A Method in Applying Psychology to Multimedia Design and HCI Education

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Abstract
This paper intends to reflect a human information processing model as a cognitive design assistant tool which supports multimedia design and/or Human Computer Interaction (HCI) education. The tool covers selection of multimedia elements and guidance of what process involve in the mind for such selection or combination. Hence, provide heuristics of potential bad media selection towards human information processing. Although it has not yet been tested by the industry and practitioners, this tool is useful as an introduction to any multimedia designer who has no psychology background or formal HCI education towards attention directing design. An evaluation was carried out to measure the perceived usefulness and effectiveness of the tool and the results showed that the tool has a positive impact on multimedia design.

Key Words
Human information processing, Human Computer Interaction (HCI), cognitive advisor, multimedia systems, bottleneck, Malaysia

1. Introduction

In multimedia, only one moving image should be presented at once. This is due to the psychological properties of human being whereby users cannot attend to a static media such as text and video or animation at the same time because of the dominant effect of movement on visual attention [9]. Hence, users lose focus and information message decays. Animation and video tends to dominate attention over static text and image when two or more dynamic media are played concurrently. According to cognitive psychology, memorisation fails because an access path either decays through lack of use or was poorly constructed in the first place [18][20]. In computer application, the first people who construct media elements are the designers or computer programmers. Therefore, it is recommended that designers/developers should avoid using both elements when trying to display important information at one time.

An awareness of the differences in the level of knowledge and experience amongst designers and/or computer developers leads to an increased understanding of how to assist designer's psychological knowledge in relation to designing computer application such as multimedia effectively. The cognitive models are useful as the models explain how perception and comprehension are related [3] [10]. Thus, cognitive guidance is important to avoid poorly designed multimedia systems by highlighting and emphasis effects for a design.

Historically, cognitive psychology has been one of the major contributors to the discipline of HCI [1, p97]. Cognitive psychology involves the total range of psychological processes – from sensation to perception, pattern recognition, attention, consciousness, learning, memory, concept formation, thinking, imaging, remembering, language, intelligence, emotions, and development processes – and cuts across all the diverse fields of behaviour [20]. The importance of cognitive psychology and the nature of its wider field has been the motivation of this research. This paper aim to provide computer-based cognitive psychology guidance for novice multimedia designers to create awareness that human mind is limited in processing different forms of cues.

To improve the effectiveness of the knowledge, a designer's and/or computer programmer's assistant toolset in related to human information processing is required. The purpose of this support is to aid the designer /developers in effectively investing the time and resources into good practices of design. Creation of such design tool as guidance to designing attention directing design and easily comprehended effects needs to be supported by psychological knowledge that details and defines attention-directing guidelines and what works for memorisation for different types of media. The tool should works from a specification of logical links between information components and how human perceive information. However, it is the designer's /developer's priority to teach and discipline them regarding good practice towards design.

2. Related Work

Although several researchers highlighted that computer models of the mind are invalid [25], there is no sense in which we can study cognition meaningfully divorced

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from the task contexts in which it finds itself in the world [12]. Sutcliffe [24] noted if the knowledge of the workings of the cognitive model regarding multimedia information processing cannot keep pace with the requirements of designers, then an alternative is to deliver usability via examples of good practice and/or reusable artefacts. He illustrates 'claims' as psychologically motivated design rationales that express the upsides and downsides of a design as a usability issue. These 'claims' therefore encourage designers to consider a trade-off in respects to the various multimedia design methods rather than accepting a single guideline or principle [23]

Although there are many models reflecting the same components and issues as mentioned above [12], the guidelines have a different graphical representation for designers to follow as a job aid [22]. Most of the guidelines are presented descriptively, providing designers with rules which link theory with psychological design rationale as well as human perception theory [26]. Another concern here is how theory-based knowledge can be conveyed and immediately presented to designers who are not experts in the area of cognitive science [18].

An easy to understand method is needed to organize these guidelines into groups filtered by media type so designers can locate the appropriate rules and make the guidelines more perceptive in a related content of use. A designer's assistant is needed to make the task simpler and intuitive [22]. Chunking the guidelines into multiple screens is one possibility for keeping the information flow simpler and manageable [5] [16]. Research on the user interface software tools by Brad Myers, Scott E. Hudson and Randy Pausch [17], suggests that the commercial tools have fairly successfully covered the aspects of user interface. In general, the tools help reduce the amount of code that designers need to produce when creating a user interface, and the tools allow designs to be created more quickly [26]. These tools enable complicated interfaces like computer games to be designed interactively.

AMODEUS project was able to identify important aspect of interaction and the advisor tool for multimedia user interface has provided methods to support multimedia designers by interfacing with development tools [22]. Sutcliffe elaborated work by Bailey (2001) who developed a sketch-based interactive multimedia storyboard tool to support the designer's need for exploring design ideas early in design process. According to Sutcliffe, Wilson et. al. (1997) provides automated support that bridges paper-based sketching and multimedia prototyping via Patchwork. However, none of these tools give practical design guidelines on type media element and attention effects concerning information types and communication goals.

Research has proved that design guideline and standards that presently exist do help designers create better designs [20]. The guide mentioned above emerges in the form of theories, models, and principles in addition to specific practical guidelines [26]. For example, multimedia presentation guidelines: ISO 14915 International Standard from the Organization for Standardization establishes ergonomic requirements and recommendations for an interactive multimedia user interface that integrates and synchronizes different media.

Guidelines are numerous and distributed among different sources: recommendation papers, design standards, style guides that are specific to a particular environment and design guides and principles [16] [26]. They vary in format, levels of confidence, and expressiveness. As mentioned before, even the most optimistic designer such as Drommi [4] would identify formidable barriers inhabiting such guidelines; cultural and linguistic constraints. The former category could incorporate gender factors, whilst the latter might include those speakers of languages that are not widely represented on the web.

According to the standard, combining media can motivate and persuade users to continue with the current application. However, it depends on the context of use, which can make the user's task easier, or more instinctive, especially where features of the information match the user's experience of the real world. The MDAT establishes knowledge from ISO sources and examples. Unlike TRIDENT [26], the MDAT will focus more on avoiding bottlenecks for each type of selected media for different types of information and communication goals.

3. Problem Background

The background of the problem is when the designer has to select which type of media to be used to create an effective attention directing multimedia application [5]. The layout of the media must be taken into account. For example one text and two or more animations on a screen translates to one paragraph of text with two or more animations displayed concurrently. The media types are perceived via a variety of senses, but memory plays a crucial role in interpreting these media [5]. This task involves many subtasks.

Cognitive psychology describes multimedia in terms of human information processing [22]. In the structural perspective, input is coded and stored in the short or long-term memory. Input is gained by the 'human processor' through the sensory organs, in this case, the eye [7]. A visual sensory register, the retina, then converts this input from an electromagnetic spectrum to an electrical signal, or 'pattern' [5]. Pattern recognition in the brain then checks for matches between the input patterns and patterns held in the long-term memory [21]. This process is dependent on attention and motivation [22]. It is this factor, which leads cognitive psychologists to suggest control processes which influence 'memorisation'.

These include motivation, retrieval and, most importantly, memory [1].

Bottleneck model of attention has been formulated by British psychologist Donald Broadbent (1958) [15]. This notion suggests that somewhere in the processing of information as bottleneck exists, part of which is due to neurological limitations [10] [21]. Previous researchers' explored that human sensory memory degrades so quickly that the capacity was approximately 12 items and will be decayed through loss within a few hundreds milliseconds [6]. In this model a pattern may be committed to long-term memory after rehearsal in the short-term memory. Pattern will be committed to memory most effectively if the task at hand holds the attention. In figure 1, the input pattern is identified as image, sound and mouse click. The user's vision moves around the image and try to interpret the objects. If the image is still less predictable, then, the user's viewing will attend to music component, although no guarantee can be given that both component is related to each other [6]. However, the attention-directing design effects can increase the probability that the user will conflict between what they see and what they hear [22].

Paying attention to input, repetition or rehearsal of input and grouping of input into coherent and easily remembered categories may all contribute to improve recall [10]. The sense of vision in the field of multimedia design is more than recognition and identification form, color, harmony as with painting and a piece of music [2]. Multimedia applications contain static and/or dynamic media such as text, video, graphics, animations that can be controlled interactively. The question is how to select which types of media to be used to create an effective attention directing multimedia application without conflicting with each other.

The combination of media is determined by how it is displayed in adjacent widows. According to Multimedia Design Guidelines from ISO 14915, Part 3, two or more media are considered combined if their presentation is concurrent or contiguous when the media are explicitly grouped in a display [8]. To select the media type, consisting of text, image, audio and animation/video, a designer must know the cognitive psychology for human information processing involved for each media type. Then, after acquiring such knowledge from the MDAT, the designer will be able to make a decision as to which type of attention directing effect and bottleneck avoidance should be taken into consideration for delivering the important message he/she wants to convey.

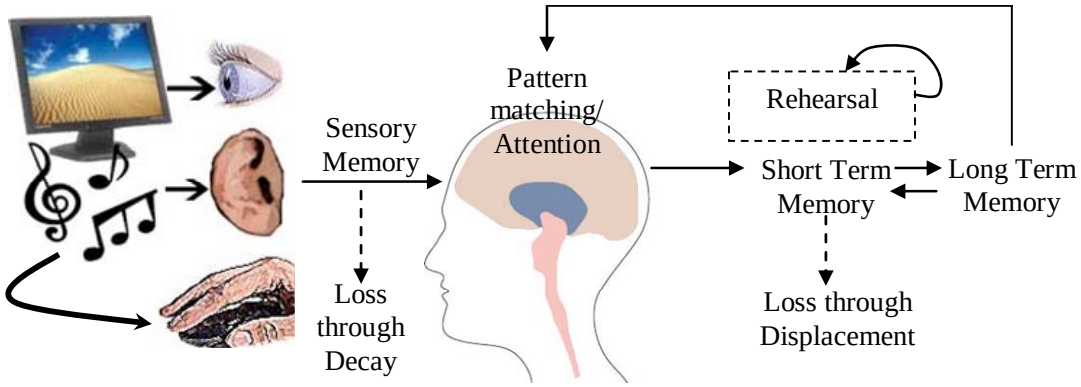

Figure 1: Human Information Processing on Multimedia Elements [6] [15]

4. Approach and Methodology

Multimedia Design Assistant Tool (MDAT) was developed as a reflection of human information processing model [18]. The tool was used as a delivery in HCI and Multimedia Systems syllabus at Universiti Malaysia Sabah. MDAT was developed at UMIST by the researcher as part of her dissertation project to provide cognitive guidelines for multimedia systems developer. MDAT was extended to assist researcher in the delivery of cognitive models [11] [13] and several attention directing techniques in the lecture series. The tool provides easy mapping of human information processing and examples of each combination media.

MDAT consists of two types of advisors: Cognitive Advisor Tool and Attention Advisor Tool. Both tools will be displayed in a different screen layout, consisting of different designs and scenarios of usage. If the user selects the Cognitive Advisor Tool, the next screen will display the media types, their combinations, and components of human information processing involves for the media type selected [5]. Each media will result in different components for the model of human information processing and guidelines. A highlighting technique

should be used to present which component of Model of Information Processing is involved for the media type selected by the designer.

Table 1: Bottleneck guidelines and explanation [5] [23]

Bottleneck	Explanation
Bottleneck 1 (B1)	Capacity overflow: information overload. May happen when too much information is presented in a short period, swamping the user's limited working memory and cognitive processor's capability to comprehend, memorize and use information [10].
Bottleneck 2 (B2)	Integration: Common Message? Integration problems arise when the message on two media is different, making integration in working memory difficult; this lead to the thematic congruence principle [21].
Bottleneck 3 (B3)	Contention: Conflicting Channels Contention problems are caused by conflicting attention between dynamic media, and when two inputs compete for the same cognitive resources. For example, speech and text require language understanding [11].
Bottleneck 4 (B4)	Comprehension Comprehension is related to congruence; we understand the world by making sense of it with our existing long-term memory. Consequently, if multimedia material is unfamiliar, we can't make sense of it.
Bottleneck 5 (B5)	Multi-tasking input/output Multi-tasking makes further demands on our cognitive processing, so we will experience difficulty in attending to multimedia input while performing output tasks.

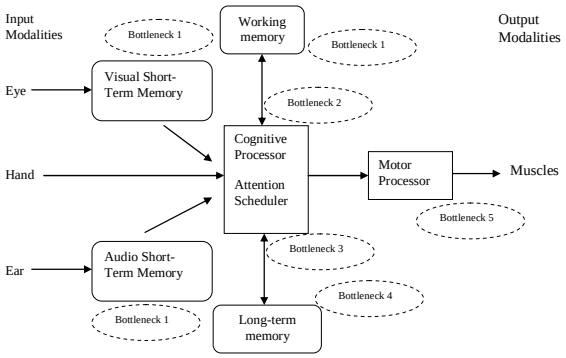

Figure 2: Cognitive Model of Bottleneck illustrated by Sutcliffe [23]

Figure 3 illustrated how the tool will show which component of the MHIP is involved for the media type selection. As can be seen from the main interface of the Cognitive Advisor tool, the component consists of:

1) Audio/Visual Short Term Memory
2) Cognitive Processor,
3) Attention Schedule,
4) Working Memory and
5) Long Term Memory
6) Bottleneck

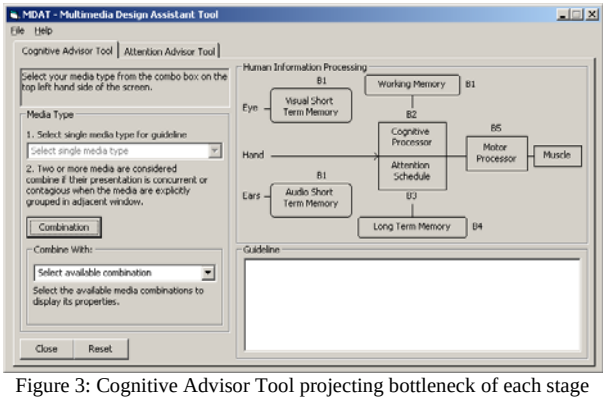

Figure 3: Cognitive Advisor Tool projecting bottleneck of each stage

Single media type like text, image and animation/video are perceived via eyes and the information will be passed into the Visual Short Term Memory [5]. In this case, the MHIP will activate the component involves which is Visual Short Term Memory and display advice in accordance to cognitive guidelines.

However, combining media can also help accommodate user preferences for information in a particular format. Therefore, the cognitive advisor will provide guidelines for media combination that map the human mental activity to appropriate media types for effective delivery. Failure to choose the right combination media will result bottleneck for each information-processing component.

For the Cognitive Advisor tool, the bottleneck will be highlighted if the combination of media is not recommended. To complete the model, the cognitive guidelines will be displayed at the bottom of the model. Each component can be clicked to get further information and explanation.

5. Tool Evaluation

For the evaluation the subjects were given complete paper-based documentation of the method and asked to read it for 5 to 10 minutes before attempting the question. Researcher will show the tool on a projected board and start explaining human information processing based on MDAT [14]. After the session, subjects were given a lecture notes on the same topic and subjects were asked to compare the effectiveness of both materials.

5.1 Subjects

The subjects were one hundred and eight students undergraduate students registered in two separate Information Technology (IT) courses. They were primarily the final year with either major in E-Commerce or Multimedia Program. The age of students ranged from 21 to 23 with an average age of 22. The participants included 56 (52%) male and 52 (48%) female.

5.2 Procedure

This section looked at the perceived benefits and usefulness of Cognitive Advisor Tool and Attention Advisor Tool. User comments were analyzed and the most interesting issues are presented in the next session. The subjects filled in a questionnaire rating the effectiveness on 1 to 7 Likert scale. Most subjects completed the task in three hours.

5.3 Measurement Items

The purpose of the measurement item is to determine the factors that lead users to use MDAT and the effectiveness of the tool in supporting users' task and goal. The questions derived from the study by Dasgupta et. al. (2002) [13].

5.3.1 Understanding the Subject's Perceived Ease of Use on MDAT

1. MDAT give immediate feedback
2. MDAT transmit a variety of different cues
3. MDAT tailor messages to my own
4. MDAT use rich and varied language
5. MDAT convey multiple types of information
6. MDAT transmit varied symbols
7. MDAT design messages to my requirement

5.3.2 Perceived Usefulness

1. MDAT would accomplish learning more quickly
2. MDAT would improve my educational performance
3. MDAT would increase my learning productivity
4. MDAT would increase my learning effectiveness
5. MDAT would makes learning easier for me
6. MDAT useful throughout HCI learning experience

5.3.3 Use

1. Learning to operate MDAT is easy
2. My interaction with MDAT is clear and understandable
3. MDAT is flexible to interact
4. I become easily skillful using MDAT
5. MDAT is easy to use
6. Provide immediate feedback

5.3.4 Awareness (Yes and no scale)

1. Subjects aware that Cognitive Model is important to learn
2. Cognitive Model can help designing better multimedia interfaces by highlighting the do's and don'ts
3. Subjects agree that user studies is the most important task when dealing with any multimedia application development
4. Subjects agree that psychological properties of end user is an important knowledge
5. A tool is another method of delivering psychology knowledge in an easy manner
6. Subject agree that reading psychology materials from book can be very boring
7. International Standard Organization (ISO) such as ISO 9421 part 11 should be organized into a tool for easy access

6. Findings and Discussions

To assess the consistency and reliability of the psychometric properties of measures, Cronbach's alpha coefficients were calculated for all the subscales. All of the values were above 0.70 the acceptable recommended by the literature and most above the 0.80 considered very good. [14] [19].

A two-way analysis of variance (ANOVA) was performed to investigate whether there is a significant difference in the mean of items of the list. There are seven (7) items being measured under perceived of use. ANOVA on all six (6) items scored less than the predetermined alpha value (0.05), thus indicates that subjects perceived MDAT ease of use. One item was identified to score more than predetermined alpha value (0.05). There exists adequate evidence to show that p=0.645 for the use of rich and varied language on MDAT. According to this result, subjects agree that MDAT do not use rich and varied language in the implementation. Five (5) subjects proposed "Bahasa Melayu" which is the national language of Malaysia to be integrated in the tool.

There are six (6) items being measured in perceived usefulness. All six (6) items scored less than 0.05, thus indicated that all items of perceived usefulness of MDAT is supported. ANOVA in the use of MDAT indicated scored less than 0.05. Thus, concluded that MDAT will be used by most participants in learning HCI. Table 2 showed the comparison between the mean and standard deviation (SD) of each measurement items.

Table 2: Measurement items of intended use, perceived usefulness, and perceived ease of use of MDAT and Likert Scores.

	Mean	SD	Range
MDAT give immediate feedback	5.90	0.80	5-7
MDAT transmit a variety of different cues	5.94	1.07	4-7
Tailor messages to your own	5.23	1.56	1-7
Use rich and varied language	1.39	0.51	1-3
Provide immediate feedback	5.99	0.73	5-7
Convey multiple types of information	5.11	1.95	1-7
Transmit varied symbols	5.72	0.93	4-7
Design messages to your requirement	5.44	1.03	4-7
Using MDAT would enable me to accomplish learning more quickly	6.45	0.69	4-7
Using MDAT would improve my educational performance	6.11	0.84	4-7
Using MDAT would increase my learning productivity	6.59	0.61	5-7
Using MDAT would increase my learning effectiveness	6.25	0.44	6-7
Using MDAT makes learning easier for me	6.35	0.77	4-7
I would find MDAT useful throughout HCI learning experiences	6.65	0.52	5-7
Learning to operate MDAT was easy for me	6.69	0.56	5-7
My interaction with MDAT is clear and understandable	6.67	0.47	6-7
I find MDAT to be flexible to interact with	6.25	0.60	5-7
It would be easy for me to become skillful at using MDAT	6.76	0.43	6-7
I would find MDAT is easy to use	6.74	0.44	6-7

Figure 4 shows the result of subjects' general awareness of the importance of cognitive guidelines and comparison between using MDAT and reading books for psychology knowledge. 87.0% of the subjects are aware of cognitive psychology before MDAT demonstration as compared to 13.0% who have never heard of cognitive model. 86.1% of the subjects agree that cognitive model should be organized into a software tool. 92.6% of the subjects agree that user must be studied by developer/designer. 7.4% of the subjects disagree to the measurement item and think that users are technology inadequate hence delaying the development processes. 89.8% of the subjects think psychology is important in design. However, 10.2% of the subjects agree that functionality is the most critical issues in systems development, thus designers should practice their skills in programming not psychology.

90.7% of the subjects agree that tool is easier to understand as compared to other method such as books and website resources. 9.3% of the subjects prefer to use their own instincts in design. An interesting comment was derived whereby the subject mentioned that creativity does not need guidelines because the rules of thumb will limit designer's creativity [18]. 80.6% of the subjects commented that reading books could be boring. 19.4% of the subjects disagree to this measurement item. This result alluded that MDAT could be useful in delivering psychology knowledge to the subjects despite presenting the materials in a descriptive manner such as a book or hyperlink resources.

91.7% of the subjects mentioned that ISO 9421 part 11 and other ISO standard should be organized into a tool for easy access. From the results, it can be concluded that majority of the subjects have a positive perception on the importance of human information processing and psychological properties of human in related to design. Figure 5 shows the cognitive processor and working memory object which will be highlighted as these models are involved in processing information that is retrieved by

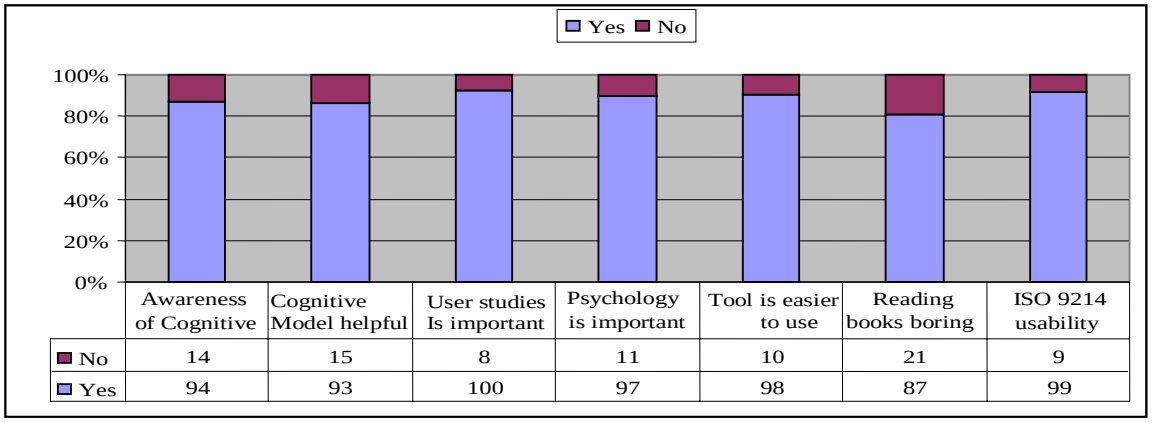

Figure 4: Results of general awareness of subjects on cognitive information processing

human vision. The guidelines for media type text will be shown as a descriptive text at the bottom of the MHIP image.

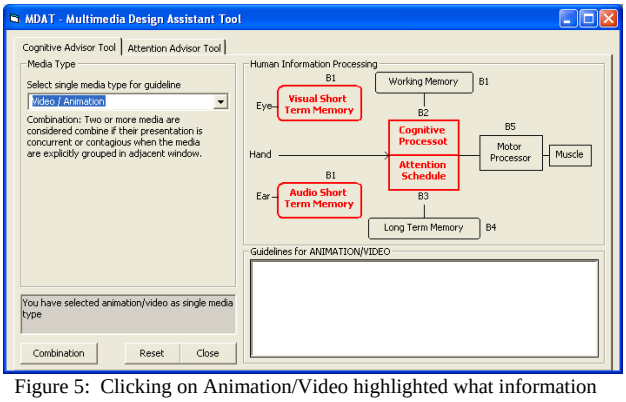

Figure 5: Clicking on Animation/Video highlighted what information processing involved in the mind

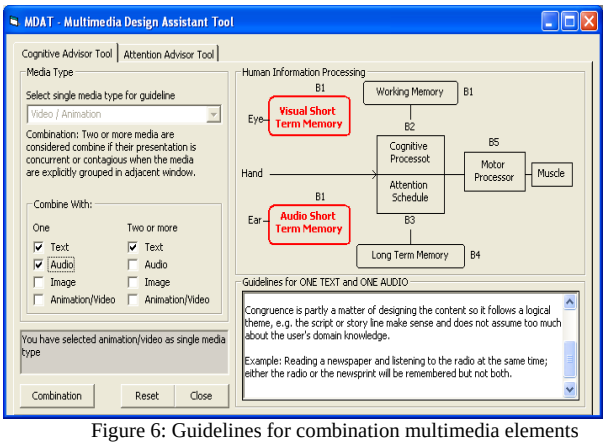

Figure 6: Guidelines for combination multimedia elements

Figure 6 shows four types of media available: Text, Image, Audio and Animation/Video. For each selection, the MHIP will display the category of input modality and information processing necessary for the media. For example: selecting 'Audio' will highlight the visual short term memory and audio short term memory as can be seen in Figure 7.

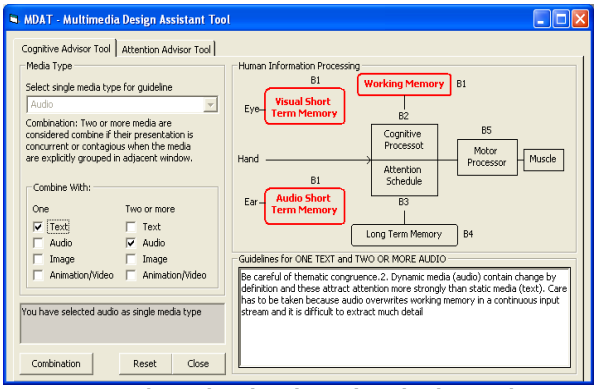

Figure 7: When audio selected as multimedia element, the MDAT highlighted information processing involved in cognition

The Attention Advisor Tool provides interactive feature to display examples for attention directing techniques. Figure 8 shows attention advisor tool selected for image.

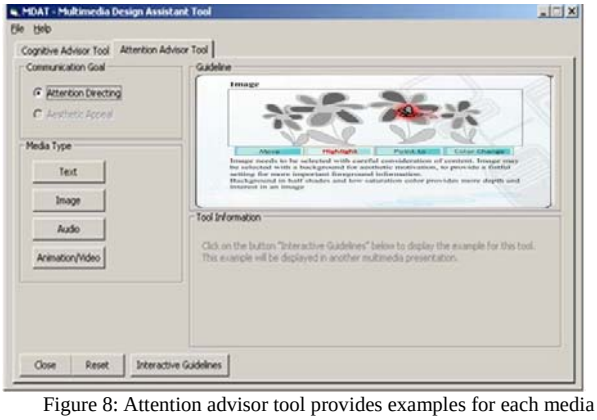

Figure 8: Attention advisor tool provides examples for each media

Figure 9 illustrated attention attracting examples on animation/video. Example of attention directing effect for animation/ video will be presented as a passive view for users.

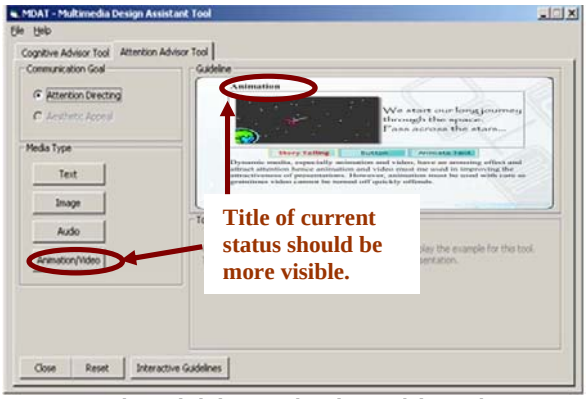

Figure 9: The circled elements show less visibility to the system's current status

However, according to 23 subjects, the tool does not provide obvious status for each media type when selected. For example, clicking on animation does not show that the "Animation/Video" button been pressed. There is only one indicator for animation guidelines which is caption below the "Guideline" title. Hence, the visibility [18] of the tool's status needed to be improved.

Based on the user's views, some commented were to include the ISO media selections and combination guidelines and the sources of these guidelines in the tool. Therefore, this feature is to provide a more trustworthy guidelines and at the same time to avoid poor design [11]. MDAT is among the current initiatives of interactive design guidelines and the perspective for enhancing their presentation in order to provide real-time, effective and interactive solutions to multimedia design.

7. Conclusions

Although the whole idea in this study looks like an old wine in a new bottle, human information processing model can be used as a support tool in delivering psychology knowledge to those who have no psychology knowledge in multimedia design. The evaluation demonstrated that there was a positive impact on the use of MDAT towards Multimedia Systems and HCI course. A further evaluation such as formative evaluation and user experience needed to be performed once the tool has been finalized and installed in the laboratory. Meanwhile, the working tool is only available for demonstration purposes.

It became apparent that not only could MDAT provide information more quickly, it could significantly extend the scope of understanding that the tool could be useful in creating awareness amongst novices of HCI especially in developing countries like Malaysia. It is worth noting, however, that there should be sufficient time for novice to familiarize themselves with the graphical notations. The comments session revealed some situations where the information provided by the graphical representation was regarded as useful by participants, but also a number of problems and suggestions were identified.

There are very few, and rather limited, applications of MDAT in practical domain, and they have not been evaluated experimentally. In this respect, the paper shows a promising application of MDAT into the increasing important domain of HCI and Multimedia Systems and points at issues that have to be addressed when selecting media type for attention directing design. In conclusion, the psychological background model has the power and flexibility to become an effective tool for designers [5]. This pedagogical approach has made the first step to the use psychological knowledge to match the multi-sensory interaction used with in human mental activity via a tool. However, future research and implementation is certainly required so that the opportunities offered by knowledge are transformed into successful practices to be used by all.

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