

**HF700: Foundations in Human Factors**

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**Assignment Five: Memory, Anxiety & Motivation**

**Creating an Index Using  
Adobe FrameMaker + SGML 5.5**

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## ***Introduction***

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Technical writers working on a BEA WebLogic Commerce and Personalization Server project can expect to produce between one and three FrameMaker books, each of which typically exceeds 200 pages. Most of a writer's time is spent gathering content, writing the documentation, inserting screenshots, incorporating technical review comments, and making editorial corrections. Prior to a release, a writer must also create an index and complete some production-related tasks for each of their books.

While most technical writers recognize the importance of creating a useful index for readers of their documentation, some are faced with challenges that may prevent them from successfully accomplishing this goal. First, although a number of indexing tools are available on the market today, many writers (like those at BEA Systems) are required by their organizations to use the built-in indexing functions of a preferred authoring tool, such as Adobe FrameMaker. If the functions provided within the required software package make index construction difficult, this will undoubtedly impact the effectiveness of the index.

Second, no matter how simple or complex, an index takes time to construct. The amount of time a writer (who may or may not be a skilled indexer) has to create the index directly affects its usability. Based on her extensive experience managing documentation efforts, Hackos estimates that a reasonable timeframe for indexing a 200-page document is approximately 40 hours (492). That's one full, uninterrupted workweek! Considering that a BEA writer may have three FrameMaker books to complete within a 3-4 month software development cycle, spending three weeks on indexing is not a feasible option. Therefore, indexing is a large task often left until the final days of a project when production tasks are increasing stress levels and cutting into available time. And while technical writers are (for the most part) highly motivated to create indexes, the pressure they may feel to complete these tasks can also affect the quality of the end product.

This paper primarily focuses on working/short-term memory as it relates to using the built-in indexing functions of Adobe FrameMaker. Additionally, it briefly describes how the emotional factors of motivation and anxiety can work for and against BEA writers when they are faced with indexing tasks. Where applicable, suggestions for improving the described indexing situation are also provided.

## ***Working/Short-Term Memory***

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This section draws upon some of the available research to provide a definition and explanation of working/short-term memory, and to describe some of its limitations. It also briefly describes a theory about how working memory may be searched, and discusses some ways to maximize the effectiveness of working memory.

### **A Definition of Working Memory**

In an effort to understand it further, many researchers have created models of the human mind whereby memory is divided into several subsystems. Although there still seem to be questions about whether short-term memory and

working memory are discrete entities or simply synonymous terms, most cognitive scientists seem to agree on a basic definition of working/short-term memory. In sum, working memory is a subset of the memory system whose function is to temporarily store a limited amount of incoming information while retaining its active state (Posner 686).

## Characteristics of Working Memory

The following paragraphs elaborate on the provided definition of working memory with the intent of describing some of its more critical and interesting characteristics.

### Information in Working Memory is Active

It is believed that the information temporarily held in working memory exists in a highly active state, along with the intermediate processing (that is, accessor) data that was used to create and store it (Kintsch, 97). Kintsch elaborates, “[short-term memory] comprises a set of items that have just been processed and are still held in consciousness. Such items are privileged in the sense that they are readily available” (86). In fact, this active information can typically be retrieved quickly and easily (in a few hundred milliseconds) from working memory (Posner, 109). Although working memory can retain large amounts of such active information, one limitation of working memory (see also *Limitations of Working Memory*) is that this information quickly loses its activation due to the passage of time or because it is replaced by incoming information that requires resources from the same active space. Therefore, the only way to prevent loss of the previously active information is for the brain to move it along to other memory systems, such as long-term memory (Stillings, 51). There are various ways to ensure that such a transition occurs, and a few are discussed in *Maximizing Working Memory Resources*.

### Working Memory May Be Linked to Goals

Some cognitive architectures suggest that in addition to the previously described active information and its accessor data, working memory also contains other information. Posner states, “...a working memory...contains a goal hierarchy, information associated with the goal hierarchy, preferences about what should be done, perceptual information, and motor commands” (110). In such memory models, the limited capacity of working memory is attributed to the fact that it is directly linked to transitory goals. When goals are achieved, the information is no longer required and thus is automatically purged from the memory system (Posner, 112).

### There is Evidence for Sub-Systems in Working Memory

There is also evidence that the working memory system itself may be further subdivided. Prior to proposing his “working-memory model”, Baddeley engaged test subjects in primary tasks that involved reading comprehension and in secondary tasks that involved numeric memorization. If both tasks required the same limited working memory resources, one would expect that the secondary task would negatively affect the primary task of comprehending textual passages (Posner, 688). Alternatively, if working memory utilized different sub-systems, there would be little (if any) interference (Proctor, 218).

Because the outcome of this and other studies clearly supported his idea of sub-systems, Baddeley was able to identify the central executive, articulatory (phonological) loop and visuospatial scratch (sketch) pad as components existing within working memory. While it is believed that the central executive acts as a processing unit that controls the functions of the other two “slave systems”, little is really known about this component. As indicated by their names, the articulatory loop is said to temporarily store information that is language/speech-based, while the visuospatial scratch pad provides temporary storage for visual/spatial input. Thus, only tasks requiring the same component within working memory will result in performance deficits (Posner, 687, 689; Proctor, 218).

### **Information in Working Memory is Encoded in Different Ways**

It has been noted that information in working memory can generally be retrieved because of the various intermediate processing steps and the accessor data that is stored with it. In other words, the information received is encoded in working memory in a way that facilitates retrieval. There are three ways in which information may be encoded: phonologically, visually, or semantically. The concept of phonological (verbal) encoding arose from studies where test subjects made errors by recalling letters that were not part of a previously memorized list, primarily when they sounded similar (for example, mistaking ‘B’ for ‘V’). However, this same problem was not observed in cases where letters were visually similar (for example, mistaking ‘E’ for ‘F’). Although this seems to imply that even visual information is encoded phonologically (or acoustically according to some research), doubts still remain about this more general conclusion (Donahoe and Wessels, 443-444; Proctor, 214). Visual encoding is fairly self-explanatory. A person visualizes, or produces a virtual image of the information that allows them to retrieve it later. One experiment in the area of visual encoding involved presenting test subjects with a letter in a normal position, or a letter that was rotated by a certain number of degrees. Based on this stimulus the subjects then had to identify whether the letter was in a normal or a rotated position. Donahoe and Wessels summarize the test results as follows:

*“The greater the angular departure of the test letter from the normal upright position, the longer the reaction times were. These data...suggested that the subjects formed an image of the test stimulus, rotated that image to the typical upright orientation, and then decided whether the imagined letter was normal” (445).*

Lastly, semantic encoding describes how meaning might be used to store information in working memory. Although the evidence has been contradictory in this area, test subjects “performed above the chance level” in assessing whether a probe word was the same or synonymous with a word in a list that was previously stored in working memory. Moreover, false recognition of a word’s synonym instead of the actual word may indicate that they are semantically similar and to some extent encoded as such (Donahoe and Wessels, 446). Some research into encoding differences has shown that the semantic level is the deepest level at which information can be encoded and therefore is the most likely to be remembered. Additionally, prior knowledge and experience with the subject matter to be memorized has been shown to lend itself more readily to semantic encoding (Posner, 689-670).

## Limitations of Working Memory

The following paragraphs provide detailed information about some limitations of working memory, including its restricted capacity and its susceptibility to change.

### Using Memory Span as a Measure of Capacity

To determine how much simultaneous information can be stored in working memory, cognitive scientists conduct what are known as memory span tests. During such tests, subjects are asked to remember lists of letters, numbers or words. If one is able to correctly recall all the items in the list, the length of the list is increased until a mistake is made. The longest list a subject can remember without error is said to be their memory span. However, it is important to note that there are several factors that can affect memory span. First, if the task is to recall letters, a subject's memory span will be greater if they are presented with letters that have distinct differences (for example, letters that do not sound alike. See *Information in Working Memory is Encoded in Different Ways* for more information). Likewise, a subject's memory span will be smaller if long words (such as helicopter) are used over short words (such as cat) ([CogLab Pages: Memory Span](#)).

### Malleability of Information Stored in Working Memory

In addition to being a storage area with limited capacity, the active information held in working memory system is also extremely fluid and subject to change. Kintsch states:

*As long as items are held in short-term memory they are still being processed. Their make-up influences the comprehension of new input words as well as their encoding; at the same time the new inputs may change the composition of the short-term memory items themselves (86).*

This continuous cycle of processing and re-encoding active information may be one reason why individuals make transposition or intrusion errors prior to completely forgetting information. Transposition errors cause test subjects to confuse the order of memorized items in a list and are the first type of observed working memory loss. In contrast, intrusion errors cause subjects to recall items that were not part of the original list, and occur after a longer period of time has passed ([Proctor, 214](#)). Furthermore, information stored in working memory can be affected by prior knowledge (called proactive interference) or from information processing that follows short-term memorization (called retroactive interference) ([Donahoe and Wessels, 452](#)). In sum, the limited amount of information that working memory can accommodate is oftentimes different from the original input because it is easily influenced by many factors both inside and outside the working memory system. It is this author's opinion that working memory should not be considered a stable nor reliable mechanism for information processing.

### Learning Environments Can Affect Working Memory Capacity

In learning environments where individuals feel a high level of stress, the already limited storage space provided by the working memory system can be further reduced. Such anxiety can cause those with fixed deadlines to overlook all the available options and make hasty decisions that may negatively impact the long-term quality of their work ([Proctor, 419](#)). For more information about anxiety's affect on working memory, see *Motivation and Anxiety*.

## Search and Retrieval in Working Memory

Perhaps because working memory has such a limited capacity, researchers also became interested in learning how the human mind searches and retrieves information temporarily held within this memory system. In a famous study initiated in 1966, Sternberg presented subjects with lists of numbers and then queried the subjects as to whether a particular “probe” number was or was not part of the list. Because the time it took test subjects to react increased linearly as the number of items in the list increased, Sternberg concluded that a search of working memory was serial ([CogLab Pages: Sternberg Search](#)). If the items in memory had been searched in parallel (that is, simultaneously), subjects would probably have had the same reaction times with one comparison or five comparisons. Based on these experiments, Sternberg estimated that comparisons of items stored in working memory occur very rapidly, at approximately 26 items per second ([Donahoe and Wessels, 457-458](#)). Since both the presence and absence of the probe number resulted in similar reaction times, Sternberg also concluded that a search of working memory was exhaustive ([CogLab Pages: Sternberg Search](#)). In other words, test subjects continued to search through items in working memory even after they had already identified the probe number ([Proctor, 216](#)). Although a degraded probe number was shown to increase overall retrieval times, it did not appear to increase the amount of time it took for a test subject to search through items for the probe. Instead, it only increased the time it took for the subject to initially encode the probe number, suggesting that these activities (encoding and comparison) may be independent characteristics of working memory ([Kosslyn, 121](#)). Although some inconsistencies regarding Sternberg’s study have been uncovered and other explanations have been offered to explain his test results, the correlation between increased list length and retrieval time appears to be sound ([Donahoe and Wessels, 459- 461](#); [Proctor, 217](#); [Kintsch, 177](#)).

## Maximizing Working Memory Resources

The following paragraphs describe two of the ways researchers believe humans can maximize the use of their inherently limited working memory resources.

### **Chunking and the Seven Plus or Minus Two Principle**

According to Miller, working memory can be described as a “bottleneck” to information processing. More specifically, he states that working memory: “impose[s] severe limitations on the amount of information that we are able to receive, process, and remember”. Intrigued by this phenomenon, Miller conducted a number of studies on the capacity of working memory and subsequently proposed that organizing information into groups or “chunks” is one method that may be used to overcome such limitations ([The Magical Number Seven Page](#)). The principle states that when people organize information into chunks, working memory encodes each chunk as a single piece of information (as opposed to encoding each individual item). The items encoded within a chunk are then typically recalled together and at nearly the same time ([Donahoe and Wessels, 449](#)). For example, instead of encoding the ten separate digits in a telephone number, we can encode and recall three chunks – area code, town code, and suffix ([Stillings, 51](#)). This capability is not limited to digits, however. People appear to be able to chunk many types of information in a variety of ways, and it has been suggested that prior experience may explain *how* people structure

information into chunks (Donahoe and Wessels, 449-450). Moreover, grouping information in this manner may not only improve short-term memory, but also can result in more efficient use of long-term memory (Tardy and Mayer, 300). Because the number of information chunks that can be effectively stored within working memory is generally seven, plus or minus two, it is important to note that the chunking technique does not necessarily increase the fixed capacity of working memory; it merely helps maximize the available storage space (Donahoe and Wessels, 448).

### **Increasing Automatic Processes**

The discussions in previous sections of this paper have focused on controlled memory processes, or activities that require some portion of the available working memory capacity. However, there are some processes that are automatic and require little or no space in the working memory resource pool. In short, automatic processes do not impose a load upon working memory; rather, individuals process automatic information without conscious thought because the information is direct and therefore, no further interpretation is necessary (Stillings, 52-54). Because the pre-attentive processing factor was discussed in earlier modules, it will not be reiterated here. However, it is clear that increasing the amount of information that is processed automatically will free up storage in the working memory for other information that cannot be specified in this manner.

### **Motivation and Anxiety**

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Although motivation can directly affect how a user interacts with a given interface (Hackos and Redish, 48), the numerous theories that attempt to explain the underlying psychological causes of motivation indicate that this area of human behavior is not yet completely understood. In the most technical sense, motivation can be described as an aspect of a stimulus that alters the perceived strength of potential responses. Prior experiences and memories (factors external to the stimulus) may also help explain why the same person sometimes behaves differently in identical environments (Donahoe and Wessels, 220-221). Additionally, motivation may be linked to the ability of people to employ learning strategies that are most comfortable to them in a given situation (Hackos and Redish, 48). While different, each of these hypotheses provide the same advice for interface designers: an interface must continuously engage the user, leverage beneficial existing knowledge while replacing bad prior experiences, and provide the user with a flexible and simple way to accomplish their goals. Increasing motivation in these ways will reduce the potential for anxiety (see next paragraph), possibly leading to an increase in working memory capacity. As quoted in Baddeley, "...recall is...a construction made largely on the basis of...attitude, and its general effect is that of a justification of the attitude" (13).

Another elusive area related to working memory is that of anxiety, and how it may impact a person's ability to recall information stored in this memory system. Depending on the study consulted, anxiety can either improve a person's memories for detailed information, or reduce the already limited capacity of working memory by negatively impacting attention levels. It appears that both the inherent susceptibility of a person to anxiety and the type/level of anxiety itself are critical factors in determining the byproducts of anxiety and accessing their severity (Effects of Trait Anxiety Page). However, the negative affect anxiety has on working memory has been replicated in many experiments and should therefore be carefully acknowledged when designing user interfaces. In fact, some

researchers are taking these emotional factors so much to heart that they are designing computer programs with “affective perception”. In other words, a computer may someday be able to sense how its users are reacting to the interaction on an emotional level, and may adjust its responses accordingly (Picard, 50-51).

## ***Application of Concepts: Evaluation Indexing Tools in Adobe FrameMaker***

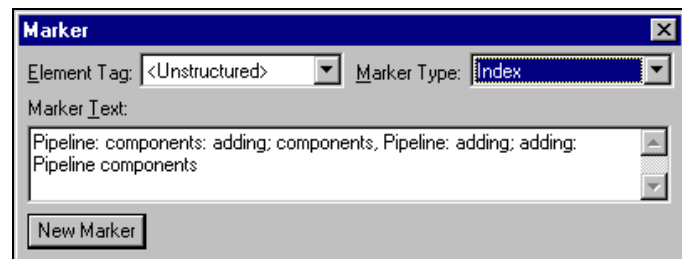
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The following sections describe how a writer typically goes about constructing an index, identifies some problems with this process that are directly related to working/short-term memory, motivation and anxiety, and provides some suggestions for improvement.

### **Examples of High-Load Working Memory Situations During FrameMaker Indexing**

#### **Marking Index Entries**

To create an index in FrameMaker, a writer must parse through each chapter in each book, marking each index entry with a special maker as shown in Figure 1, below. The writer must remember the FrameMaker syntax for the marker text. Colons are used to separate index levels, while semicolons are used to separate index entries. Commas are acceptable punctuation and will be displayed as entered, but some other special symbols (such as “<” and “>”, often used in JSP tag syntax) must be escaped with a backslash character to be properly displayed.



**Figure 1: Marker Pop-Up Window**

#### **Crafting Word/Phrase Permutations**

Most experts in the field of technical communication agree that to be useful, an index must contain the words and phrases for which a reader is likely to search. Because readers have different mental models about how the information should be organized, the index should include many different word/phrase permutations to describe the same content. Writers must think of headwords to group related information, of synonymous terminology, and potentially use language that is not even present within the document to describe the content (Anderson, 609). In addition, it is generally the case that a word/phrase occurs multiple times within a chapter, or throughout a book. In this phase of the indexing process, the writer must remember what words/phrases they marked and use the same FrameMaker syntax (see *Marking Index Entries*) to mark each of them. Using `origins: global` versus `Origins: global` (a difference of one character) will produce duplicate entries in the index that must be consolidated later.

#### **Generating the Index and Consolidating Entries**

After marking all the index entries, the writer must return to the FrameMaker book file and select the appropriate series of commands to generate the index. The index file can then be opened like any other chapter in the book and examined. Most often, a writer will notice that their index has the following problems:

- Duplicate entries resulting from incorrect marker syntax (see *Marking Index Entries*).

- Missing or duplicate entries caused by the writer’s inability to remember all the permutations previously used to index the same content.

To correct the first problem, the writer must note the page number for the index item, open the file for that chapter (thereby pushing the index file to the background), locate the offending index marker, and correct it using the same steps as were required to create it (everywhere it may occur). In the case of the second problem, the writer most likely noticed a missing entry because other, similar entries were present in the generated index. Therefore, the writer must follow the same steps described above, but attempt to locate places in the text where a marker is mistakenly absent and mark them using syntax that is similar to the entries that already exist. Duplicate entries are corrected as previously described.

### Suggestions for Improvement

Adobe FrameMaker does allow users to generate a list of hyperlinked index markers as shown below in Figure 2. However, this feature is rarely used because it is perceived as an extra step in the process that overall, does not alleviate many of the previously discussed problems; it basically just helps in locating an index marker.

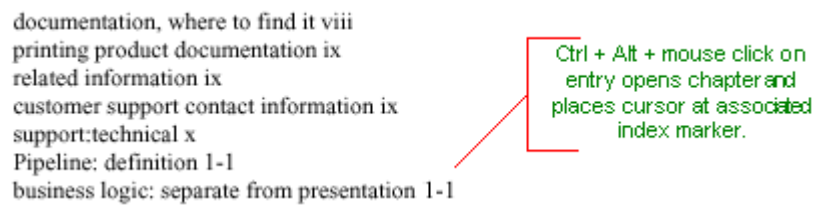


Figure 2: Hyperlinked Index Markers

One way to decrease the load on working memory by taking into account all the issues is shown below in Figure 3.

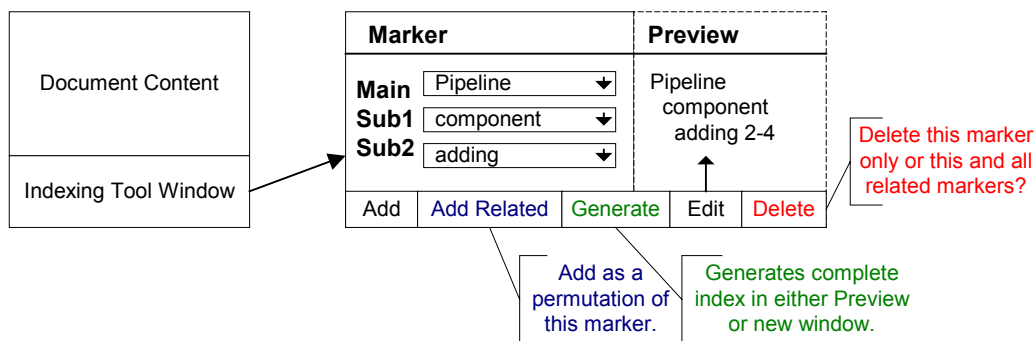


Figure 3: Proposed Redesign

Although the details cannot all be discussed here, default settings could be provided to assume three index levels are sufficient, that the preview pane is on, that the index window is docked to the document, and so on. Users could browse through each chapter in the document content area, and select the text to index. User-selected text will appear in the editable Main text field, and if sub-levels are necessary, they can also be specified. Main and sub-level text that has previously been used could also appear in these fields, making them editable pull-down menus. This way, the user can select from a list of previously typed text. Permutations could be associated with one another,

enabling the interface to ensure that the user remembered (or blatantly chose not) to include them for each marker. Together, the preview pane and edit option could be used to extend the already built feature shown in Figure 2.

## Motivation and Anxiety Regarding Indexing Tasks

Motivation and anxiety are factors related to working memory that operate at opposite ends of the emotional spectrum. Motivation is typically seen as “the great enabler” and anxiety is viewed as having negative affects on working memory. In this case, it appears as though the positive results of high motivation are *at the very least* cancelled out by the high level of anxiety created by both environmental factors (that is, deadlines) and the poor usability of the indexing tool itself. Frustrated writers are therefore likely to make indexes available to readers of their documentation, but the quality of those indexes may be poor. The existing indexing tools make it extremely difficult and time consuming to create a thorough, accurate index. Technical writers at BEA Systems would no doubt benefit from an indexing tool that facilitated their goals and tasks, as well as supported them emotionally by allowing them to complete the indexing process quickly and accurately the first time.

## **Conclusion**

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While technical writers on the WebLogic Commerce and Personalization Server team may be highly motivated to create indexes because they know how important indexes are to readers, it is clear that the tools available in Adobe FrameMaker make the indexing task difficult. The load these tools place on working memory is unreasonably high in ideal situations; it is even worse in the BEA environment, when fixed deadlines and increased pressures to complete the documentation increase anxiety and cut into the already limited working memory space. It is unlikely that the interface designers at Adobe were presented with any evidence of this kind from human factors professionals when creating their indexing tools. However, the increasing interest in the field of human factors and usability gives this up-and-coming human factors specialist hope that with some education, such problems can and will be rectified in future versions of the product.

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