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Factors that Influence the Memory of Entertainment Experiences

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Abstract: When generating an entertainment experience, such as that of a movie, a novel, or a computer game, not only the experience itself, but also the memory of the experience plays an important role. Pleasurable memories can generate additional pleasure during recall, be instrumental to generate secondary social pleasure when communicating the experience, and be important for word-of-mouth advertising of the entertainment product. In order to optimize entertainment experiences, especially for an online dynamic generation of experiences within computer games, we need to build formal models of these processes. This paper is a summary of a research study we conducted with 50 university students in order to identify factors that influence the memory of entertainment experiences. Our findings show that when watching a short film, a range of factors, including the level of attention of the person, the predictability of the storyline, and the valence of the content, all have substantial impact on the amount of information the test subject can recollect at a later stage. Psychophysiological measurements like skin conductance are also found to be indicators of the memory performance. In terms of the application of the results, some of the factors suggest the use of profiling techniques to best match the target audience's background, e.g., when used for automated story generation within a game.

I. Introduction

Entertainment can take many different forms such as movies, television, theatrical performances, literature and games. But no matter which form of entertainment it is, when generating an entertainment experience, memory of the experience is just as important as the experience itself. Once an entertainment experience is remembered, the intended effect of entertainment, i.e., the "pleasure" in common parlance, is allowed to transcend the limitation of time, continuing to please after the entertainment activity. For example, when a person is able to remember a funny episode of a movie, he might get a smile from this again. He can also share it with his friends later so that they can all have a good laugh over it, and thereby receives further pleasure by way of social rewards. Such sharing, in addition, also forms the basis for word-of-mouth publicity for the entertainment product and may potentially help to increase its sales. In short, besides generating great entertainment experiences during an entertainment activity, both the entertainment goal and the commercial interest require the activity to be designed in a way that the experiences can be easily remembered and communicated to generate future pleasure responses as well as to allow communication about the experience.

Unfortunately, to date, little research has been done in the area of memory mechanisms for entertainment experiences. This paper presents an initial research study that aims to uncover factors that constitute a memory-friendly entertainment experience, focusing on the aspect of facilitating future communication about the experience. A review of existing research on human memory is presented in Section II and serves as the basis for forming a hypothesis on what may influence people's memory of entertainment experiences. A test study to test the effectiveness of the identified factors is described in Section III, with its results and implications being discussed in Section IV. Finally, a summary of the results and suggestions for future directions are provided in Section V.

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II. Background

In this section, results of a literature review on what human memory is, how memory works, and what may affect memory performance are summarized. Relevant factors for our research are then extracted for further experimental study.

A. Introduction to Human Memory

In psychology, *memory* is defined as "the ability of an organism to store, retain, and subsequently recall information" [1]. It is closely related to the ability of learning. Both memory and learning are vital for our survival as they lay the foundations for our daily functioning.

B. Classification of Human Memory

There is a number of ways to classify memory. In the following, some influential theories of human memory are briefly summarized. Most of the contents in sections B and C are summarized from [2].

1) The Three-Stage Model of Memory

The Three-Stage Model (see Fig. 1) is based on the work of Atkinson and Shiffrin [3] and Waugh and Norman [4]. It identifies three different types of memory stores - sensory, short-term and long-term memory stores. It also specifies how information flows among these stores (see Fig. 1). A *memory store* is essentially a set of neurons in the human brain that serves to retain information. The three types of memory stores differ primarily in the time span over which they work and in the amount of information they can retain.

a) Sensory Memory (SM)

Sensory memory occurs automatically along with perception of the surroundings, with no efforts required to process the information. A large amount of perceptual input can be retained, but only for a very short duration of time, typically less than one second. This type of memory cannot be prolonged via rehearsal [5].

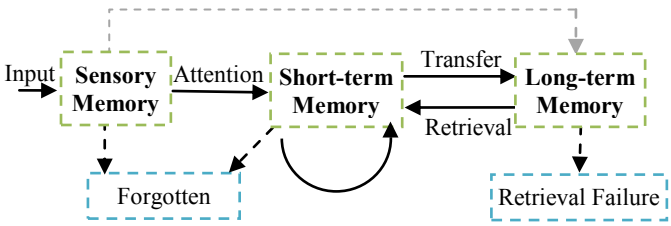

Fig. 1: The Three-Stage Model of Memory (combining diagrams from [2] and [6])

b) Short-Term Memory (STM)

After entering SM, only limited information is transferred into the short-term memory store. What a person pays attention to plays an important role in what is transferred from SM to STM. Short-term memory, also known as immediate memory, holds information for several seconds and can be prolonged voluntarily, typically for about 30 seconds. People are only conscious of information in STM, which holds only a limited number of "chunks" of information. A chunk is a unit of information such as a digit, letter, or word.

c) Long-Term Memory (LTM)

One way to transfer information into LTM is to move it from STM to LTM by means of *rehearsal*. In addition, information can also move directly from SM to LTM. Long-term memory holds a large amount of information (theoretically the capacity of LTM is unlimited) for a very long time, typically from hours to years. The information stored in LTM includes a person's memories of everything he has done or learnt, such as the meaning of a picture, word, or object. For a person to be conscious of certain information previously stored in LTM, the information has to be retrieved from LTM and moved into STM – that is to say, until a person is asked for a piece of information, such as a song he knows, he is not directly aware of that information, i.e., the song is "not in his head" (subconscious) unless he recalls it.

2) The Multicomponent Working Memory Model

The Multicomponent Working Memory Model (see Fig. 2), which provides important insights into how information is stored in STM, replaces the original concepts of Short-Term Memory in the Three-Stage Model by that of *working memory (WM)*. Working Memory comprises of four components, each having a limited capacity but different capacity limitations. More information is available in [7-9].

3) Classification by Information Type

In general, according to information type, memory can be categorized into visual, auditory, and olfactory memories, as well as memories for touch, movement, and language. These are called modality-specific memory stores, which retain input from a single sense or processing system.

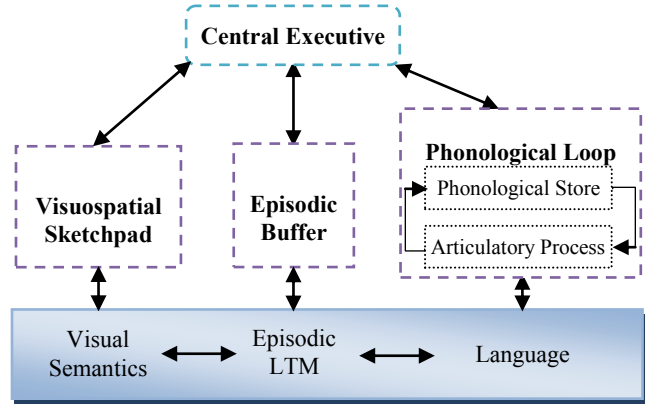

Fig. 2: The Working Memory Model proposed by Baddeley & Hitch (adapted from [7])

In each type of modality-specific memory store in LTM, two types of information can be retained. One is the semantic memories, i.e., the memories of meanings of words, concepts, and general facts about the world; and the other is the episodic memories, which provide a context and are in essence the memories of events that are associated with a particular time, place, and circumstance.

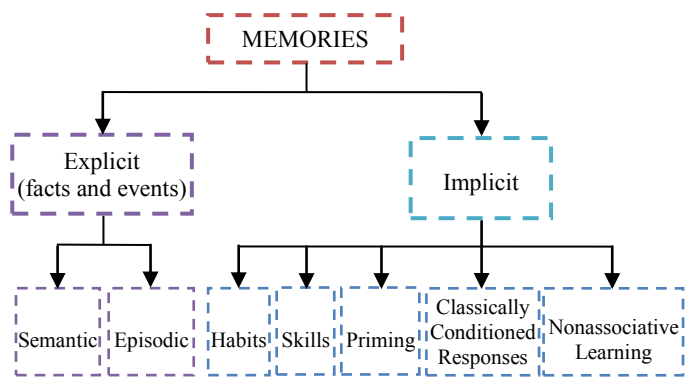

Fig. 3: Types of Memories in LTM Store (adapted from [3])

d) Explicit Memory

Explicit memory is also known as declarative memory, which is what a person can consciously think about and put into words. Verbal and visual memories are explicit if they can be called to mind in words or images. Explicit memories comprise of semantic and episodic memories. All the facts and events that a person has learnt and can recall fall into the category of explicit memory, and are subject to forgetting [10].

e) Implicit Memory

Discussed in [2] and [11], implicit memories, or nondeclarative memories, are what a person is unaware of having, but governs the ways the person behaves in the presence of specific stimuli or what make it easier for the person to repeat an action performed before. Unlike explicit memories, implicit memories cannot be called to mind voluntarily or easily articulated with words. These include habits, skills, priming, classically conditioned responses and nonassociative learning. For example, both the skill of writing and the skill of riding a bicycle are a form of implicit memory, which allows people to perform certain actions without consciously thinking about it (note that it is the skills that we are talking about, not the experiences).

C. Basic Memory Processes

The functioning of human memory relies on three basic processes: encoding, storage, and retrieval, (sometimes also known as registration, retention, and remembering) which can be defined as follows:

- *Encoding*: the process of organizing and transforming incoming information so that it can be entered into memory, either to be stored or to be compared with previously stored information
- *Storage*: the process of retaining information in memory
- *Retrieval*: the process of accessing information stored in memory

Among these three processes, we will discuss only the retrieval in more detail because we are especially interested in recalling.

1) Retrieving Information from Memory

In a nutshell, remembering involves tapping into the right fragments of information stored in the LTM and people can remember information in two ways: recall and recognition.

Recall is the act of intentionally bringing explicit information to awareness, which requires transferring information from LTM to STM. As discussed earlier, once information is in STM, it can be consciously thought of and communicated.

Recognition, on the other hand, is the act of encoding an input and matching it to a stored representation (i.e., a stored memory). When a person recognizes a stimulus, she/he not only knows the stimulus is familiar, she/he also has access to stored associations (such as when and where the stimulus occurred).

Generally speaking, tests that require recognition of information are easier than tests that require recall. But if a recognition test demands discriminating between similar choices, it can become very difficult, the same way how a multiple choice question can be designed to be hard to answer. As a rule, the more distinctive properties of a stimulus stored in memory, the better chance it may be recognized later.

D. Forgetting

Research has shown that most forgetting occurs soon after learning; and as time goes on, less and less additional information is lost from memory [2]. The famous forgetting curve discovered by Ebbinghaus [12] also yields similar results.

1) Ebbinghaus's Famous Forgetting Curve

As revealed by Ebbinghaus's forgetting curve, the most rapid forgetting takes place soon after learning: just 20 minutes after learning, more than 40 percent of the material learnt is forgotten; and by 9 hours, more than 60 percent is lost. As the retention interval increased, the rate of forgetting slows down considerably. More specifically, the drop between 1 and 31 days is only about 12 percent. Although Ebbinghaus's forgetting curve may not provide perfect numerical predictions on the memory retention percentage for all cases, it has been proven true that most forgetting does happen in the first few hours after learning, with progressively less and less of a loss as time passes.

E. Factors that Affect Overall Memory Performance

With the understanding in human memory, we now examine factors that may affect memory in general. These factors can be categorized into four groups [10]. The factors are given in Table I.

1) Organismic Variables

Organismic variables refer to permanent or relatively permanent characteristics of a person that affect general memory performance.

2) Antecedent Variables

Antecedent variables, in contrast to organismic variables, are usually temporary. They are the ones that have recently altered a person's typical organismic level.

3) Task Variables

Task variables, which refer to the particular characteristics that are unique to a given situation, are further divided into four subtypes:

- *Instructional Variables*: explicit or implicit instructions given to the subject (participant) during a memory task.
- *Presentational Variables*: the way stimuli (materials) are presented. Examples include the order in which stimuli are presented and whether the stimuli are presented verbally or visually.
- *Stimulus Variables*: the properties associated with the stimuli that the subject is expected to learn. Note that some of these factors are subjective, for example, familiarity with the stimuli, the relatedness of content, and how difficult the stimuli are for someone to understand.
- *Context*: The fourth type of task variables is related to the context in which a memory task occurs. The components of contexts generally include the environment (including all conditions in the environment: the time, place, sound, lighting condition, odors in the air, whether someone else is present or not, and so forth), the state of the person (for example, being drunk or feeling tired), the mood of the person, and the activities involved (e.g., if a person is using the phone, driving a car etc).

F. Summary of Relevant Information Extracted

Through the literature review and analysis, the following conclusions can be made with regards to memory mechanisms for entertainment experiences.

1) Memory Type

Note that the type of memory that we are interested in should be capable of being recalled voluntarily and put into words so as to allow communications. Therefore, the memory that is relevant in the context of this paper falls into the category of *explicit memory*, which is located in the *Long-term Memory Store (LTM)*.

Explicit memory is the type of memory which people can consciously think about and put into words. Explicit memories comprise of semantic and episodic memories. All the facts and events that a person remembers are essentially explicit memories and are subject to forgetting.

2) Type of Memory Task

The form of remembering that we are interested in enhancing is *recall* as opposed to recognition.

Recall is the act of intentionally bringing explicit information to awareness, which requires transferring information from LTM to *Short-term Memory Store (STM)*. Only when information is in STM, it can be consciously thought of and communicated.

In other words, when conducting the laboratory experiment, the memory task designed to test memory performance should be a *recall test containing open-ended questions* instead of a recognition test with multiple choice or true/false questions.

3) Factors that May Affect Memory of Entertainment Experiences

Among the factors that have known impact on overall memory performance, we identify some factors as relevant to our project. A factor is identified as irrelevant if it satisfies any of the following criteria:

- Its status cannot be altered by an entertainment activity such as playing a videogame or watching a film, i.e., such factor cannot be manipulated in order to enhance a person's memory of an entertainment experience
- It is a confounding variable for the laboratory test and should be kept constant for all subjects in order to minimize its confounding effect.

Gender and age are the only two exceptions we make because they are important factors in market analysis for the entertainment industries. Very often, a movie, a novel, or a video game will have a very specific target group that is of the same gender or age group. Hence, we include them as relevant factors though they are not manipulable.

TABLE I: Factors that May Affect Overall Memory Performance [10]: Among these factors, some are considered relevant to our project and will be tested in the laboratory test

Nature of Factors	Factors	Irrelevant Factors		Relevant
		Not Manipulable	Confounding	Possible Factors
Organismic Varriables	Degree of intelligence	✓		
	Knowledge base	✓		
	Ability to concentrate	✓		
	Normal attention span	✓		
	General motivation to do well	✓		
	Physical and psychological state of health	✓		
	Development	✓		
	Gender			✓
	Age			✓
Antecedent Variables	Amount of sleep	✓		
	Influence of Drugs or medications	✓		
	Diet (food & supplement)	✓		
	Exercise	✓		
	Biological rhythms	✓		
	Attention			✓
	Motivation			✓
	Arousal			✓
	Stress			✓
	Emotion			✓
Task Variables	Instructional Variables		✓	
	Presentational Variables		✓	
	Stimulus Variables			Familiarity
				Relatedness
				Relative frequency of occurrence in everyday living
				Concreteness
				Interference
				Difficulty to understand
				Valence
	Context		✓	

III. METHODOLOGY

In this section, the design of our test study as well as the methodology to analyze the test results is explained.

1) Test Study

The objective of the test study is to find out which of the above-mentioned relevant factors actually have an impact on memory of entertainment experiences. With this objective in mind, we make the following decisions.

a) Sampling Method

50 student volunteers from the university were recruited to be our test subjects. As such, the difference in memory performance due to age difference will be minimal because the subjects' ages all fall in the range of 20 to 27. In addition, since most subjects are Chinese, we will not be able to investigate how race may make a difference.

To test whether gender is an influential factor, an equal number of male and female subjects is ensured, i.e., 25 are female and 25 are male.

In order to minimize the confounding effect of irrelevant

factors shown in Table I, test subjects are informed in advance that before they participate in the test they should get enough sleep, have proper meals, and avoid using any medicine or consuming food or beverage that may contain caffeine.

b) Test Procedures

In the test, each subject is first asked to watch a short film, which is about 10 minutes in length. After this, the subject fills up a questionnaire.

Eight different short films are used in the test. These films are selected in a way that they differ in many aspects so that the subjects' responses will vary for different films. For example, some films are easy to understand while others are difficult; some films are emotional while others are less emotional. The following films were selected from YouTube:

- "Signs:" http://www.youtube.com/watch?v=uy0HNWto0UY
- "Nought:" http://www.youtube.com/watch?v=1zmB4W4mzuc
- "Please!": http://www.youtube.com/watch?v=AiCw8V_pF9o
- "Little man, the way girls are": http://www.youtube.com/watch?v=dpHpq5mozMg
- "9": http://www.youtube.com/watch?v=umxUMhiIpJQ
- "The Open Doors": http://www.youtube.com/watch?v=pBXb-8YoR0E
- "The Clap": http://www.youtube.com/watch?v=LsWuH0-Q8UU
- "Peter & Ben": http://www.youtube.com/watch?v=JFTGBmX19VQ

Each subject only watches one short film. For each film, there are at least 3 female and 3 male subjects assigned to watch it.

Each subject completes a memory test later on, which comprises of open-ended questions that test how much information the subject remembers from the short film. Subjects had the freedom to decide when they are comfortable to complete the memory test, as long as it is 24 hours after the test. The subjects were told not to watch the short film again before she/he completes the memory test.

c) Data Collection

The questionnaire collects data for the factors shown in Table II. Each factor is rated on a 10-point Likert Scale (rating from 0 to 10). Although the most common Likert Scale used is 5- or 7-point [13], we choose to use a 10-point Likert Scale to obtain more detailed responses from the subjects.

TABLE II: Factors / data collected by the questionnaire

Symbol	Factor
V2	Gender (Male=1, Female=0)
V3	Age
V20	Attention level when watching the film
V21	How interested the subject is in watching the film
V57	Stressed feelings experienced when watching the film
V58	Happy feelings experienced when watching the film
V59	Scared feelings experienced when watching the film
V60	Surprised feelings experienced when watching the film
V61	Disgusted feelings experienced when watching the film
V62	Sad feelings experienced when watching the film
V63	Angry feelings experienced when watching the film
V22	How predictable the storyline is to the subject
V24	How familiar the subject is with the context in which the story in the film takes place (i.e., general setting including time, place, environment, background etc.)
V25	To what extent the storyline is structured in a way that the events are linked to one another, logically, in time order, or in any other manner that makes sense to the subject (i.e., relatedness of content)
V26	To what extent the subject thinks some scenarios in the film are common in the real life
V27	To what extent the subject thinks some scenarios are common in movies/performances/TV series
V28	To what extent the subject thinks the scenarios of the story are concrete and tangible as opposed to abstract or hard to perceive (i.e., concreteness)
V29	To what extent the subject thinks the story difficult to understand
V30	To what extent the subject likes to watch the short film again
V31	To what extent the subject thinks some scenario(s) are similar to what they have known/seen/heard of before (i.e., interference of scenarios)
V32	To what extent the subject thinks some character(s) in the film are similar to whom they have known/seen/heard of before (i.e., interference of characters)
V34	Race (Chinese=0, Non-Chinese=0); since out of 50 participants, only 6 are non-Chinese, we only differentiate between Chinese and Non-Chinese
V35	Whether there is verbal and/or written communications in the film (Yes=1, No=0)

Many of the factors represent variables that the subject cannot necessarily consciously perceive correctly, and the questionnaire can only indicate what the subject "thinks" she/he experienced (or in the worst case, provides misleading information consciously).To get a clearer picture, we thus also collect real-time psychophysiological data during the test for factors listed in Table III (using the ProComp5 Infiniti biofeedback equipment).

As introduced in [14], the Law of Initial Values (LIV) is a special type of relationship between the size of a response and the prestimulus level. For psychophysiological recordings that support LIV, the greater the prestimulus level, the smaller the response to stimulation. If a significant correlation exists between the prestimulus levels and the magnitude of the response to a stimulus, the LIV should be neutralized statistically. Lacey's Autonomic Lability Score (ALS) is one

of the methods. ALS is obtained for each subject separately for each measure using the following formula:

$$ALS = 50 + 10\frac{Y_z - X_z r_{xy}}{\left(1 - r_{xy}^2\right)^{0.5}}$$

where X_z is the individual's average for prestimulus test data; Y_z is the average for the actual test data; and r_{xy} is the correlation for the sample between prestimulus and actual test data levels. The prestimulus test is a 5-7 minute test that is carried out before the actual test. During the prestimulus test, the subject is told to relax and sit in the room alone, doing nothing, while psychophysiological measurements are taken. Note that X_z is the average of the prestimulus test data excluding the first two minutes because there usually are disturbances caused by the experimenter leaving the room and closing the door, as well as the subjects adjusting themselves on the seat. The actual test is the experiment during which the subject watches a short film and psychophysiological measurements are taken. Y_z is the average of the actual test data, again excluding the first two minutes.

We test for correlation between the response and the prestimulus level in order to decide whether any of the psychophysiological measurements support LIV. With at least 95% probability, we find that a significant correlation exists for BVP, skin temperature, respiration amplitude, and respiration rate. As such, data collected for these psychological measurements are adjusted to ALS using the above formula while the data of the other measurements are not adjusted. For EMG, skin conductance and heart rate, we use both the actual poststimulus level and the response (obtained by subtracting prestimulus level from the poststimulus level) in the regression process.

TABLE III: Factors / Biomeasure Data

Symbol	Factor
VV1	Response of electromyogram (EMG) on the masseter muscle (which detects smiling)
V7	Post-stimulus level of electromyogram (EMG) on the masseter muscle
VV2	ALS of blood volume pulse waveform (BVP) (measured from the finger)
VV3	ALS of skin temperature (measured from the thumb)
VV4	ALS of respiration amplitude (measured from the abdomen)
VV5	Response of skin conductance (measured between the index finger and the ring finger)
V15	Post-stimulus level of skin conductance (measured between the index finger and the ring finger)
VV6	Response of heart rate
V17	Post-stimulus level of heart rate
VV6	ALS of respiration rate

Besides the factors of Table III, we also include the peak values, lowest values, and ending values (average over the last 30 seconds) of the psychophysiological data in the hope of verifying the peak-and-end rule proposed by Fredrickson [16].

In addition to the factors discussed so far, we also consider two other factors which are included in Table IV.

TABLE IV: Factors / Other

Symbol	Factor
V4	Length of short film
V5	Number of hours elapsed after the test before the subject completes the memory test

d) Memory Test Evaluation

The questions in the memory test are designed to test how much information a subject remembers about the film. For each short film we have compiled a list of all possible details of the film. Each list is generated by a careful analysis of the film and recording the details one by one. Each detail is given a weight of one point, and different films typically have different number of points in total. The details cover the aspects of character information (names, appearances, personalities, backgrounds, behaviors, and so on), the full storyline, background music, and other information (such as names of directors, actors, etc). Such a list is then used as a reference to obtain a memory score for each subject. For example, if a list contains 100 details and the subject is able to recall 50 correctly, the memory score of the subject is 50% or 0.5. For the eight films, the total number of points is 138, 153, 135, 211, 137, 172, 208 and 166. The variation is due to the difference in length of the film and different properties of the film. For example, some films have more conversations while some have none.

e) Regression Analysis

Using the data collected, we performed a regression analysis in order to identify which factors have relatively significant influence on how much information a person can remember from a short film.

IV. Results

A. Regression Analysis Results

The regression analysis suggests that the factors shown in Table V have most significant influence on memory score. The t-Test probability is the probability of the respective factor's coefficient being zero, i.e., the factor being insignificant to the model. As such, the smaller the probability, the more significant the factor is to the model.

The equation which describes the relationship between memory score (denoted by V1) and the following factors is

$$
\begin{aligned}
V1 = 0.2073 &+ 0.1973VV5 - 0.0002357V5 \\
&- 0.00209VV3 - 0.8066V15 \\
&+ 0.01599V20 + 0.009622V22 \\
&- 0.01206V27 + 0.008015V30 \\
&+ 0.01758V31 + 0.01106V61 \\
&- 0.004421VV1 \times VV6 + 0.00271VV2 \\
&\times V15 - 0.001961VV3 \times VV5 \\
&+ 0.0008914VV3 \times V15 \\
&- 0.0001866VV4 \times VV5 \\
&- 0.003338VV5 \times VV6 \\
&+ 0.0002708VV5 \times VV7
\end{aligned}
$$

TABLE V: Factors that Have the Most Significant Influence on the Memory Score

Factors	Coefficients	t-Test		ANOVA (f-Test)	
	Estimate	Pr(>|t|)		Pr(>F)	
(Intercept)	0.2073	-		-	
VV5	0.1973	0.0000645	***	0.0036628	**
V5	-0.0002357	0.019361	*	0.0003363	***
VV3	-0.00209	0.126847		0.0013569	**
V15	-0.8066	0.0000057	***	0.1161467	
V20	0.01599	0.016065	*	9.243E-07	***
V22	0.009622	0.001671	**	0.0317563	*
V27	-0.01206	0.001287	**	0.1420376	
V30	0.008015	0.012986	*	0.0063406	**
V31	0.01758	0.000204	***	0.0014376	**
V61	0.01106	0.001327	**	0.0004806	***
VV1*VV6	-0.004421	0.005156	**	0.0026976	**
V15*VV2	0.00271	0.0000243	***	5.276E-05	***
VV5*VV3	-0.001961	0.00000646	***	0.0003587	***
VV3*V15	0.0008914	0.00516	**	0.0010376	**
VV5*VV4	-0.0001866	0.028444	*	0.148255	
VV5*VV6	-0.003338	0.022884	*	0.0429872	*
VV5*VV7	0.0002708	0.122891		0.1228914	

B. Linear Correlations that Exist Between Factors

We also test the linear correlation between each two factors. With more than 95% confidence, we conclude that there exists strong linear correlation (correlation coefficient greater than 0.6) between the following factor pairs:

- V25 (relatedness of content) and V28 (concreteness of content) are found to be positively correlated
- V25 and V28 are found to be negatively correlated with V29 (difficulty of content)
- V29 (difficulty of content) and V35 (communications) are negatively correlated, which means among the eight films that we use in the experiments, the films without verbal and/or written communication have a relatively low level of difficulty for people to understand
- V57(stressed feelings) and V59 (scared feelings) are correlated
- Not surprisingly, linear correlation also exists for many psychophysiological factors, for example, between the peak and average value of the same factor.

C. Interpretation of Results

Due to the fact that our sample size of 50 is very limited, the results obtained from regression analysis cannot be considered conclusive. However, some implications may be drawn from the results:

- Besides the factor pairs mentioned in Section *B* above, there are many other factor pairs which are found to have a significant correlation with 95% confidence. Such collinearity that exists between factors may adversely influence the regression results, especially the quality of the estimates (i.e., the coefficients of the factors). As such, while we can conclude that the factors in Table V are most significant, the following interpretations are only initial results and need to be confirmed with further studies.
- While V5 is the time elapsed after a subject participates in a test and before she/he completes the memory test, it is also a possible indicator of how motivated a subject is in completing the memory test (and this in turn may be related to how much effort the subject puts in to recall information about the short film, resulting in better memory scores).
- VV3, the average skin temperature ALS, is found to have a negative coefficient. It is known that skin temperature varies according to the amount of blood perfusing the skin, which is in turn dependent on the person's state of sympathetic arousal. When a person gets stressed, the skin temperature of fingers will decrease [16]. Therefore, a decrease in skin temperature may be an indicator of increased stress level, which will result in an increase of memory score according to the test result.
- From the sign of coefficient of VV5 (response of skin conductance), we can tell that an increase in the response of skin conductance may contribute to an increased memory score. This is one of the patterns observed for increased arousal level, which may include an increase in muscle tension, skin conductance, and respiration amplitude, and a decrease in respiration rate and heart rate. [17]
- V15, the post-stimulus level of skin conductance, has a negative coefficient, suggesting that the higher the post-stimulus level, the poorer the memory. This is contradictory to our discussion about VV5. Because the post-stimulus level of skin conductance is highly correlated to its pre-stimulus level (p= 1.632028×10^{-14}, and r=0.8473502), and because for different individuals the pre-stimulus level can vary substantially (for people who have more hand perspiration, the skin conductance recordings are found to be much higher), we cannot conclude that people with higher skin conductance levels are better in the memory tasks.
- V20, attention, has already been proven to have a

significant influence on memory performance. The result we obtain is consistent with such findings – the higher the attention level, the better the memory performance.

- V22 is the subject's subjective rating on how predictable the storyline is. According to our results, the more predictable the storyline, the easier it is for people to remember more information.
- Similar to V22, coefficient V31 indicates that an experience closer to what they experienced before has a better impact on memory performance. Interestingly though, V27 indicates that scenes should be less similar to what they experienced in other movies/performances/TV series.
- V30, the subjective rating on the extent to which the subject likes to watch the short film again, has a positive coefficient, indicating that increased memory performance goes hand in hand with a person's reward received in the experience.
- V61 has a positive coefficient – if there are scenes that make the audience feel disgusted, the audience may remember more about the film. Possible explanation is that the scenes may elicit negative feelings in the audience (i.e., negative valence of the content), which in turn increases the memory performance. This explanation comes because in the correlation test, we also find V61 to be positively correlated with V57 (stressed) and V59 (scared), and negatively correlated with V58 (happy).

The last four factors in Table V are interaction terms which suggest that psychophysiological measurements should not be examined only individually – two or more factors together may form certain patterns that are indicators of how well a person may perform in the memory task.

V. Conclusions

In this paper, we surveyed existing theories and findings on human memory and what affects overall memory performance, and identified potential factors that affect people's memory performance related to entertainment experiences. We conducted a test study based on short films, which identified the most important factors. The results suggest that an increase in stress level, arousal level, attention level and reward level in the audience, as well as the valence of the experience may directly or indirectly lead to an increase in the amount of information remembered.

Some of the identified factors are dependent on the audience's demographics, and for a game to optimally exploit/adapt the experience during gameplay for a maximal memory impact, profiling techniques need be employed. For example, placing a key game scene into a setting of an auditorium will likely be much better remembered if the game player is a university student and thus familiar with the setting. Similarly, a storyline that the game player is familiar with can boost the memory performance, and requires profiling for finding the most appropriate content matches.

It is important to note that our test has a very limited sample size as opposed to the number of factors we are considering. Therefore, the predicting power of the model is not especially high. For the future, we will carry out test studies with a larger sample size, more diverse demographics, and test situations with more clearly controllable/separable factors (which is not easy because off-the-shelf movies etc can hardly be used for this). In addition, research in other areas of entertainment experiences suggests a number of additional factors that we should look into.

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