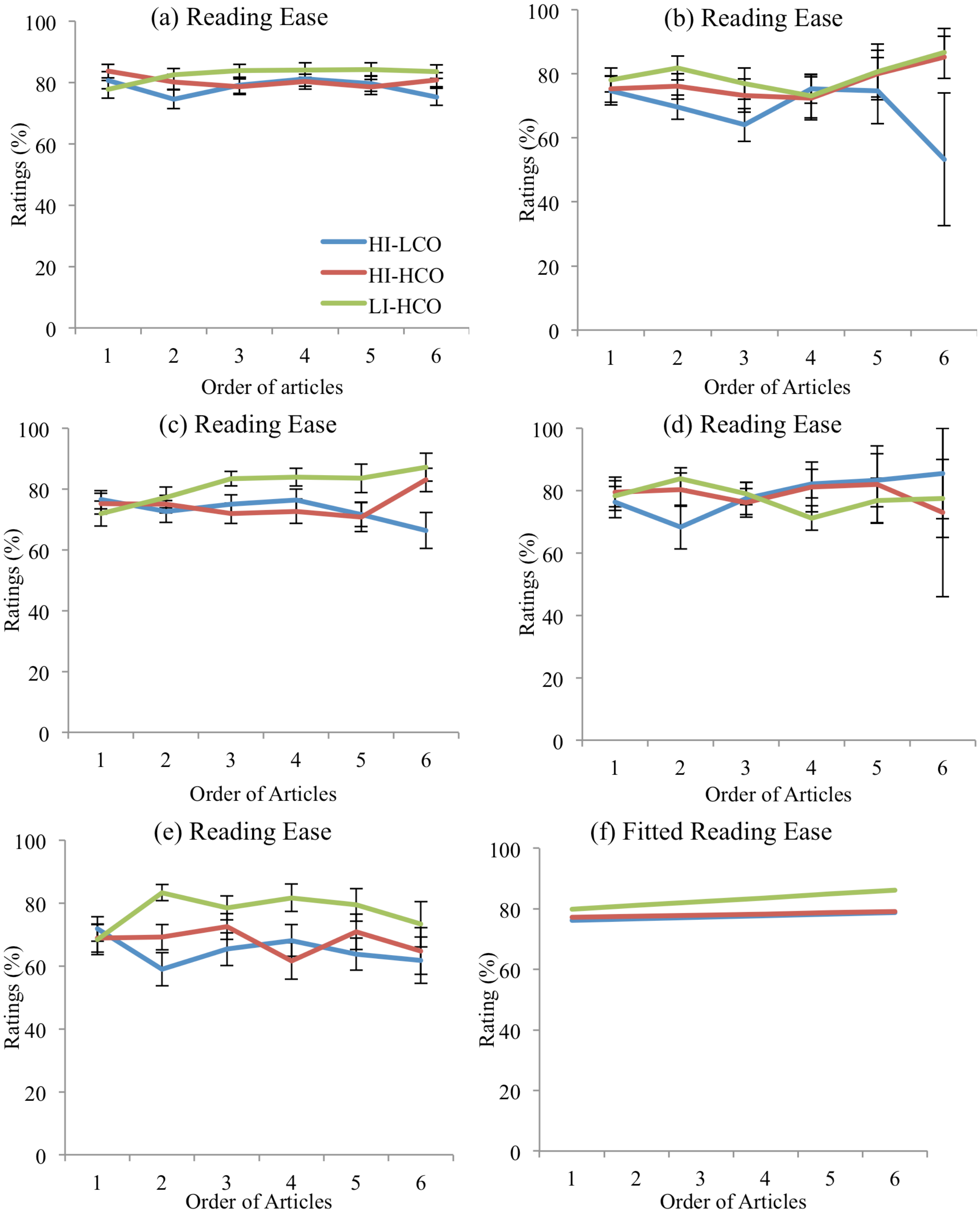


Figure 4. Perceived reading ease from articles on the same topic, as a function of condition. (a) = Study 1; (b) = Study 2; (c) = Study 3; (d) = Study 4; (e) = Study 5; (f) = Fitted reading ease from the model in Table 10.

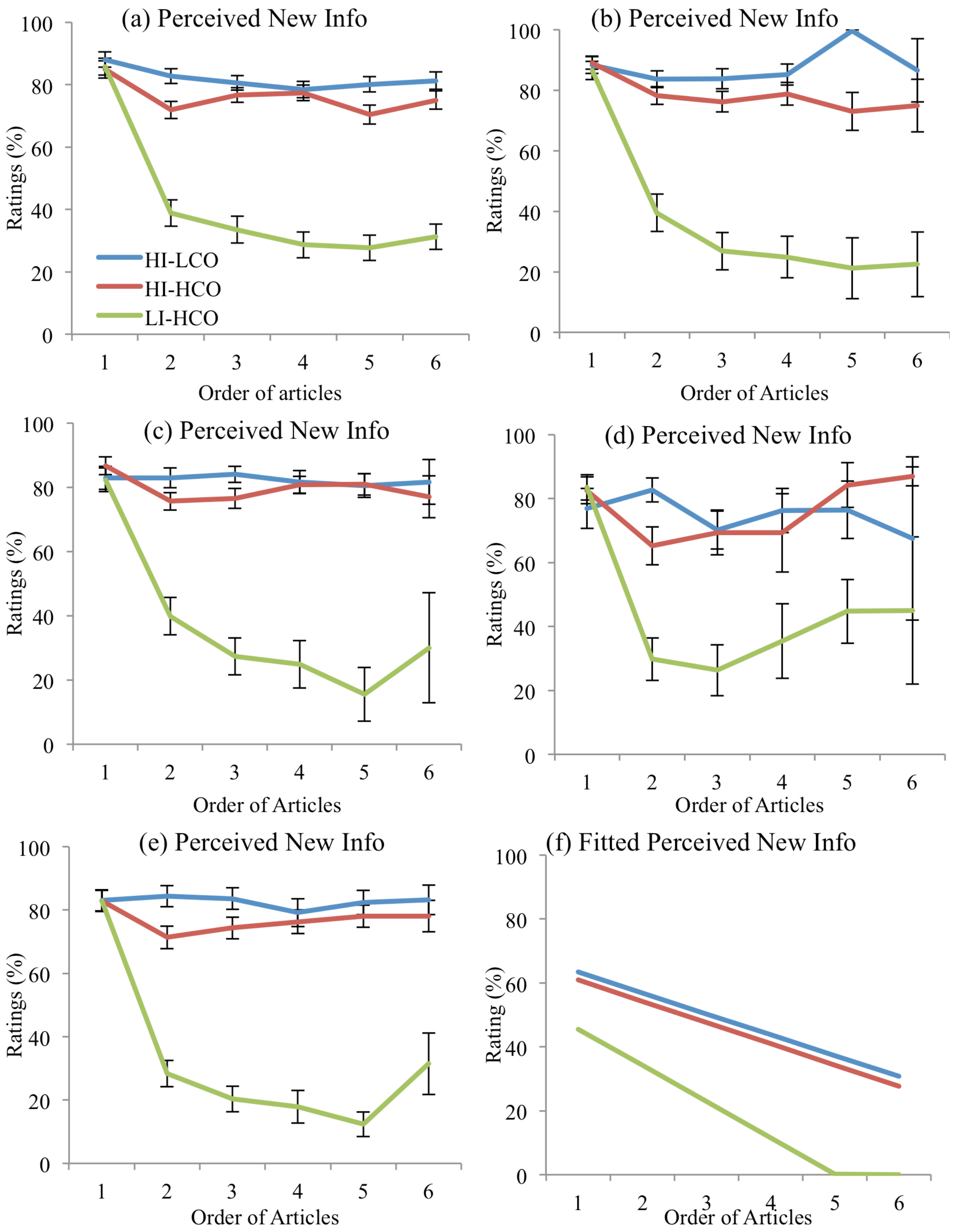


Figure 5. Perceived new information from articles on the same topic, as a function of condition. (a) = Study 1; (b) = Study 2; (c) = Study 3; (d) = Study 4; (e) = Study 5; (f) = Fitted perceived new information from the model in Table 11.

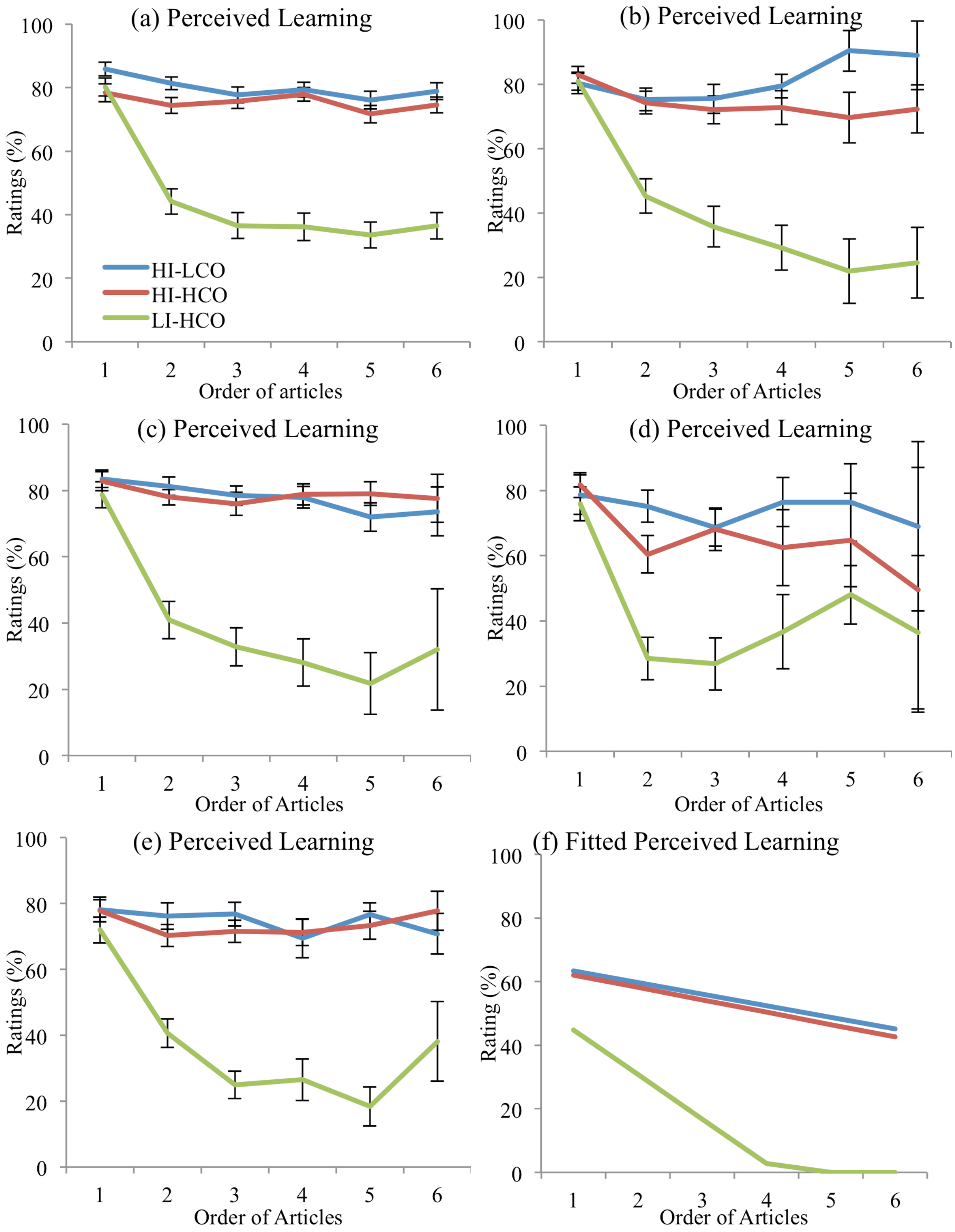
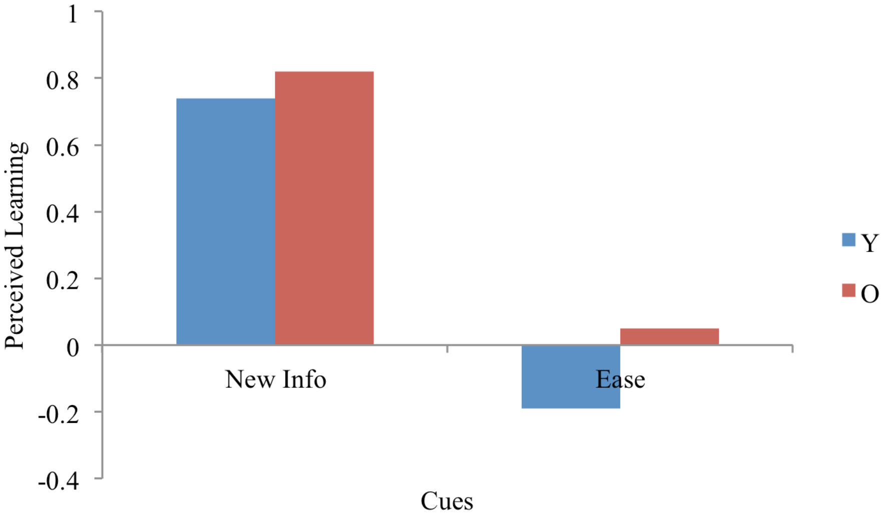
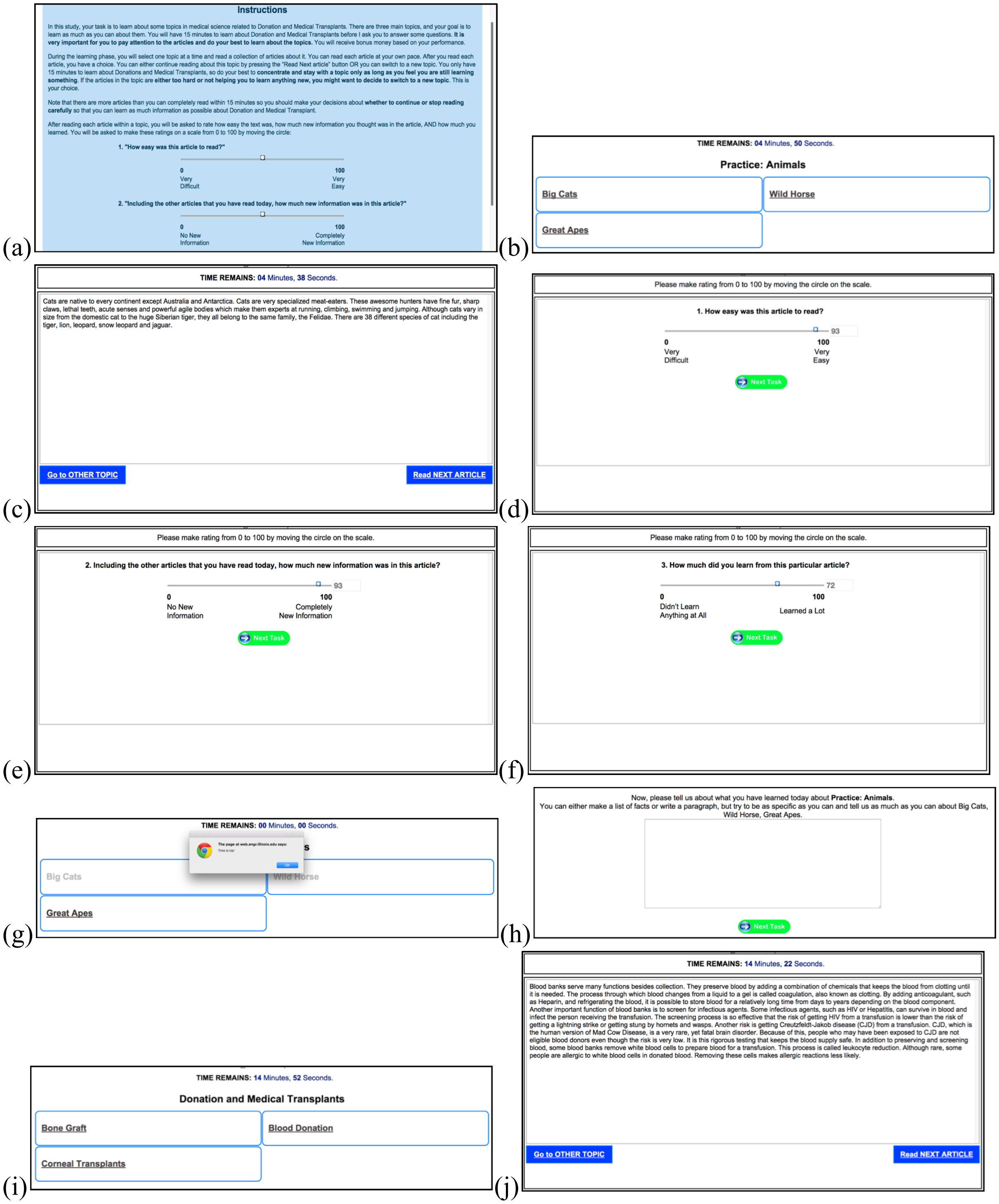


Figure 6. Perceived learning from articles on the same topic, as a function of condition. (a) = Study 1; (b) = Study 2; (c) = Study 3; (d) = Study 4; (e) = Study 5; (f) = Fitted perceived learing from the model in Table 12.



Note. New Info: the perceived amount of new information; Ease: reading ease; Y: younger (mean age – 1SD); O: older (mean age +1 SD)

Figure 7. The amounts of perceived learning changed when a unit of cue (the perceived amount of new information and reading ease) increased



(a)

Instructions

In this study, your task is to learn about some topics in medical science related to Donation and Medical Transplants. There are three main topics, and your goal is to learn as much as you can about them. You will have 15 minutes to learn about Donation and Medical Transplants before I ask you to answer some questions. **It is very important for you to pay attention to the articles and do your best to learn about the topics.** You will receive bonus money based on your performance.

During the learning phase, you will select one topic at a time and read a collection of articles about it. You can read each article at your own pace. After you read each article, you have a choice. You can either continue reading about this topic by pressing the "Read Next article" button OR you can switch to a new topic. You only have 15 minutes to learn about Donations and Medical Transplants, so do your best to **concentrate and stay with a topic only as long as you feel you are still learning something**. If the articles in the topic are **either too hard or not helping you to learn anything new, you might want to decide to switch to a new topic**. This is your choice.

Note that there are more articles than you can completely read within 15 minutes so you should make your decisions about **whether to continue or stop reading carefully** so that you can learn as much information as possible about Donation and Medical Transplant.

After reading each article within a topic, you will be asked to rate how easy the text was, how much new information you thought was in the article, AND how much you learned. You will be asked to make these ratings on a scale from 0 to 100 by moving the circle:

1. "How easy was this article to read?"

2. "Including the other articles that you have read today, how much new information was in this article?"

(b)

TIME REMAINS: 04 Minutes, 50 Seconds.

Practice: Animals

(c)

TIME REMAINS: 04 Minutes, 38 Seconds.

Cats are native to every continent except Australia and Antarctica. Cats are very specialized meat-eaters. These awesome hunters have fine fur, sharp claws, lethal teeth, acute senses and powerful agile bodies which make them experts at running, climbing, swimming and jumping. Although cats vary in size from the domestic cat to the huge Siberian tiger, they all belong to the same family, the Felidae. There are 38 different species of cat including the tiger, lion, leopard, snow leopard and jaguar.

(d)

Please make rating from 0 to 100 by moving the circle on the scale.

1. How easy was this article to read?

93

(e)

Please make rating from 0 to 100 by moving the circle on the scale.

2. Including the other articles that you have read today, how much new information was in this article?

93

(f)

Please make rating from 0 to 100 by moving the circle on the scale.

3. How much did you learn from this particular article?

72

(g)

TIME REMAINS: 00 Minutes, 00 Seconds.

The page at web.engr.illinois.edu says:

Time is Up!

(h)

Now, please tell us about what you have learned today about **Practice: Animals**.
You can either make a list of facts or write a paragraph, but try to be as specific as you can and tell us as much as you can about Big Cats, Wild Horse, Great Apes.

(i)

TIME REMAINS: 14 Minutes, 52 Seconds.

Donation and Medical Transplants

(j)

TIME REMAINS: 14 Minutes, 22 Seconds.

Blood banks serve many functions besides collection. They preserve blood by adding a combination of chemicals that keeps the blood from clotting until it is needed. The process through which blood changes from a liquid to a gel is called coagulation, also known as clotting. By adding anticoagulant, such as Heparin, and refrigerating the blood, it is possible to store blood for a relatively long time from days to years depending on the blood component. Another important function of blood banks is to screen for infectious agents. Some infectious agents, such as HIV or Hepatitis, can survive in blood and infect the person receiving the transfusion. The screening process is so effective that the risk of getting HIV from a transfusion is lower than the risk of getting a lightning strike or getting stung by hornets and wasps. Another risk is getting Creutzfeldt-Jakob disease (CJD) from a transfusion. CJD, which is the human version of Mad Cow Disease, is a very rare, yet fatal brain disorder. Because of this, people who may have been exposed to CJD are not eligible blood donors even though the risk is very low. It is this rigorous testing that keeps the blood supply safe. In addition to preserving and screening blood, some blood banks remove white blood cells to prepare blood for a transfusion. This process is called leukocyte reduction. Although rare, some people are allergic to white blood cells in donated blood. Removing these cells makes allergic reactions less likely.

Figure 8. Layouts of the Text Foraging Study

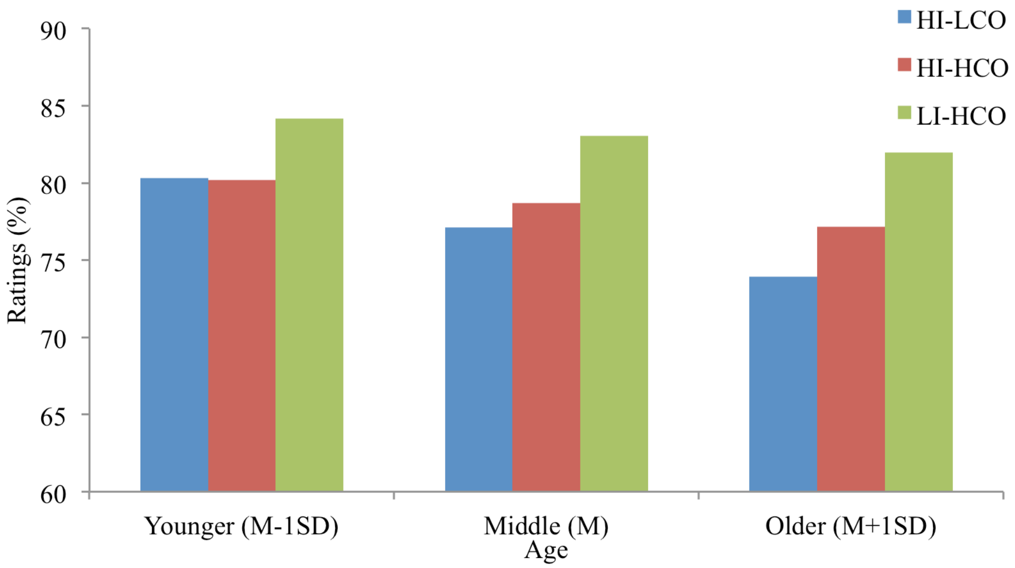


Figure 9. Effects of age and condition on the ratings of reading ease

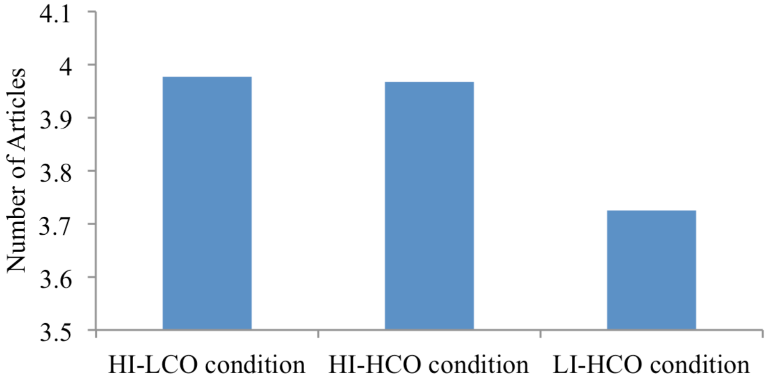


Figure 10. The effect of condition on the number of articles read in each topic

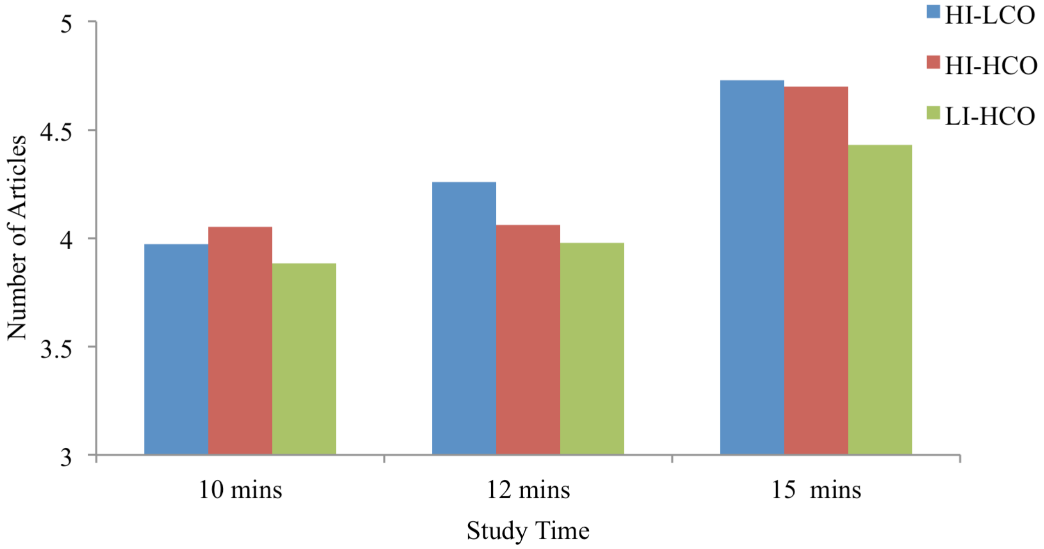


Figure 11. The effects of study time and condition on the number of articles read in each condition

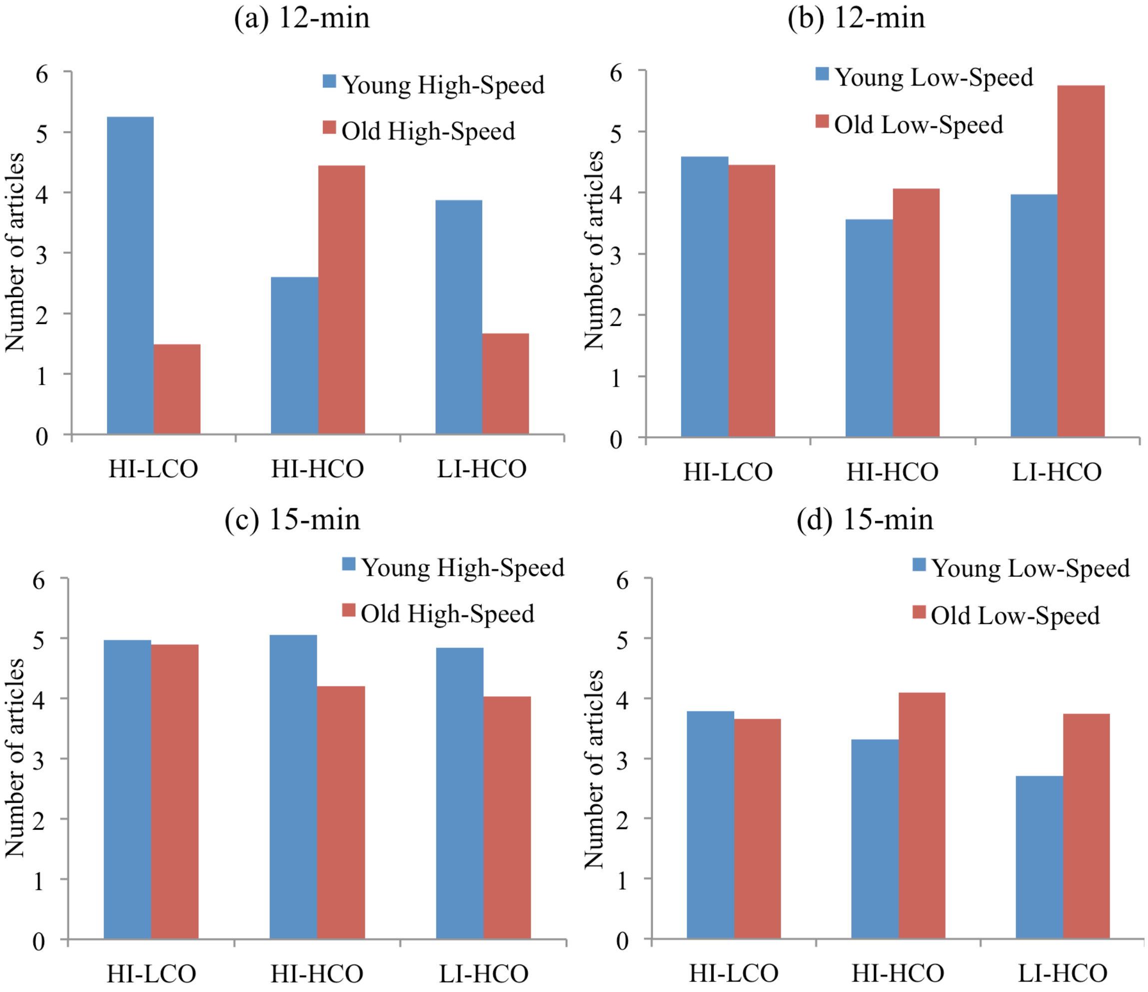


Figure 12. The effects of age, speed of processing (speed) and condition on the number of articles read in each condition varying with the study time

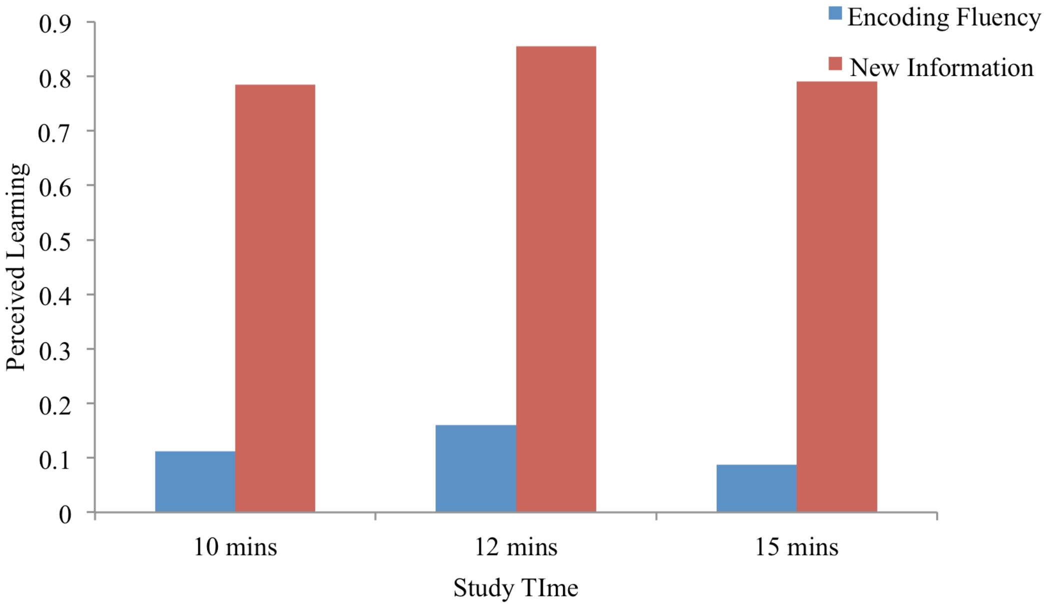
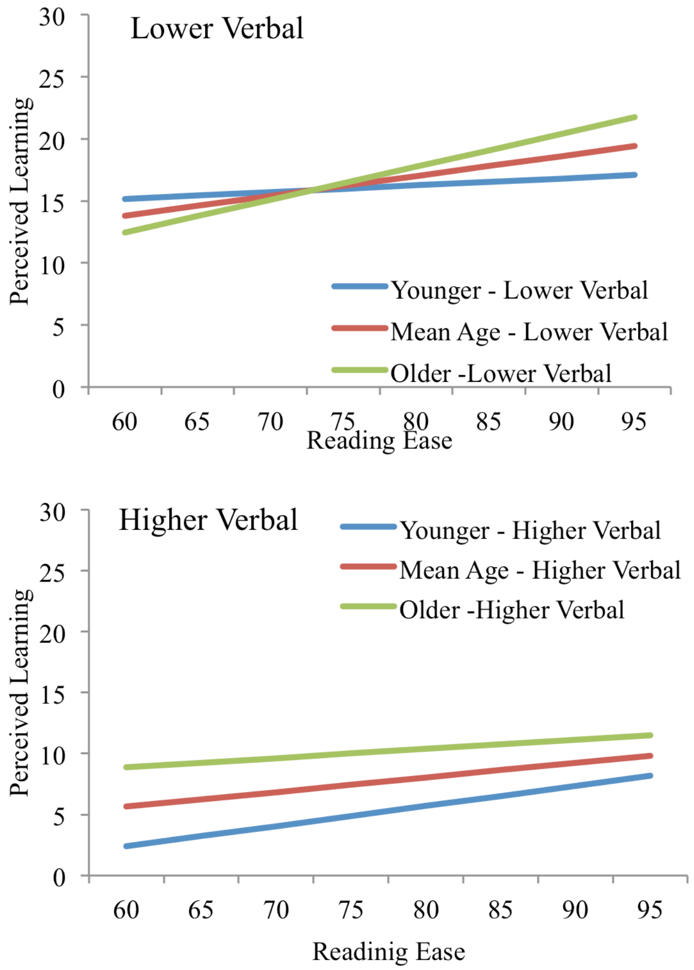
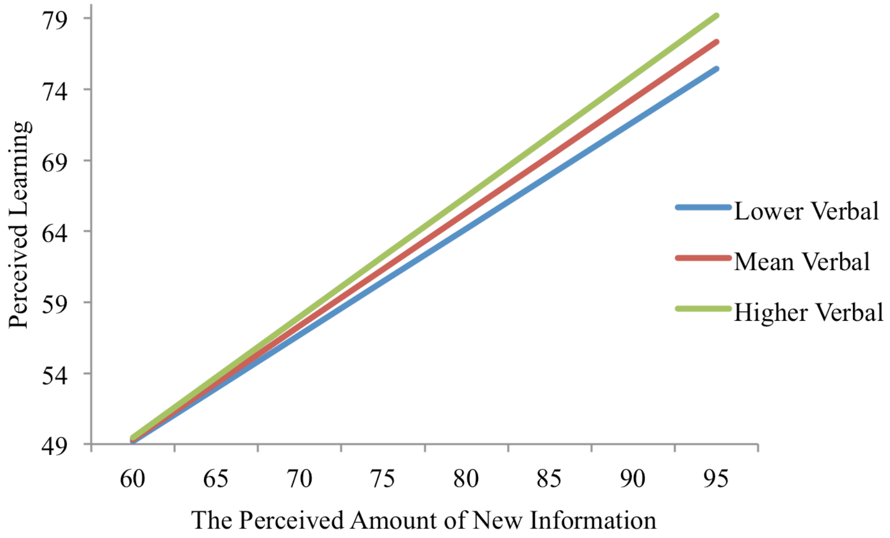


Figure 13. Perceived learning changed as functions of (a) encoding fluency (measured as reading ease) and (b) the perceived amount of new information across different study times



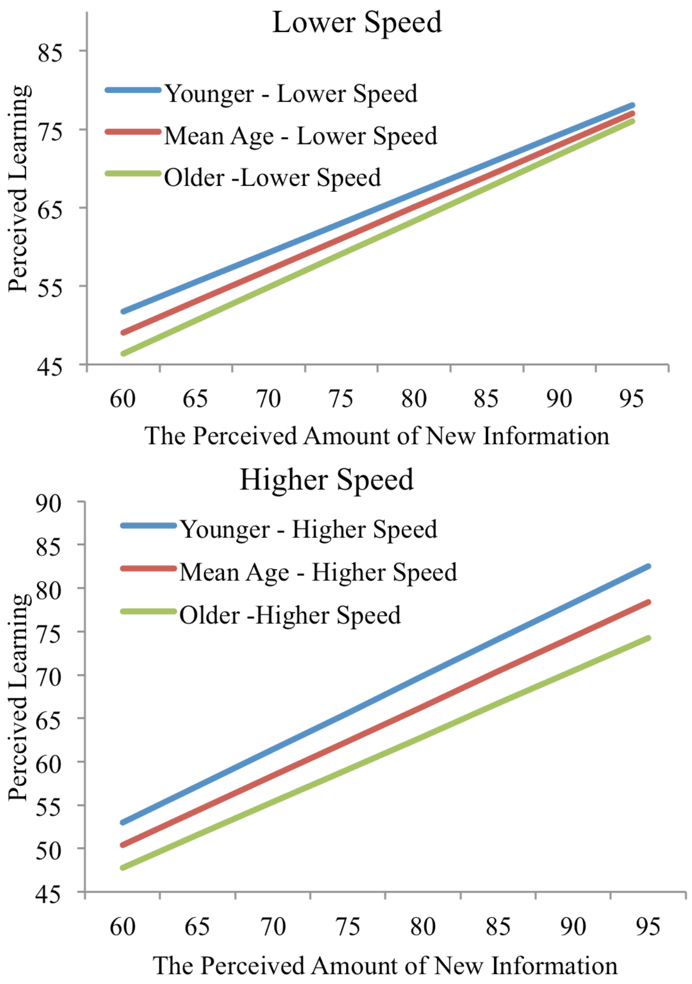
Note. Younger and older ages were 1 SD below and above the mean age. Lower and higher verbal were 1SD below and above the mean verbal ability.

Figure 14. Moderation effects of age and verbal ability on perceived learning as a function of encoding fluency



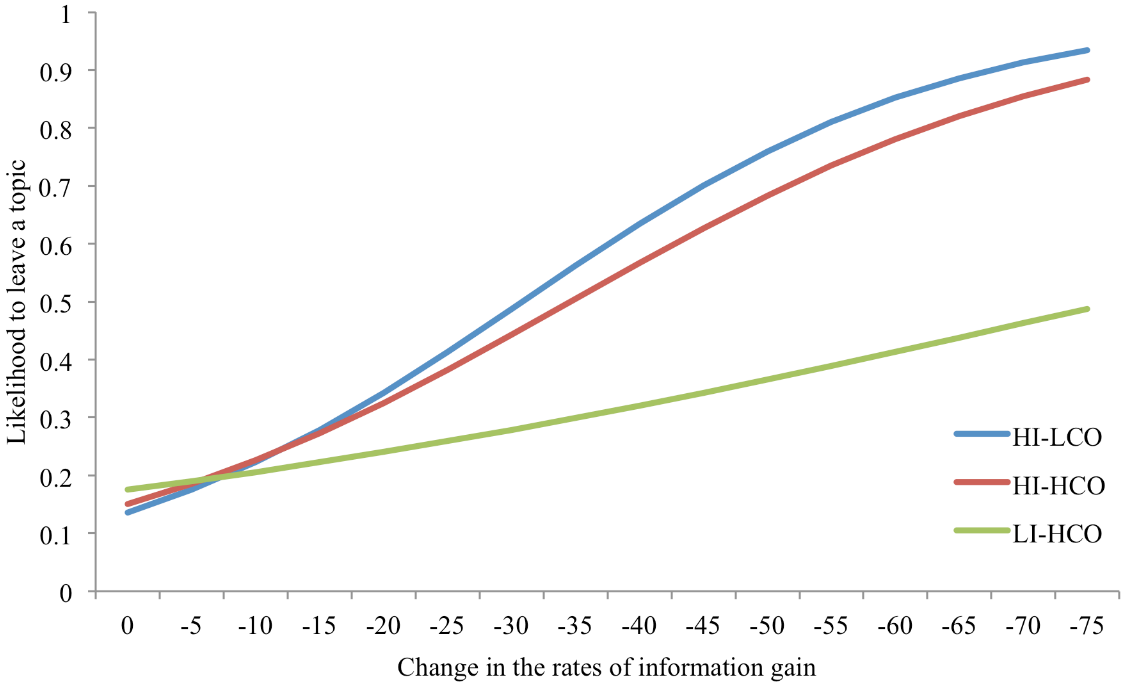
Note. Lower and higher verbal were 1SD below and above the mean verbal ability.

Figure 15. Moderation effects of verbal ability on perceived learning as a function of the perceived amount of new information



Note. Younger and older ages were 1 SD below and above the mean age. Lower and higher speed were 1SD below and above the mean speed of processing.

Figure 16. Moderation effects of age and speed on perceived learning as a function of the perceived amount of new information



Note. Change in the rates of information gain was the mean deviance in perceived learning for the most recent two consecutive pairs of articles. The average of (deviance of perceived learning between $Article_N$ and $Article_{N-1}$) and (deviance of perceived learning between $Article_{N-1}$ and $Article_{N-2}$).

Figure 17. Likelihood to leave a topic as a function of the rates of perceived information gain in three conditions

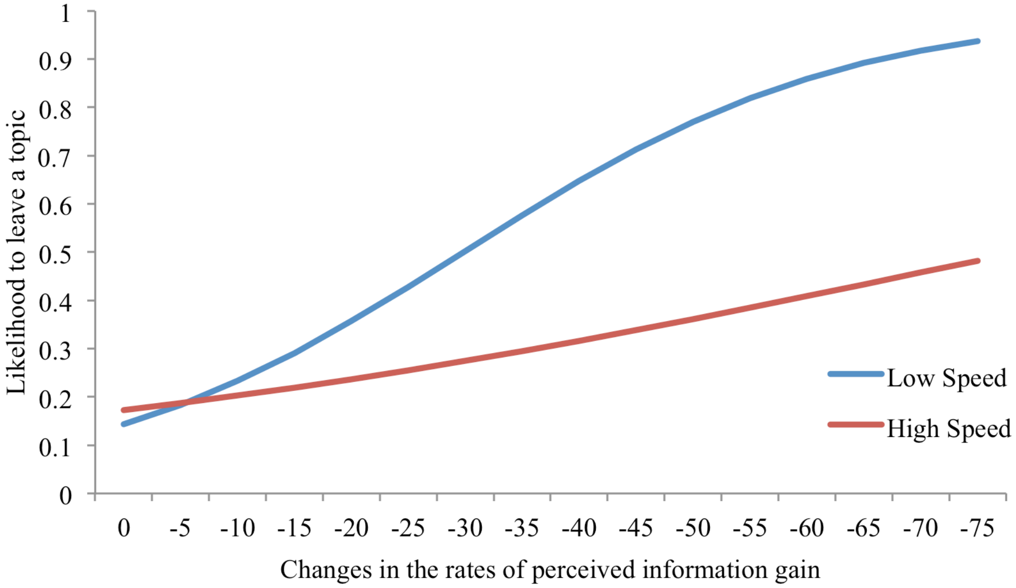
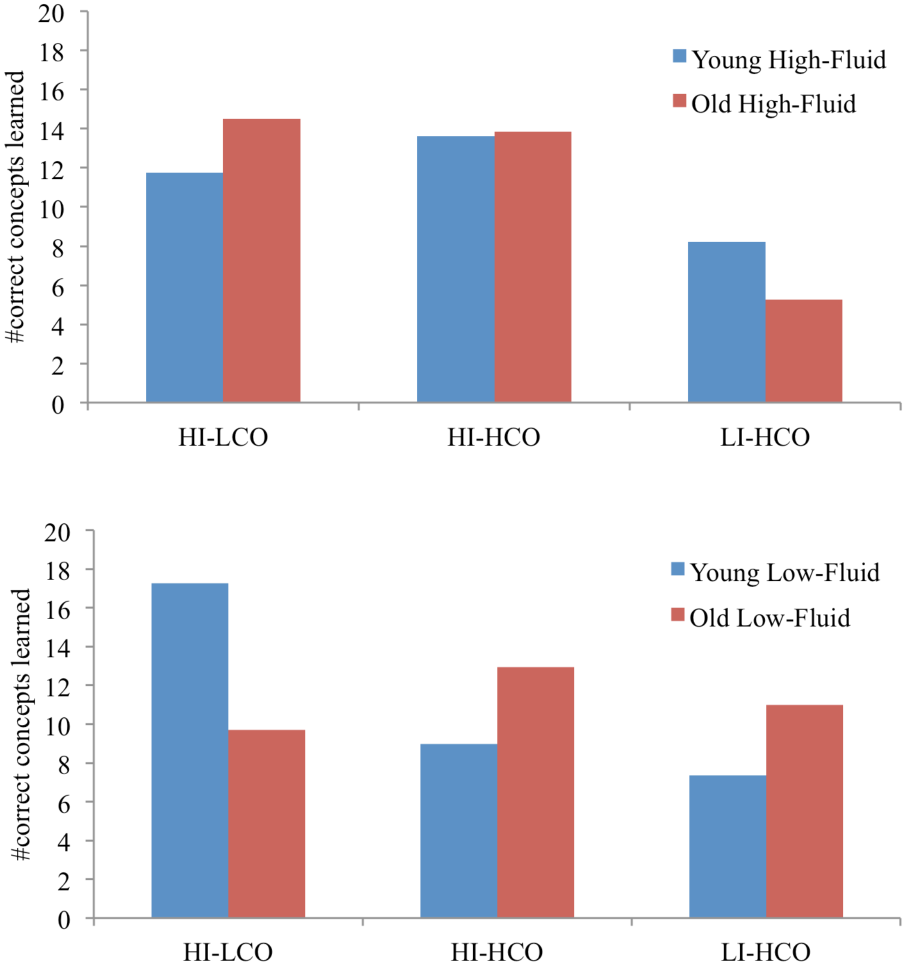


Figure 18. Likelihood to leave a topic as a function of the rates of perceived information gain of adults varying in speed of processing



Note. Fluid = Mechanics (composite of the standardized scores of pattern comparison and reading span task).

Figure 19. Effects of age, mechanics and condition on the number of correct concepts learned in each condition

APPENDIX A. STIMULUS MATERIALS

Topic. Bone Graft

Article 1

A bone graft is the transplant of bone tissue. Surgeons use bone grafts to repair and rebuild diseased bones, tendons and cartilage in the hips, knees and spine. Grafts can also be used to repair bone loss caused by fractures from accidents, or to enhance the density and quality of existing bone, or to reduce suffering from a variety of illnesses, such as tumors or cancers. Once the body receives the bone graft, it provides a framework for growth of fresh and living bone. If the transplanted bone comes from another person, it is called an allograft. Most allograft bone comes from donors who have died. Tissue banks carefully screen the medical histories of the donors and freeze the donated bones. After harvesting, the tissue bank will process and prepare the donated bone to ensure that it is safe to use to reduce the risks of contamination, infection or disease transmission. If the transplanted bone originates from another part of the patient's own body, it is called an autograft. In some cases, a man-made bone substitute is used as an alternative for the bone graft. During the surgery, the physician often makes a cut into the bone near the defect where the graft is to be placed. The potential drawbacks of the surgical procedure include chronic pain from the surgical site (e.g., if nerves are inadvertently cut) or rejection of transplants.

The HI-LCO condition (High Information Low Conceptual Overlap)

Topic. Bone Graft

Article 2

Only living cells can make new bone, so the success of any bone grafting procedure is dependent on having enough bone-forming cells in the location of the graft. Such bone-forming cells are called “osteogenic” bone cells. Osteogenic cells are located in the periosteum, which is the tissue surrounding the bone and the bone marrow. A wound such as a fracture triggers cell production by the osteogenic cells, creating new osteoblasts and osteoclasts for damage remedy as quickly as possible. Osteoblasts are responsible for the creation of new bone. Osteoclasts are responsible for breaking down bone cells, which is required for bone reconstruction. However, locations of scarring, previous surgery or infection, bone gaps, and locations previously treated with radiation therapy are all likely to be deficient in osteogenic cells. In this situation, osteogenic stimulation is needed. Osteogenic cells can be added to a graft site from two sources, bone or bone marrow. Typically, healthy bone is removed from a location where it is unlikely to cause a disability and then transferred into the graft site. This is often from sites of the anterior or posterior pelvic iliac crests. It has recently become more accepted to transfer bone-forming cells from bone marrow, which can be obtained with a needle, without an open, incisional operation.

The HI-LCO condition (High Information Low Conceptual Overlap)

Topic. Bone Graft

Article 3

Bone grafts refer to a wide variety of surgical methods to augment or stimulate the formation of new bone where it is needed. One function of bone graft is to support the healing of fresh fractures or fractures that have failed to heal after an initial attempt at treatment. It can also be used to regenerate bone, which is lost or missing as a result of trauma, infection, or disease. Reconstruction or rebuilding of missing bone can vary from filling small cavities to replacing large segments of bone that are 12 or more inches in length. Another function of bone grafts is to regenerate the bone tissue around the devices implanted in a surgery, such as in artificial joint replacements (e.g., hip replacement) or devices used to support bone alignment. Finally, another function is to stimulate healing between two bones across a diseased joint. This is called "arthrodesis" or "fusion." One of the most common examples is to promote spinal fusion. Spinal fusions are performed to relieve pain and provide stability to spines in people who have been suffering from a vertebral fracture or when motion between the vertebrae causes pain. Once the bone "bridge" between the vertebrae is in place, the spine is stabilized. Then, the pressure on nerve roots is relieved. Thus, it can further ease pain.

The HI-LCO condition (High Information Low Conceptual Overlap)

Topic. Bone Graft

Article 4

There are a number of different reasons that a physician may recommend bone grafting. Situations in which the recovery process from bone surgery is compromised often call for grafting. Diseases such as diabetes or autoimmune deficiencies can slow bone cells growth so that bone grafts can offset the effects of disease. Another case for which the physician may suggest grafting is when a large amount of bone or disc material is taken during surgery, such as spinal procedures that span many levels of vertebrae. Many medical studies show that patients who are constantly exposed to nicotine tend to have limited progress in recovery. So smokers facing spinal surgery routinely receive bone grafts. One study tested how well the bone mass fuses together in spinal fusion patients. Results showed that the nonunion rate is lowest (14%) for nonsmokers, slightly higher (17%) for patients who quit smoking for at least 6 months after surgery, and is highest (26%) for patients who continued to smoke. Nicotine acts like a poison in the bone, inhibiting fusion of the bone. One of the most negative effects of nicotine is decreased blood flow of the bone graft. In essence, the bone graft does not get enough nutrients due to a lack of blood supply; therefore, the bone does not recover smoothly.

The HI-LCO condition (High Information Low Conceptual Overlap)

Topic. Bone Graft

Article 5

After a bone graft operation, recovery time depends on the injury or defect being treated and the size of the bone graft. The process may take 2 weeks to 3 months. The bone graft itself will take up to 3 months or longer to completely heal. Children heal faster than adults. Pain is normal for a few days following surgery, and medication is given regularly to alleviate this problem. Antibiotics may be given to help lower the risk of infection. Patients are asked to take the prescribed antibiotics as directed; however, they can discontinue the use of antibiotic in the event of a rash or other unfavorable reaction. Patients have to keep the bone graft sites clean and dry. Doctors or nurses often give detailed instructions about showering. If wearing a cast, it is beneficial to apply heat to the injured site to improve blood circulation and speed up healing. After the cast is removed, patients have to massage the injured site with ice and avoid extreme exercise for up to 6 months. However, patients still need to exercise the non-affected muscle groups to maintain overall health during the recovery process. Finally, patients are told to follow a nutritious diet and avoid alcoholic beverage. If possible, radiation therapy, chemotherapy, NSAIDs and systemic corticosteroids should be avoided since all of these treatments are known to slow down the recovery process.

The HI-LCO condition (High Information Low Conceptual Overlap)

Topic. Bone Graft

Article 6

Scientists have long searched for materials that could be used to replace transplanted bone. Although most of the substitutes available produce successful outcomes, none have yet achieved the advantages of real bone. There are some bone graft alternatives. Demineralized Bone Matrix (DBM) contains collagen, proteins and growth factors that are extracted from the bone. DBM is extensively processed and therefore has little possibility for disease transmission. However, because it contains mostly collagen, and not the composite materials of calcium that make the bone rigid, it does not provide strength to the surgical site. Ceramics are also used as a substitute for bone grafts. Ceramics offer no possibility for disease transmission, although they may be associated with inflammation in some patients. They are available in many forms such as porous and mesh. Although ceramics may offer a frame for bone regeneration, they contain none of the natural proteins that influence or facilitate bone regeneration. Another bone graft substitute is graft composite. Graft composites use combinations of other bone grafting materials and bone growth factors to gain the benefits of a variety of substances. One composite combines both collagen and ceramic, which closely reproduces the composition of natural bone. The other composite combines DBM with bone marrow cells, which aid in the growth of new bone.

The HI-HCO condition (High Information High Conceptual Overlap)

Topic. Bone Graft

Article 2

An allograft is bone or tissue that is transplanted from one person to another. The tissue is often received directly from donors who have died or from a bone tissue bank. Surgeons use allografts widely to repair bone, tendons and cartilage in many different surgeries. In the United States, over 900,000 allografts are harvested each year. The greatest advantage of allografts is to enhance the quality of life for patients by reducing the number of surgical sites. Athletes who need to rebuild their knees usually receive allografts to provide the framework for the growth of fresh bone. Patients suffering from back pain often receive harvested allografts that ensure bone quality and density. Cancer patients sometimes receive allografts to fill bone loss caused by tumor surgery. The procedure to prepare the donated bone for transplantation is called processing. Processing is performed in carefully controlled environments to prevent contamination or infection. All potential donors are carefully screened for medical histories before a donation can take place. Most donors are young people who have died in accidents or from sudden illness. Patients with any history of cancer cannot donate their bones. In most cases, allografts are very safe and effective. There are cases where the allografts don't perform as expected. This can be caused by a variety of factors, including patient age, life style, or medical condition.

The HI-HCO condition (High Information High Conceptual Overlap)

Topic. Bone Graft

Article 3

In contrast to an allograft, an autograft involves using bone from the same person who received the graft. Autografts can be harvested from what are considered “non-essential” bones. Theses bones often include the hip, but never the knees or the spine. If a bone graft involves a bigger area, which is usually called a “block graft,” surgeons may suggest an autograft to patients for greater support of bone growth. Because the graft originates from the patient’s own body, the risk of bone graft rejection is much reduced. However, as in an allograft, an autograft also carries the risk of chronic pain at the site where the bone tissue was placed. Most commonly, chronic pain associated with a bone graft transplant is either caused by an injury to a tendon, or to cartilage or a muscle. Pain may also result if the small nerves near the surgical site are cut. As the quality of surgical techniques has advanced over the years, the risk of having chronic pain from autograft surgery has been reduced. Also, given there are a growing variety of effective alternatives to autograft tissue, such as man-made substances, fewer and fewer medical procedures (especially spine procedures) include autograft bone harvesting.

The HI-HCO condition (High Information High Conceptual Overlap)

Topic. Bone Graft

Article 4

There are different advantages of using autografts and allografts. Autograft bone is one of the safest because there is no risk of disease transmission from other donors. Patients from whom an autograft is harvested commonly have a better chance of accepting the graft, which results in a more effective transplant to repair and rebuild the diseased bones. Because the bone growing cells and proteins originate from the patient’s own body, there is reduced risk of rejection. After the surgery, autograft bone provides a strong framework for the fresh bone to grow into. Because the autograft substance is living bone, with all the bone cells and proteins that support tissues and enhance bone formation, new bone growth is ensured. On the other hand, the biggest advantage of allograft bone is the reduction in the area of surgery. Receiving allograft tissue from another person means that a second surgery to remove autograft bone, tendon or cartilage from the patient’s own body, is not necessary. It also reduces the risk of infection, and reduces the pain because there is no second surgical site for harvesting. Without having the second surgery, it also reduces the expense for patients. Patients who cannot handle multiple surgeries because of medical or financial conditions are recommended to receive an allograft.

The HI-HCO condition (High Information High Conceptual Overlap)

Topic. Bone Graft

Article 5

There are different drawbacks of autografts and allografts. Although one of the advantages of an autograft is the reduced chance of disease transmission, a potential drawback of autograft is that it involves a second procedure to harvest the bone, which may cause pain at the surgical site from which the graft is taken. This also increases surgical risks; the second site sometimes takes a longer period of time to heal than the site of the primary surgery, which can be up to years longer. It also may not be a best option in cases where the patient's overall bone quality and density is poor, or when a large area of graft substance is needed. This is because there is a relatively small amount of bone available for autograft. The final drawback is the additional financial expense of the second procedure. Drawbacks of allograft bone include the slight chance of disease transmission and the problem of bone variability because it may be harvested from a variety of donors. As a result, grafted bone may take longer to grow with the host bone (than in an autograft). Also, because the bone growth cells and proteins are removed during processing in an allograft, it is not as effective as an autograft. Sometimes, the patient's immune system may reject the grafted bone tissue. Patients are recommended to take drugs for reducing the chance of rejection.

The HI-HCO condition (High Information High Conceptual Overlap)

Topic. Bone Graft

Article 6

One drawback of bone allograft harvesting is the potential risk of disease transmission. Patients may have concerns about the actual chance of disease transmission in the surgery. An allograft may be obtained from living donors who are having bone removed during surgery or donors who had died. There are a variety of allografts including the fresh frozen allograft and the freeze-dried bone allograft. There have been no cases of disease transmission during the 30-year history of using freeze-dried bone allografts. However, there have been four cases of HIV infection using fresh-frozen bone allografts. It is important to note, however, that fresh-frozen allografts are not commonly used in this surgery. A freeze-dried bone allograft is the primary kind of allograft. Its processing procedure takes a relatively longer time. It includes additional tests to ensure there is no risk of disease transmission. Most bone banks follow the guidelines available from the American Association of Tissue Banks. The guidelines provide a careful screening and processing procedure of donated bone substances, such as removing proteins. With donor screening and processing recommendations, the chance of receiving a bone graft from an HIV-infected donor is one in 1.67 million, a very slight chance. Therefore, the established donor screening and processing procedures will ensure that bone allografts are safe for bone graft harvesting.

The LI-HCO condition (Low Information High Conceptual Overlap)

Topic. Bone Graft

Article 2

Bone grafts, which involve transplanting bone tissue, can be used to repair and rebuild bones, tendons, or cartilage. Bone grafts can be used when there is damage in the hips, knees, or spine for many conditions, and for repairing fractures from an accident. Grafts can also enhance bone density and quality that are compromised by tumors, cancers, or other illnesses. Bone grafts enable the body to build new bone by providing a framework to support the growth of new cells. Bone grafts can originate from the patient needing the graft or another person. It is called an allograft when the bone is transplanted from another person. A major source of allograft is from deceased individuals who had had good medical histories and has volunteered for organ donation before death. The donated bones are carefully screened and frozen at bone banks, which ensure that the tissue is safe to use by preparing the bones through a process that eliminates contamination. These procedures reduce the risk of transmitting infection and disease. There is also a chance that the transplant will be rejected. An autograft, which reduces the risk of rejection, is transplanted bones that originates from another part of the patient’s own body. As a substitute for autografts and allografts, man-made bone is sometimes used. Physicians often cut into the bone near the site where he or she will place the graft. If the nerves near the site are cut, the patient may suffer from chronic pain after the surgery.

The LI-HCO condition (Low Information High Conceptual Overlap)

Topic. Bone Graft

Article 3

People can suffer from bone loss because of a fracture from an accident or from illnesses. For example, tissue can be lost in tumors and other forms of cancer. In these cases, bone grafts are an option for repairing and rebuilding the diseased bones. A bone graft is the transplantation of bone tissues, including bones, tendons and cartilage. Bone grafts can be used to enhance the quality and density of bones in the hips, knees and spine because it can offer a framework for bone cells to grow once the body accepts the bone graft. Transplanting bones from another person is an allograft, and transplanting bones from another part of patient's own body is an autograft. The tissue bank processes and prepares the donated bones to make sure it is safe without the risks of contamination, infection or disease transmission. Most allograft bone comes from people who had agreed to organ donation before death. These are people whose medical histories had been carefully screened and were in good health. In some cases, a man-made bone alternative is used in bone grafting instead of autografts and allografts. There are some potential drawbacks of bone graft surgeries, such as the risk of chronic pain from the surgical site, or occasionally rejection of transplants. To insert the bone graft, the physician usually makes a deep cut into the bone. Therefore, sometimes the nerves maybe inadvertently cut and result in pain after the surgery.

The LI-HCO condition (Low Information High Conceptual Overlap)

Topic. Bone Graft

Article 4

Bone grafting is the transplantation of bone tissue. Bone tissues can be obtained from either another donor, which is called an allograft, or the patient's own body, which is called an autograft. A man-made substitute can also be used. The donated bone tissues, including bones, tendons and cartilage, are first harvested from the qualified donors whose medical histories are carefully screened. Then tissue banks process and freeze the donated bone tissues to ensure that they are safe to use in the surgeries to prevent the risks of contamination, infection or disease transmission. Once the donated bones are ready for transplantation, surgeons often make a cut into the damaged bone and fill the incision with the bone graft. Common areas of bone grafting include hips, knee and spine. Bone grafts can be applied to people who have fractures caused by accidents or to people suffering with illness that result in bone loss, such as tumors or cancers. The advantage of a bone graft is that it provides a framework to support the growth of living bone cells, as well as new bone cells. However, there is a risk of transplant rejection. Under certain circumstances, patients may also have chronic pain at the surgical site because of the inadvertent damage to the nerves during surgery.

The LI-HCO condition (Low Information High Conceptual Overlap)

Topic. Bone Graft

Article 5

Receiving bone tissue from a donor or from oneself is called a bone graft. Receiving bone tissues from the patient’s own body is called an autograft; receiving bone tissues from others is called an allograft. Whether an allograft, autograft, or a man-made alternative, bone grafts can be used to repair and rebuild damaged bone tissue, including tendons and cartilage as well. The most typical sites for bone grafts are in the spine, the bones of the knees, and also the hips. During the surgery, physicians often carve out the diseased bones and place the bone graft in. The safety of the bone graft is ensured by the careful screening of the bone tissue bank. The medical history of each potential donor is taken to be sure that only healthy bone is harvested. The bone tissue banks process and freeze the donated bones to prevent the tissue from becoming contaminated. The careful screening by the bank reduced the risks of disease transmission. In addition to rejection of transplants, there is a risk that patients may suffer from chronic pain at the surgical site after bone graft. That is because there is a chance that the surgeon will cut a nerve when inserting the graft into the bone. However, bone grafts can enhance bone growth by providing a framework for bone cells and ensure bone density and quality for patients suffering from bone loss. Therefore, patients with fractures, tumors or cancers are often recommended to receive bone grafts.

The LI-HCO condition (Low Information High Conceptual Overlap)

Topic. Bone Graft

Article 6

Bone tissue transplantation, a so-called bone graft, can be applied to people who suffer from bone loss. The reason for bone loss includes having illness, such as tumors or cancers, or having accidents that damage the bones (e.g., fractures). Bone grafts can repair and rebuild diseased bones, tendons, and cartilage in the hips, knees and spine. Bone tissue banks often store bones from deceased donors who had been screened for qualified medical histories and provide these donated bones in an allograft surgery. Surgeons may use bones from another part of the patient's own body for bone grafts, which is called an autograft; in some cases, surgeons may use man-made alternatives for bone grafts. Bone grafts are safe because the bone tissue banks carefully process and freeze the donated bone tissue to reduce the risks of contamination, infection and disease transmission. Bone grafts can also enhance bone growth by providing the framework for living bone cells; therefore, after surgery, the quality and density of bones are often improved for the patient. The potential drawbacks of bone graft surgery include chronic pain at the surgical site, in part because the surgery may affect the nerves near the site where the bone graft is placed. There is also a small chance of transplant rejection for the bone graft.

Topic. Blood Donation

Article 1

Blood donation is a procedure in which a person agrees to have blood drawn so that it can be used for transfusions or separated into components to make blood products. Millions of people need blood transfusions or blood products each year because of surgery or disease. Given the methods of obtaining blood from a donor, there are different types of donation. The most common way is to take blood from a vein as whole blood. The skin over the vessel from where the blood will be drawn is carefully cleaned. A large needle is used to minimize the shearing forces that can physically damage the red blood cells as they flow through the needle. The blood is usually stored in a flexible plastic bag. Another way is called apheresis, in which the whole blood goes through a special machine to separate it during the donation, so that only certain parts of blood are collected. This allows more of a single component, such as red blood cells, plasma or platelets, to be collected in one sitting. Healthy adults can usually donate a pint of blood without endangering health. The body replaces the lost fluids within 24 hours of a blood donation, and the lost red blood cells within several weeks.

The HI-LCO condition (High Information Low Conceptual Overlap)

Topic. Blood Donation

Article 2

Blood banks serve many functions besides collection. They preserve blood by adding a combination of chemicals that keeps the blood from clotting until it is needed. The process through which blood changes from a liquid to a gel is called coagulation, also known as clotting. By adding anticoagulant, such as Heparin, and refrigerating the blood, it is possible to store blood for a relatively long time from days to years depending on the blood component. Another important function of blood banks is to screen for infectious agents. Some infectious agents, such as HIV or Hepatitis, can survive in blood and infect the person receiving the transfusion. The screening process is so effective that the risk of getting HIV from a transfusion is lower than the risk of getting a lightning strike or getting stung by hornets and wasps. Another risk is getting Creutzfeldt-Jakob disease (CJD) from a transfusion. CJD, which is the human version of Mad Cow Disease, is a very rare, yet fatal brain disorder. Because of this, people who may have been exposed to CJD are not eligible blood donors even though the risk is very low. It is this rigorous testing that keeps the blood supply safe. In addition to preserving and screening blood, some blood banks remove white blood cells to prepare blood for a transfusion. This process is called leukocyte reduction. Although rare, some people are allergic to white blood cells in donated blood. Removing these cells makes allergic reactions less likely.

The HI-LCO condition (High Information Low Conceptual Overlap)

Topic. Blood Donation

Article 3

Blood type is a classification of blood based on the presence or absence of inherited substances on the surface of red blood cells. These substances, called antigens, are proteins that can stimulate the production of antibodies. When people who have one blood type receive blood from someone with a different blood type, it may cause the immune system to react. Every person has one of the following blood types: A, B, AB, or O, depending on whether the blood contains the A- or B-antigen, both, or neither. In America, about 40 percent of the population has Type O, but the distribution varies geographically. For example, in Northern India and central Asia, the frequency of Type B is relatively high. Blood Type A is more typical in Europe. People with Type O are called universal donors because this type is safe for almost everyone. Type O is used for emergencies when there's no time to test a person's blood type. People who have type AB blood are called universal recipients because they can get any type of blood. Blood type is also classified as Rh-positive or Rh-negative. If you have Rh-positive blood, you can get Rh-positive or Rh-negative blood. Both blood and plasma transfusions must be matched to avoid an immune reaction. The symptoms of ABO incompatibility include back pain, blood in the urine, chills, fever and yellow skin. Blood type incompatibility can be a very serious problem that can result kidney failure, low blood pressure, and even death.

The HI-LCO condition (High Information Low Conceptual Overlap)

Topic. Blood Donation

Article 4

A medical history is taken from potential blood donors to ensure that they are unlikely to have any adverse consequences to a transfusion. Potential donors are asked if they have ever had heart, lung, or blood diseases. In general, people with heart disease, heart valve conditions, irregular heartbeat, disease of the blood vessels in the brain, heart failure, and certain lung conditions are not allowed to donate blood unless this has been cleared with a healthcare provider. People who have undergone recent surgery are permitted to donate blood when healing is complete and they have resumed full activity. However, if a transfusion was given at the time of surgery, donation is not allowed for one year. Women who are pregnant are not permitted to donate blood during, or six weeks after, pregnancy. There are age and weight requirements for blood donation. The minimum age is 16 or 17 years, depending upon the state. The less a donor weighs, the greater the likelihood of having a reaction, such as dizziness and fainting following donation. That is why individuals weighing less than 110 pounds are not permitted to donate blood. There is no upper weight limit for donating blood, although some centers have an upper weight limit based on the size and strength of the donor chair.

The HI-LCO condition (High Information Low Conceptual Overlap)

Topic. Blood Donation

Article 5

Some diseases require large amounts of blood for transfusion. For instance, in newborn jaundice, a baby has a high level of bilirubin in the blood. Bilirubin is a yellow pigment that is normally released when old red blood cells are broken down. The liver filters this substance into the intestine so it can be removed from the body in the stool. A newborn’s immature liver sometimes cannot filter the bilirubin quickly enough. High levels of bilirubin make a baby's skin and whites of the eyes look yellow. It is perfectly normal for a baby's bilirubin level to be a bit higher after birth. When the baby is growing in the mother's womb, the placenta removes bilirubin from the baby's body. After birth, the baby's liver starts doing this job. It may take some time for the baby’s liver to be able to do this efficiently. Bilirubin is toxic to the cells of the brain. One risk of severe jaundice is that the bilirubin may pass into the brain, a condition called acute bilirubin encephalopathy. If this condition is prolonged, it can result in permanent brain damage, which is called kernicterus. Jaundice is easy to diagnose, so this rarely happens. Most often, it is treated with phototherapy, but severe cases may require an exchange transfusion.

The HI-LCO condition (High Information Low Conceptual Overlap)

Topic. Blood Donation

Article 6

Apheresis is commonly used for extracting individual blood components from whole blood. This procedure can be used to treat certain medical conditions. Apheresis has been considered a safe and effective treatment to selectively remove harmful or disease-provoking substances from the blood. The filtered, clean blood is then returned back to the patient. In many situations, apheresis is an ongoing treatment, so patients need multiple sessions of apheresis over several weeks to be fully cured. Apheresis is suggested for patients with leukemia, multiple myeloma, and other conditions. During therapeutic apheresis, the patient is connected to a blood cell separator machine, which has two or three channels for blood flowing between the body and the machine. After the separation, the unwanted components are discarded and the remaining parts are returned back into the blood. This procedure requires two needles to be inserted into the veins, one in each arm. However, for patients with small or inadequate veins, it may be necessary to insert a catheter into one of the large veins in the neck to allow enough blood flow. Based on the disease being treated, the blood flow rate, and the size of the patient, the procedure can take from one to four hours.

The HI-HCO condition (High Information High Conceptual Overlap)

Topic. Blood Donation

Article 2

Patients may receive a pint of whole blood or just specific components of the blood needed to treat a particular condition. Whole blood is the human blood from a standard blood donation without further processing. When only specific components are used, it is called blood component therapy. Up to four components can be derived from donated blood: red blood cells, white blood cells, platelets and plasma. Blood component therapy allows several patients to benefit from one pint of donated whole blood. Different parts of blood serve different functions. Red blood cells contain hemoglobin, a complex protein containing iron that carries oxygen through the body. Platelets form clots to control bleeding. Plasma, which constitutes about 55% of blood volume, is the liquid part of the blood that contains antibodies and also helps clotting. Depending on the parts of blood being obtained, there are different kinds of blood donations. Apheresis is a medical procedure to collect individual blood components. The process for whole blood donation usually takes about one hour with the collection itself usually lasting only about 10 minutes. It takes about two hours for the apheresis. The storage of different blood components may vary from a few days to dozens of years. The storage of whole blood, similar to red blood cells, can be kept up to 30 days.

The HI-HCO condition (High Information High Conceptual Overlap)

Topic. Blood Donation

Article 3

Red blood cells are the most frequently used blood component and are needed by almost every type of patient requiring a transfusion. In double red cell donation, twice as many red blood cells are collected as in a single donation of whole blood. During double red cell donation, blood is drawn from one arm through a sterile, single-use needle connected to the apheresis machine. This machine separates and collects two units of red cells. Then, it safely returns the remaining blood components -- white blood cells, plasma and platelets, along with some saline -- aback to the donor through the same arm. Saline is given to the donor intravenously. Otherwise, the donor's blood pressure could become low enough to cause light-headedness or even loss of consciousness. Since the liquid portion of blood is not lost, the donor may feel more hydrated after donation. However, donors need to meet slightly more stringent criteria in order to be able to give a double red cell donation. The criteria include higher levels of hemoglobin, as well as height and weight requirements. People also may be less able to exercise vigorously for a few days after double red cell donation. This donation takes approximately 30 minutes longer than a whole blood donation. People can donate approximately every four months. Red blood cells may be treated and frozen for an extended storage of 10 years or more.

The HI-HCO condition (High Information High Conceptual Overlap)

Topic. Blood Donation

Article 4

Platelets are small colorless blood cells that help the clotting process by sticking to the blood vessels. Platelets are usually given to people who have too few platelets and are susceptible to severe and spontaneous bleeding. Because aspirin can impair the clotting of platelets, donors should not take any products containing aspirin, 48 hours before donation. During a platelet donation, a small portion of blood, about one fourth of a pint, is drawn at a time. Similar to the process used in double red cell donation, a machine for apheresis collects the platelets and some plasma and returns the red cells and most of the plasma back to the donor. The donation takes approximately two hours. After the donation, donors can resume normal activities that day. A single platelet donation can provide enough platelets for a full treatment unit for a patient in need. In fact, some platelet donations yield enough platelets for two or three treatment units. By contrast, it takes four to six whole blood donations to produce a single treatment unit. Many patients who need platelets are either patients who have cancer, or who are undergoing surgery but happen to have weakened immune functions. Instead of obtaining platelets from multiple donors through whole blood donations, physicians prefer having patients obtaining platelets from a single donor through platelets donation to reduce risks. Platelets can be stored for only five days.

The HI-HCO condition (High Information High Conceptual Overlap)

Topic. Blood Donation

Article 5

Plasma, the fluid part of the blood, is 92 percent water and constitutes 55 percent of blood volume. Plasma serves a variety of functions, from maintaining a healthy blood pressure and volume to supplying critical proteins for blood clotting and immune functions. During a plasma donation, blood is drawn by a process called apheresis. The machine for apheresis collects plasma or a fluid of plasma and platelets, and then safely returns the remaining blood along with some saline to donors. Plasma and platelet donation can be collected at the same time. Plasma can potentially be collected once per month. The average donation takes about seventy-five minutes. Plasma is usually frozen immediately after it is separated from fresh blood in order to preserve clotting components. Plasma frozen within 24 hours of collection can be stored for up to one year. It is used for bleeding diseases in which the missing clotting component is unknown or when the specific clotting component is not available. Plasma also is used when bleeding is caused by insufficient production of all or many of the different clotting components as a result of liver disease or severe infection. Type AB plasma is universal which means this type of plasma can be received by any adults, regardless of blood type.

The HI-HCO condition (High Information High Conceptual Overlap)

Topic. Blood Donation

Article 6

Not only do blood donations vary in terms of the different blood components to be drawn from the donors, but also in terms of the types of donors. One of the special types of blood donations is autologous donation. Autologous donations are donations in which individuals give blood for their own needs. For example, in the weeks before undergoing surgery, a person may donate several units of blood for transfusion that maybe needed during or after the surgical procedure. The person takes a supplement of iron after donating the blood to help the body replace the lost blood cells before surgery. Also, during some types of surgery, blood that is lost can be collected and immediately given back to the person. An autologous donation reduces the risks of blood type incompatibility and blood-borne disease. However, it is not used as often as standard donation. This is because blood products are very safe due to the stringent donor screening. In addition, elderly patients may not be allowed to donate blood before surgery because they are more likely to have other health problems during donation. These health problems include low blood pressure, light-headedness and even loss of consciousness. People are also not allowed to do autologous donation within three days of their surgery.

The LI-HCO condition (Low Information High Conceptual Overlap)

Topic. Blood Donation

Article 2

Every year millions of people need products from blood transfusions because of disease or surgery. People agree to donate blood so that it can be used for transfusions or to make products that are separated from the blood. There are different types of blood donations that vary in the methods of obtaining blood from a donor. Among those different types of donations, taking blood from a vein as whole blood is the most common way. The nurse first carefully cleans the skin near the vessel where the blood will be drawn. Red blood cells can be damaged by a shearing force as they flow through the needle, so a large needle is used to reduce these forces on the red blood cells. Apheresis is another method of blood donation, in which the whole blood is separated into components by a special machine that collects different parts of blood. It can collect different blood components, such as red blood cells, plasma or platelets, in one sitting. A flexible plastic bag is usually used to store the blood or blood products. The fluids lost in donation are usually replaced after about 24 hours, and red blood cells are replaced within several weeks of a blood donation. As a result, healthy adults can usually donate a pint of blood without damaging their health.

The LI-HCO condition (Low Information High Conceptual Overlap)

Topic. Blood Donation

Article 3

A blood donation involves a person who agrees to give blood that will be transfused into another person. Donated blood is also used to make blood products made up of different components. The method used to separate the blood into components is called apheresis. A special machine is used to separate the whole blood into red blood cells, plasma, platelets and other components. Apheresis can be used to collect these different blood products in one sitting. Many people, who either have certain diseases or have surgery that might be expected to involve a lot of bleeding, take advantage of transfusions. Of the different methods of obtaining blood, of course, the most common way is to take whole blood from a vein with a needle and store it in a flexible plastic bag. A large needle is used to take the blood to prevent damaging the red blood cells as they move through the needle. The skin where the needle is inserted must be carefully cleaned before the blood is drawn. Adults who are in good health can typically donate a pint of blood without doing themselves any damage. The lost fluids and blood cells can be replaced within several weeks of a blood donation.

The LI-HCO condition (Low Information High Conceptual Overlap)

Topic. Blood Donation

Article 4

The procedure in which people have blood taken out of their own bodies and transfer it to others who need blood transfusions is called blood donation. The body regenerates fluids and red blood cells that are taken from blood donation within 24 hours to several weeks after the blood donation. Therefore, it is recommended that healthy adults donate one pint of blood each time. People who have surgery or disease may need blood transfusions from donors. Under certain circumstances, patients may also require donation of certain blood products instead of the whole blood. Whole blood can be directly drawn from the veins of the donors through a large needle. The large needle is to prevent the red blood cells being damaged by the shearing force when the red blood cells flow through the needle. Blood components, such as red blood cells, plasma, or platelets, can be obtained through a procedure called apheresis. In an apheresis, the whole blood flows through a special machine and become separated into different components for different blood products. Apheresis can collect only certain parts of the blood and return the remaining components back to the donors in one occurrence. The blood is usually stored in a plastic bag with adequate flexibility.

The LI-HCO condition (Low Information High Conceptual Overlap)

Topic. Blood Donation

Article 5

There is a great need for blood donation because millions of people receive blood transfusions each year. The donated blood and the blood products can be used by people who are undergoing surgery or suffer from a disease. The blood products are different blood components that are processed from the whole blood, including red blood cells, plasma and platelets. These blood components can be obtained through a special procedure called apheresis. People who donate whole blood often have their blood drawn from the vein using a large needle. On the other hand, people who donate separated blood products need to go through apheresis. In apheresis, whole blood is first drawn, and then separated into different components. Only the needed parts of the blood are further selected for donation, and the remaining components of the blood are returned back to the donors. Blood is carefully stored in clean, plastic bags. Note that a large needle is often used in blood donation, because the red blood cells may be damaged due to the shearing forces when they flow through a smaller needle. Blood can be regenerated in a healthy body within several weeks of blood donation, and donors can have their blood drawn up to one pint each time without impairing their health conditions significantly.

The LI-HCO condition (Low Information High Conceptual Overlap)

Topic. Blood Donation

Article 6

Blood donation is unexceptional since there is a need of blood transfusions for people with surgeries or disease. Actually, millions of people require blood transfusion annually. There are different types of blood donation that vary in the procedure through which the blood is drawn from the donors. To obtain whole blood, donors need to have their skin first carefully cleaned, and then have a large needle draw blood from their veins directly. Because the red blood cells are susceptible to damage due to the shearing force exerted when the red blood cells flow through a needle, a large needle is usually applied. Under certain circumstances, instead of the whole blood transfusion, only certain blood components, such as red blood cells, plasma or platelets, are required. The single blood component can be further processed as the "blood product" for people who need blood transfusions. The blood component is carefully obtained through a special procedure called apheresis. Donors who go through apheresis will use a special machine to separate their blood into different components. Donors who agree to have their blood drawn are usually asked to donate one pint of blood. The health of donors will not be significantly damaged because the body can regenerate the red blood cells and the fluid in the blood within one day to several weeks of a blood donation.

Topic. Corneal Transplants

Article 1

A cornea transplant is a surgical procedure to replace part of your cornea with tissue from a donor. The procedure is also called a keratoplasty. The cornea is the transparent, dome-shaped surface of your eye. The cornea accounts for a large part of your eye's focusing power with multiple layers of tissue. In fact, the cornea has three different layers. The outermost layer is called the epithelium. The innermost layer is the endothelium. Sitting between the epithelium and the endothelium is the stroma. Interestingly, these layers have no blood vessels, so the cornea is nourished by absorbing oxygen from tears. A transplant doesn’t always involve all the layers. The procedure that transplants all the layers of the cornea is called a penetrating cornea transplant. The procedure that replaces only some of the layers of cornea is called lamellar cornea transplant. Both penetrating and lamellar transplants can restore vision, reduce pain and improve the appearance of a damaged cornea. Most corneas used in transplants come from deceased donors. There are more people requesting that their corneas be available for donation after they die, relative to other organs such as livers or kidneys. Hence, people needing cornea transplants generally will not endure long waits.

The HI-LCO condition (High Information Low Conceptual Overlap)

Topic. Corneal Transplants

Article 2

Keratoconus is a non-inflammatory ocular condition characterized by progressive changes in the shape of the cornea. It is an uncommon condition in which the normally round and clear cornea becomes thin and develops a cone-like bulge. Keratoconus literally means “cone-shaped cornea.” The cause of keratoconus is still not known. Some researchers believe that genetics play a role, since an estimated 10 percent of people with keratoconus also have a family member with the condition. Keratoconus usually affects both eyes, though symptoms in each eye may differ. Symptoms usually start to occur in people who are in their late teens. The rate of progression varies. It will often progress slowly for 10 to 20 years and then suddenly stop. The symptoms include blurring and distortion of vision, increased sensitivity to light, glare and mild eye irritation. An ophthalmologist will be able to diagnose keratoconus during a routine eye exam. There are different eye exams. A slit lamp, which is an instrument with high-intensity light, can be used to diagnose severe cases of keratoconus, but corneal topography is needed to diagnose the more subtle cases. There are additional procedures to determine the shape of the cornea, including the computerized corneal mapping. This procedure is used to take a picture of the cornea and generate a topographical map of your eye's surface.

The HI-LCO condition (High Information Low Conceptual Overlap)

Topic. Corneal Transplants

Article 3

Patients with Fuchs' dystrophy usually need a cornea transplant. Fuchs' dystrophy is an eye disease in which cells lining the inner surface of the cornea slowly start to die off. The disease usually affects both eyes. It can be inherited, and if either of your parents has the disease, you have a 50% chance of developing the condition. However, the condition may also occur in persons without a known family history of the disease. Fuchs' dystrophy is more common in women than in men. Vision problems usually do not appear before age 50, although doctors may be able to see signs of the disease in affected persons by their 30s or 40s. The thin layer of cells that line the back part of the cornea help pump excess fluid out of the cornea. As more and more cells are lost in Fuchs' dystrophy, fluid begins to build up, causing swelling in the cornea and causing it to become cloudy. At first, fluid may build up only during sleep, when the eye is closed. As the disease gets worse, small blisters may form. The blisters get bigger and may eventually break, causing eye pain. Because Fuchs' dystrophy can cause the shape of the cornea to change, it can lead to permanent vision problems if not treated.

The HI-LCO condition (High Information Low Conceptual Overlap)

Topic. Corneal Transplants

Article 4

Herpes keratitis is a viral infection of the eye caused by the herpes simplex virus. There are two major types of the virus. Type I is the most common and primarily infects the face, causing the familiar "cold sore" or "fever blister." Type II is the sexually transmitted form of herpes, infecting the genitals. While both Type I and Type II herpes can spread to the eye and cause infection, Type I is by far the most frequent cause of eye infections. Type I herpes is very contagious and is commonly transmitted by skin contact with someone who has the virus. Almost everyone is exposed to Type I herpes, usually during childhood. After the original infection, the virus lies in a dormant state, living in nerve cells of the skin or eye. Reactivation can be triggered in a number of ways, including stress, sun exposure, fever, menstruation, trauma to the body and certain medications. The symptoms of herpes keratitis may include pain, redness, blurred vision, tearing, discharge and sensitivity to light. Treatment of herpes keratitis depends on its severity. Mild infection is typically treated with topical and sometimes oral antiviral medication. Doctors may gently scrape the affected area of the cornea to remove the diseased cells. In case of severe scarring and vision loss, a corneal transplant may be required.

The HI-LCO condition (High Information Low Conceptual Overlap)

Topic. Corneal Transplants

Article 5

People who have cataract surgery sometimes experience complications including bleeding, increasing pressure inside the eye, retinal detachment, and swelling of the cornea. Therefore, there is a risk of needing a cornea transplant after cataract surgery. Before the cataract surgery, physicians will measure the curve of the cornea with a technique called keratometry, in which a circle of light is focused on the cornea, and the reflection is used to determine the curve of the cornea. The most common procedure used for removing cataracts is called phacoemulsification. In this procedure, a small incision is made in the side of the cornea. The physician inserts a tiny instrument that uses high-frequency ultrasound to break up the center of the cloudy lens and carefully suctions it out. After the cloudy lens has been removed, the surgeon will replace it with an intraocular lens, an implant made of plastic, silicone, or acrylic. This new, clear lens allows light to pass through and focus properly on the retina. This artificial lens then becomes a permanent part of the eye. The artificial lens is inserted behind the iris, the colored part of the eye. When it is in place, the surgeon closes the incision, either with stitches or surgical glue. In the rare instance in which the cornea is damaged during this process, a transplant is necessary.

The HI-LCO condition (High Information Low Conceptual Overlap)

Topic. Corneal Transplants

Article 6

A synthetic cornea has been recently developed as a substitute to use in a transplant. When it is used in a patient's eye, it encourages damaged cells to rebuild and colonize the new tissue. This new cornea was developed by scientists in Sweden, Canada and California. The scientists made the artificial cornea from collagen, a common connective tissue found in tendons, ligaments, and other parts of the human body. By using synthetic collagen, the researchers eliminated the need for corneas from donors, which can sometimes be in short supply. During the testing, the scientists inserted the synthetic cornea into the eyes of ten patients after removing their diseased tissue. After two years, a majority of the patients' own healthy cells had fully covered the synthetic cornea. With the artificial corneas, their vision had been much improved. The new corneas even produced tears and responded to touch. The risk of cornea rejection is not trivial, occurring in about one in five cases. Having the synthetic cornea merged with the original cells reduces the risk of rejection to a large extent. Synthetic implantations also avoid the risk of diseases that could be transmitted in donor tissue such as hepatitis, AIDS and Creutzfeldt-Jakob disease, which is a degenerative brain disorder that leads to dementia and death.

The HI-HCO condition (High Information High Conceptual Overlap)

Topic. Corneal Transplants

Article 2

Whether the corneal transplant involves a penetrating or lamellar procedure, it is often done on an outpatient basis in which patients enter the hospital a few hours prior to surgery and leave that same day. Patients generally leave the hospital a few hours after the surgery. Local or general anesthesia can be used for this procedure to reduce pain. The entire procedure is done under a microscope. A circular instrument that looks something like a tiny cookie cutter is used to remove the layers from the center of the diseased cornea. This is a very precise instrument that can cut through only the layers that are needed. So for example, if the endothelium is substantially healthy, a lamellar keratoplasty can be used to replace just the diseased stroma and epithelium. The surgery can even be done replacing only the endothelium, which is the innermost layer. The donor tissue is usually sewn in place with extremely fine nylon sutures. Because the cornea has no blood supply, the transplant heals relatively slowly. That is why sutures are left in place for a long time, usually three months to one year, but sometimes, they are left in permanently. Vision gradually improves as the new cornea heals. There is often useful vision within a few weeks. However, in some cases, it may take several months to a year to recover full focusing power.

The HI-HCO condition (High Information High Conceptual Overlap)

Topic. Corneal Transplants

Article 3

The different procedures for corneal transplants actually require very different techniques. With the penetrating keratoplasty, in which all three layers are replaced, nylon sutures are always used to hold the tissue in place. Sutures are also used in a lamellar keratoplasty when only the outermost and middle layers have to be replaced. When the endothelium (innermost) layer is the only layer that is diseased, patients can benefit from a lamellar keratoplasty to replace just the endothelium tissue. This is called an endothelial keratoplasty. In this surgery, the abnormal inner tissue of the cornea is removed. A thin disc containing a layer of healthy endothelium cells from a donor is placed underneath the stroma of the cornea. In this case, sutures are not used. Instead, the surgeon uses a tiny needle to inject an air bubble that pushes the donated cell layer into place underneath the cornea. After the surgery, the air bubble sits in place and the new tissue heals around it. This is a relatively new technique that has been shown to lead to faster recovery and fewer complications because the healthy layers can be left in place. What was once a technically difficult procedure has now become a quite routine type of keratoplasty.

The HI-HCO condition (High Information High Conceptual Overlap)

Topic. Corneal Transplants

Article 4

The epithelium, the outermost layer of the cornea, stops matter from entering the eye. It is about only 10% of the total thickness of the cornea. The epithelium contains six extremely thin layers of tissue. These layers consist of fast-growing and easily regenerated cells that are kept moist with tears. There are three different functions of the epithelium. First, as above, it serves to prevent matter from outside the body from entering the other layers of the cornea (i.e., the endothelium and the stroma), thereby protecting the eye. Second, it functions as a smooth surface that absorbs oxygen and cell nutrients from tears, and distributes these nutrients to the other places of the cornea to keep it healthy. Third, it functions as a quite significant component of the total focusing power of the eye, so damage to the epithelium can severely reduce visual acuity. The epithelium actually benefits from thousands of tiny nerve endings that make it extremely sensitive to pain when scratched, thus reducing the likelihood of severe injury. Different from the endothelium, the epithelium has the power to regenerate, so that it can recover from damage. Therefore, the surgery is not always required to replace this layer if it is only slightly scratched. If the epithelium is diseased and is not able to heal gradually, both penetrating keratoplasty and lamellar keratoplasty can be used.

The HI-HCO condition (High Information High Conceptual Overlap)

Topic. Corneal Transplants

Article 5

The stroma, which is the middle layer of the cornea, is the thickest layer. It is about 90% of the cornea's total thickness. It consists primarily of water (78%) and collagen (16%), and like the other layers of the cornea, contains no blood vessels. When light enters the eye, it first contacts the outermost layer, the epithelium, which has a smooth surface to help focus the light. The light then enters the stroma, which has thick layers of tissue to help conduct the light. The stroma has approximately 200 layers of collagen tissue, which gives the cornea its strength and elasticity, but also keeps the cornea transparent and light-conducting. The stroma consists of regularly arranged collagen fibers along with sparsely distributed keratocytes. Keratocytes are specialized fiber cells in the stroma that play a significant role in keeping the cornea transparent. They also serve to heal slight damage of stroma. If there is severe damage to the collagen fibers, keratoplasty surgery is required, especially if the keratocytes are damaged. Depending on the thickness of diseased layers, the surgeon technically can remove only some layers of the stroma and keep the healthy ones in place. This type of surgery is a kind of lamellar keratoplasty. Replacing only some of the layers of cornea will reduce the risk relative to the penetrating keratoplasty. Because the stroma is very thick, patients can benefit from the lameller keratoplasty in most of the cases.

The HI-HCO condition (High Information High Conceptual Overlap)

Topic. Corneal Transplants

Article 6

The endothelium, the innermost layer of the cornea, is a single layer of cells. Like the epithelium (which is the outermost layer), the endothelium is a thin layer of tissue. The cells are significant in keeping the cornea clear. Normally, fluid leaks slowly from inside the eye into the middle layer, the stroma. The main function of the endothelium is to pump this excess fluid out of the stroma. Without this pumping action, the stroma would swell with water, become hazy, and ultimately not transparent, which would reduce vision. In a healthy eye, a perfect balance is maintained between the fluid moving into the cornea and fluid being pumped out of the cornea. Once the cells are damaged by disease or injury, they are lost forever. Unlike the epithelium, its cells do not regenerate or restore. In other words, the damaged endothelium cannot recover through healing itself. Instead, the cells of the endothelium stretch to compensate for dead cells so that they cover the area. This reduces the pumping function of the endothelium because the total cell density is reduced. If the endothelium can no longer maintain the fluid balance, the stroma will lose its primary function of being light-conducting and transparent, thereby impairing vision. Surgery, such as endothelial keratoplasty, which is a type of lamellar keratoplasty, is required to replace the diseased endothelium for maintaining visual acuity.

The LI-HCO condition (Low Information High Conceptual Overlap)

Topic. Corneal Transplants

Article 2

The cornea, which is the transparent, dome-shaped surface of the eye, plays an important role in the focusing function of the eyes. The cornea has multiple layers of tissues. From the outermost to the innermost layer, the three major layers of the cornea are the epithelium, stroma and endothelium. None of the three layers of the cornea have blood vessels, so instead of getting oxygen and other nutrients from the blood, the cornea is nourished from tears. Given that the cornea is vital for vision, people whose cornea is damaged usually need to have a cornea transplant. Vision can be restored through this surgery, and the appearance of a defective cornea can also be repaired through a cornea transplant. Furthermore, a transplant can also reduce the pain from the defective cornea. Patients do not have to transplant all the layers of a cornea in surgery, which is called a penetrating cornea transplant. Instead, they can have only some of the layers of cornea transplanted, which is called a lamellar cornea transplant. Cornea transplants are more common than kidney or liver transplants because there are many donated corneas from people who have died. As a result, people who are in need of corneas generally can receive timely transplants.

The LI-HCO condition (Low Information High Conceptual Overlap)

Topic. Corneal Transplants

Article 3

The cornea is an organ that is located at the outer surface of the eye. There are multiple layers of tissues in the cornea, which together form the clear and dome-shaped surface. In the cornea, the endothelium is the innermost layer; the stroma is the middle layer; and the epithelium is the outermost layer. All three layers contribute to the focusing power of the eyes. As a result, people who have damaged corneas may have impaired vision, and can also experience pain. To restore vision, reduce pain in the eyes, and improve the appearance of a diseased cornea, people often choose to receive cornea transplants. The surgery used in cornea transplants is called keratoplasty. In this surgery, depending on the conditions of the defective cornea, people can have a transplant that involves all of the layers of the cornea, which is called a penetrating cornea transplant, or only some of the layers, which is called a lamellar cornea transplant. In contrast to kidney or liver transplants, there are more people deciding to donate their corneas for transplants after they have died. This saves waiting time for the patients who are in need of corneas. Another interesting fact about the cornea is that it has no blood vessels. Therefore, the cornea receives nutrition by absorbing oxygen from tears rather than through the bloodstream.

The LI-HCO condition (Low Information High Conceptual Overlap)

Topic. Corneal Transplants

Article 4

People who have lost or damaged their corneas may need a cornea transplant. Many people have decided to donate their corneas after they are dead, so generally there is no need for patients who plan to receive cornea transplants to wait for a long time. It is especially different from liver or kidney transplantation in which patients who need transplants often endure long waits. The cornea is a transparent and multi-layer surface of the eye. The surgery in which the cornea is transplanted is called a keratoplasty. The keratoplasty surgery can be used to replace all or only some of the layers of a patient's cornea with a donor's tissue. In other words, patients don't always require a transplant of all the layers of cornea in the surgery. Transplanting all the layers of the cornea is called a penetrating cornea transplant. Replacing only some of the layers of cornea is called a lamellar cornea transplant. In the lamellar cornea transplant, only some of the layers, such as epithelium, stroma or endothelium, need to be transplanted. These different layers of cornea tissue are responsible for most of the focusing function of vision. Having a cornea transplant can help restore vision, eliminate pain and even improve how a diseased cornea looks. Interestingly, there are no blood vessels in the cornea. As a result, the cornea obtains nutrition by absorbing oxygen from tears.

The LI-HCO condition (Low Information High Conceptual Overlap)

Topic. Corneal Transplants

Article 5

Different from other kinds of organ transplants, such as kidney or liver transplantations, people who are in need of corneas generally do not need to wait for a long time to receive the donated corneas. This is because there are many people planning to donate their corneas after death. The cornea is a transparent and dome-shaped surface of the eye. With its multiple layers of tissue, the cornea is responsible for the majority of the focusing power of the eyes. The cells of the cornea absorb oxygen and nutrition from tears since there are no blood vessels in the cornea. The surgery used in cornea transplants is called a keratoplasty. Depending on the number of layers of the cornea being transplanted, there are different kinds of cornea transplants. A penetrating cornea transplant is to replace all the layers of the cornea with a donor’s tissue. A lamellar cornea transplant is to replace only one or some of the layers. The three different layers include the epithelium, stroma and endothelium that are located in the outermost, middle and innermost layers of the cornea, respectively. This surgical procedure has many advantages, including restoring vision, reducing pain and improving the appearance of a damaged cornea.

The LI-HCO condition (Low Information High Conceptual Overlap)

Topic. Corneal Transplants

Article 6

Focusing is fundamental to vision. Therefore, losing the focusing power of the eyes will result in the impairment of visual acuity. The cornea accounts for the major focusing power of the eyes with its multiple layers of tissue. Because the cornea does not have any blood vessels, it must be nourished by absorbing oxygen from tears in the eyes. Although the cornea looks transparent, it contains at least three different layers of tissue. The outermost layer is called endothelium; the innermost layer is called epithelium; and the one that is in between is called the stroma. Together, they form the thin, dome-shaped surface of the eye. If all the layers get diseased, the patients may need a penetrating cornea transplant. If only one or some of the layers need to be replaced, the patient might need a lamellar cornea transplant. The surgical procedure used in both penetrating cornea transplants and lamellar cornea transplants is called keratoplasty. Having a cornea transplant can eliminate pain and restore vision. Keratoplasty can also be used for the reconstruction of the appearance of a diseased cornea. It is more common to donate corneas after death compared to other organs, such as the liver or kidney. Therefore, unlike patients who are waiting for kidney or liver transplants, patients who need to corneas usually do not have to wait for too long.

APPENDIX B. MAIN THEMES AND KEY CONCEPTS OF ARTICLES IN HIGH INFORMATION LOW CONCEPTUAL OVERLAP CONDITION (THE HI-LCO CONDITION) AND HIGH INFORMATION HIGH CONCEPTUAL OVERLAP CONDITION (THE HI-HCO CONDITION)

The HI-LCO condition (More new ideas about new concepts)						
	Bone Graft		Blood Donation		Corneal Transplants	
	Theme	Key Concepts	Theme	Key Concepts	Theme	Key Concepts
P1	Overview	Accident Allograft Alternative Autograft Bank Bone Cancer Cartilage Case Contamination Defect Density Donor Drawback Fracture Graft Growth Hip History Infection Knee Nerve Pain Procedure Process Rejection Risk Spine Substitute Surgery Tendon Tissue Transmission Transplant Tumor Variety	Overview	Apheresis Bag Blood Cell Component Damage Disease Donor Flow Fluid Force Health Machine Method Needle Pint Plasma Platelet Procedure Product Shearing Skin Surgery Transfusion Vein Vessel	Overview	Account Appearance Blood Cornea Donor Endothelium Epithelium Eye Fact Keratoplasty Kidney Layer Liver Organ Oxygen Pain Power Procedure Stroma Surface Tear Tissue Transplant Vessel Vision

	Bone Graft		Blood Donation		Corneal Transplants	
	Theme	Key Concepts	Theme	Key Concepts	Theme	Key Concepts
P2	Osteogenic cells	Bone Cause Cell Creation Crest Damage Disability Fracture Gap Graft Infection Marrow Needle Operation Osteoblast Periosteum Procedure Production Radiation Reconstruction Remedy Situation Source Stimulation Success Surgery Therapy Tissue Trigger	Blood banks	Addition Agent Anticoagulant Bank Blood Brain Cell Chemical Coagulation Collection Combination Component Cow Disease Disorder Donor Heparin Hepatitis Hornet Leukocyte Process Reaction Reduction Risk Screening Supply Transfusion Version Wasp	Keratoconus	Blurring Bulge Case Condition Cornea Distortion Exam Eye Family Genetics Glare Instrument Irritation Keratoconus Lamp Light Map Ophthalmologist Procedure Progress Rate Researcher Sensitivity Slit Symptom Teen Vision

	Bone Graft		Blood Donation		Corneal Transplants	
	Theme	Key Concepts	Theme	Key Concepts	Theme	Key Concepts
P3	Functions and methods	Alignment Arthrodesis Attempt Bone Bridge Cavity Device Disease Ease Example Formation Fracture Function Fusion Graft Healing Hip Infection Length Motion Nerve Pain Pressure Reconstruction Replacement Result Root Segment Spine Stability Support Surgery Tissue Trauma Treatment Variety Vertebrae	Blood types	Absence America Antibody Antigen Asia Blood Cause Cell Chills Classification Death Distribution Donor Emergency Europe Failure Fever Frequency Incompatibility India Kidney Pain Plasma Population Pressure Production Protein Reaction Recipient Skin Substance Surface Symptom System Transfusion Urine	Fuchs' dystrophy	Cell Cornea Disease Dystrophy Fuchs History Patient Transplant Vision Fluid Age Blister Condition Doctor Eye Form Layer Line Pain Pump Shape Sign Surface

	Bone Graft		Blood Donation		Corneal Transplants	
	Theme	Key Concepts	Theme	Key Concepts	Theme	Key Concepts
P4	Reasons	Act Blood Bone Case Cell Deficiency Diabetes Disc Disease Effect Essence Flow Fusion Graft Growth Lack Level Mass Material Nicotine Nutrient Patient Physician Poison Procedure Process Progress Rate Reason Recovery Result Situations Smoker Span Supply Surgery Vertebrae	Screening and safety	Activity Age Blood Brain Chair Condition Consequence Disease Dizziness Donor Failure Fainting Healthcare Heartbeat History Individual Likelihood Limit Lung Minimum Pound Pregnancy Provider Reaction Requirement Size State Strength Surgery Transfusion Valve Vessel Weight	Herpes keratitis	Area Blister Body Cell Childhood Cold Cornea Exposure Fever Genital Herpe Infection Keratitis Loss Medication Menstruation Reactivation Redness Sensitivity Severity Symptom Transplant Trauma Treatment Virus Case Scrape Skin

	Bone Graft		Blood Donation		Corneal Transplants	
	Theme	Key Concepts	Theme	Key Concepts	Theme	Key Concepts
P5	Recovery	Antibiotic Beverage Blood Cast Chemotherapy Children Circulation Defect Diet Exercise Graft Health Heat Ice Infection Injury Instruction Message Medication Muscle Operation Pain Patient Process Radiation Rash Reaction Recovery Risk Speed Surgery Therapy Treatment	Disease that needs blood transfusion	Amount Baby Bilirubin Birth Bit Blood Body Brain Case Cell Condition Damage Disease Encephalopathy Exchange Eye Filter Instance Intestine Jaundice Kernicterus Level Liver Phototherapy Pigment Placenta Risk Skin Stool Substance Transfusion Womb	Cataract	Cataract Complication Cornea Detachment Implant Incision Instance Instrument Iris Keratometry Len Phacoemulsification Physician Reflection Retina Silicone Suction Surgeon Technique Ultrasound Acrylic Circle Curve Glue Risk Process Stitches

	Bone Graft		Blood Donation		Corneal Transplants	
	Theme	Key Concepts	Theme	Key Concepts	Theme	Key Concepts
P6	Bone graft substitutes	Advantage Aid Alternative Benefit Bone Calcium Cell Ceramic Collagen Combination Composite Disease Graft Growth Inflammation Influence Marrow Material Matrix Mesh Patient Protein Regeneration Scientist Strength Substance Substitute Transmission Variety	Apheresis	Apheresis Arm Blood Body Catheter Cell Channel Component Condition Disease Flow Leukemia Machine Myeloma Neck Needle Patient Procedure Rate Separator Session Situation Substance Treatment Vein	Synthetic cornea	Brain California Canada Cell Collagen Cornea Death Dementia Disease Disorder Donor Extent Hepatitis Implantation Ligament Majority Rejection Researcher Scientist Sweden Tear Tendon Tissue Vision Aid Supply Touch Substitute

The HI-HCO condition (More new ideas about old concepts)						
	Bone Graft		Blood Donation		Corneal Transplants	
	Theme	Key Concepts	Theme	Key Concepts	Theme	Key Concepts
P1	Overview	Accident Allograft Alternative Autograft Bank Bone Cancer Cartilage Case Contamination Defect Density Donor Drawback Fracture Graft Growth Hip History Infection Knee Nerve Pain Procedure Process Rejection Risk Spine Substitute Surgery Tendon Tissue Transmission Transplant Tumor Variety	Overview	Apheresis Bag Blood Cell Component Damage Disease Donor Flow Fluid Force Health Machine Method Needle Pint Plasma Platelet Procedure Product Shearing Skin Surgery Transfusion Vein Vessel	Overview	Account Appearance Blood Cornea Donor Endothelium Epithelium Eye Fact Keratoplasty Kidney Layer Liver Organ Oxygen Pain Power Procedure Stroma Surface Tear Tissue Transplant Vessel Vision

	Bone Graft		Blood Donation		Corneal Transplants	
	Theme	Key Concepts	Theme	Key Concepts	Theme	Key Concepts
P2	Allografts	Accident Advantage Age Allograft Athlete Bank Bone Cancer Cartilage Case Condition Contamination Density Donor Environment Growth History Illness Infection Knee Life Loss Pain Patient Procedure Process Surgery Tendon Tissue Transplant Tumor Variety	Whole blood vs blood components	Antibody Apheresis Benefit Blood Cell Clot Collection Component Condition Control Donor Form Function Hemoglobin Iron Oxygen Patient Pint Plasma Platelet Procedure Process Protein Storage Therapy Volume	Penetrating vs lamellar keratoplasty	Anesthesia Basis Blood Case Center Cornea Cutter Donor Endothelium Epithelium Hospital Instrument Keratoplasty Layer Microscope Nylon Pain Patient Power Procedure Stroma Supply Surgery Suture Tissue Transplant Vision

	Bone Graft		Blood Donation		Corneal Transplants	
	Theme	Key Concepts	Theme	Key Concepts	Theme	Key Concepts
P3	Autografts	Allograft Alternative Autograft Block Bone Cartilage Contrast Graft Growth Hip Injury Knee Muscle Nerve Pain Patient Procedure Quality Rejection Result Risk Site Spine Substance Support Surgery Technique Tendon Tissue Transplant Variety	Red blood cell donation	Apheresis Arm Blood Cause Cell Component Consciousness Criteria Donor Exercise Height Hemoglobin Level Loss Machine Needle Order Plasma Platelet Portion Pressure Requirement Return Saline Storage Transfusion Unit Weight	Different kinds of lamellar keratoplasty	Air Benefit Bubble Case Cell Complication Cornea Disc Donor Endothelium Keratoplasty Layer Needle Nylon Patient Procedure Recovery Stroma Surgery Suture Technique Tissue Transplant

	Bone Graft		Blood Donation		Corneal Transplants	
	Theme	Key Concepts	Theme	Key Concepts	Theme	Key Concepts
P4	Advantages of allografts and autografts	Advantage Allograft Area Autograft Bone Cartilage Cell Condition Donor Expense Formation Framework Graft Growth Hand Infection Pain Patient Protein Reduction Rejection Result Risk Substance Support Surgery Tendon Tissue Transmission Transplant	Platelet donation	Activity Apheresis Aspirin Blood Cancer Cell Contrast Donor Fact Function Machine Patient Physician Pint Plasma Platelet Portion Process Product Return Risk Surgery Treatment Unit Vessel	Outermost layer: Epithelium	Acuity Benefit Cell Component Cornea Damage Endings Endothelium Epithelium Eye Function Injury Keratoplasty Layer Likelihood Matter Nerve Nutrient Oxygen Pain Stroma Surface Surgery Tear Thickness Tissue

	Bone Graft		Blood Donation		Corneal Transplants	
	Theme	Key Concepts	Theme	Key Concepts	Theme	Key Concepts
P5	Drawbacks of allografts and autografts	Advantage Allograft Amount Autograft Bone Case Cell Density Disease Donor Drawback Drug Expense Graft Growth Host Pain Patient Procedure Process Protein Quality Rejection Result Risk Substance Surgery System Tissue Transmission Variety	Plasma donation	Apheresis Blood Collection Component Disease Donor Fluid Function Infection Liver Machine Order Plasma Platelet Pressure Process Production Protein Result Return Saline Variety Volume Water	Middle layer: Stroma	Benefit Blood Case Cell Collagen Contact Cornea Damage Elasticity Epithelium Eye Fiber Keratocytes Keratoplasty Layer Patient Risk Strength Stroma Surface Surgery Thickness Tissue Vessel

	Bone Graft		Blood Donation		Corneal Transplants	
	Theme	Key Concepts	Theme	Key Concepts	Theme	Key Concepts
P6	Drawback: disease transmission	Allograft Association Bank Bone Case Concern Disease Donor Drawback Graft History Infection Patient Procedure Process Protein Recommendation Risk Screening Substance Surgery Tissue Transmission Variety	Different types of donations (different recipients)	Addition Blood Cell Component Consciousness Disease Donor Example Health Incompatibility Individual Iron Loss Patient Pressure Procedure Product Risk Screening Supplement Surgery Term Transfusion Unit	Innermost layer: Endothelium	Action Acuity Balance Cell Cornea Density Disease Endothelium Epithelium Eye Fluid Healing Injury Keratoplasty Layer Leak Pump Stretch Stroma Surgery Swell Tissue Vision Water

APPENDIX C. INSTRUCTIONS

Instruction (Study1)

This is a study about how people learn health information when they read more than one article about a topic. Your task today is to learn as much as you can about topics related to Donation and Medical Transplants by reading a series of articles. There are three main topics, with six articles under each topic. Your goal is to read each article carefully and learn as much as you can about the topic from each one.

We are interested in your impressions about how much new information about the topic you encounter in each article, and also how well you are able to learn that information. In other words, sometimes an article can tell you a lot of new things and sometimes an article can tell you things you already know. By the same token, regardless of how much new information is in an article, you may have the experience of learning a lot from the article or not learning very much. As you read through the articles on a topic, we want to know both about how much new information you thought was in the article AND about how much you learned. After you read each article about a topic, you will provide ratings of both of these things.

So for example, suppose you read the passage, “Mary went to the store to buy spaghetti and cheese…” If then you read another passage, “Mary needed spaghetti, so she went to the store…” you might notice that the second passage doesn’t have any new information. “Because Mary was having a dinner party, she bought spaghetti and wine at store,” has somewhat more information. Finally, if you read, “John was disappointed because he wanted tacos,” this would have completely new information. The articles you will read will be longer and more technical, but your judgments about new information would work the same way.

You will read each article at your own pace. After reading each article, you will be asked to make some ratings. When you are ready, you can go to the next article. Articles within each topic will be presented sequentially, and you will read all six articles about a topic before going to a new topic. You will make your ratings on a scale from 0 to 100 by moving the circle:

1. Including the other articles that you have read today, how much new information was in this article?
2. How easy was it for you to understand this article?
3. How much did you learn from this particular article?

After answering these questions about each article, you will move to the next article. After you read all six articles about a topic, there will be some true/false questions to assess how much you learned about that topic.

Instruction (Study 2)

Your task is to learn about some topics in medical science related to Donation and Medical Transplants. There are three main topics, and your goal is to learn as much as you can about Donation and Medical Transplants. You will have 10 minutes to learn about these topics, before I ask you to answer some questions.

During the learning phase, you will select one topic at a time and read a collection of articles about it. You can read each article at your own pace. After you read each article, you have a choice. You can either continue reading about this topic by pressing the “Read Next article” button OR you can switch to a new topic. You only have 10 minutes to learn about Donations and Medical Transplants, so do your best to concentrate and stay with a topic only as long as you feel you are still learning something. If the articles in the topic are either too hard or too easy, you might want to decide to switch to a new topic. This is your choice. Note that there are probably more articles than you can completely read within 10 minutes so you should choose carefully so that you can learn as much information as possible about Donation and Medical Transplant.

After reading each article within a topic, you will be asked to rate how easy the text was, how much new information you thought was in the article, AND how much you learned. You will be asked to make these ratings on a scale from 0 to 100 by moving the circle:

1. How easy was this article to read?
2. Including the other articles that you have read today, how much new information was in this article?
3. How much did you learn from this particular article?

After answering these questions, you can decide to keep reading about this topic by moving to the next article, or to go back to the main page to choose another topic. Once you decide to leave a topic, you will not be able to return.

The goal is to learn as many facts about Donations and Medical Transplants as possible instead of memorizing the passages word for word.

You will be asked to what you have learned at the end of the task. Your performance will be awarded based on the number of facts you learned. Please try your best to learn as much information about “Donation and Medical Transplantation” in 10 minutes (not including rating time).

Instruction (Study 3, 4, 5)

Your task is to learn about some topics in medical science related to Donation and Medical Transplants. There are three main topics, and your goal is to learn as much as you can about them. You will have 15 minutes to learn about Donation and Medical Transplants before I ask you to answer some questions. It is very important for you to pay attention to the articles and do your best to learn about the topics. You will receive bonus money based on your performance.

During the learning phase, you will select one topic at a time and read a collection of articles about it. You can read each article at your own pace. After you read each article, you have a choice. You can either continue reading about this topic by pressing the “Read Next article” button OR you can switch to a new topic. You only have 15 minutes to learn about Donations and Medical Transplants, so do your best to concentrate and stay with a topic only as long as you feel you are still learning something. If the articles in the topic are either too hard or not helping you to learn anything new, you might want to decide to switch to a new topic. This is your choice.

Note that there are more articles than you can completely read within 15 minutes so you should make your decisions about whether to continue or stop reading carefully so that you can learn as much information as possible about Donation and Medical Transplant.

After reading each article within a topic, you will be asked to rate how easy the text was, how much new information you thought was in the article, AND how much you learned. You will be asked to make these ratings on a scale from 0 to 100 by moving the circle:

1. How easy was this article to read?
2. Including the other articles that you have read today, how much new information was in this article?
3. How much did you learn from this particular article?

Again, after reading each article, you can decide to keep reading about this topic by moving to the next article, or to go back to the main page to choose another topic. Once you decide to leave a topic, you will not be able to return.

The goal is to learn as much about Donations and Medical Transplants as possible instead of memorizing the passages word for word. You will need to do your best to optimize your learning outcome.

You will be asked to what you have learned at the end of the task. Your performance will be awarded based on the number of facts you learned. Please try your best to learn as much information about “Donation and Medical Transplantation” in 15 minutes (not including rating time).