

Effect of Affect on Mental Health

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Abstract

Objective: Passive measures of memory are in increasing demand since active measures like EEG, fMRI etc. are not a viable way of cognitive measurement in environments where such devices are difficult to be accessed or for age groups and set of people to which such measures are difficult. **Methods:** Thus, in this paper, we propose a novel mathematical model for a passive measure of recall memory in children of age group 10 to 15 who are suffering from memory difficulties owing to affective effects. **Findings and Applications:** Though such passive measures are still abstract, such a methodology can be used 'on the go' and such can be supported with the help of clinical methods that support the improvement of cognitive abilities like memory.

Keywords: Affect, LTM, Memory, Memory Disorders, Memory Loss Causes, Reaction Time, Recall, Recognition, STM, Types of Affect

1. Introduction

Memory is not a concrete thing which one can touch or sense like other parts of the body eyes, fingers, nose for instance. Memory is an abstract concept that can be conceptualized in lot many ways by people studying different disciplines. Some perceive memory as a process, some think of it as an attribute, while some others see it as a progression of brain. Owing to each discipline, ranging from Psychology, Biology, Neurology to Cognitive Science and Computer Science, we have a motley of notions regarding the same Memory with each branch incorporating analogies to make the model suit their field's needs. But a unified agreement of the abstractness of memory is the point of concordance, instead of it deeming it something physical. The notion of Memory is so titillating that a multitude of models have been proposed for it, than any other mental phenomenon. Memory is a concept of remembering and is a collection of all the experiences not just a single thought itself. It is the unison of all the memories that make us who we are. The belief of associating memory to one specific place in the brain has been discarded, with the acceptance of the model containing different complex subsystems taking the floor. Different expanses of brain

parallelly works at very high processing speeds giving the semblance of a simple single Memory located at a specific point; but this does not holds true. Memory is a complex unanimity of different parts of brain simultaneously working to yield the comprehensible idea. This cognizable thought stemming from 4 different processes is ensnarled in 3 different stores¹.

These 4 processes are in the order of Encryption, Unification, Storage and Reminiscence.

- Encryption is the method of creation of new paradigm by allowing the thought to be remembered to be attentively perceived by the senses. Encryptions can be classified as Sensory or non-Sensory. The former includes stimulus from audio signals or visual aids or the feel from touch; whereas the latter entails associativity from a milieu or a particular connotation.
- Unification is the process of blending the new thought along with pre-existing ideas after encrypting the information to be stored in form that it can later be recalled. By and large it is the process of steadying the memory chunk after its initial encryption.
- Storage is the amalgamation of unified memories into areas called Stores. The three are named as sensory storage, short term storage, long term storage jointly

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serving to screen loads of information, human brain daily meets. Depending on the number of iterations, an information is remembered, the information passes from one stage to the other. For instance reciting a rhyme over and over again a number of times will root it in the long term storage and it remains etched even till the old age.

- Reminiscence is the act of recollecting an already chanced event which has been encrypted and stored previously. The brain reflects back the series of events according to its own perception. And this may happen by either of the two: Direct answer or hierarchical insinuation. Reminiscence may happen either in-order or unordered or based on cues following the locality of reference^{2,3}.

1.1 Types of Memory

Memory storage classification occurs in the brain based on the time it takes to hold a given piece of information. These are categorized as under:

1.1.1 Sensory Memory

The untamed, autonomous and off the cognitive control kind of area where information gained from the basic senses lasts less than even a second is called SMS or Sensory Memory Store. Since idea gained from the senses degrades so quickly over time (i.e. on the order of few milliseconds), it cannot be sustained via rehearsal. Optical memory, Acoustic memory, Olfactory memory and Haptic memory are the memory stores which correspond to visual, auditory, aromatic and touch information which briefly stores the image, sound, smell and feel of the object at hand for a short duration of time respectively. Instances of information that is stored in the sensory memory are like showing a mango and gauging information about its color, its fragrance, etc⁴.

1.1.2 Short Term Memory

This part of the memory is known as working store wherein small piece of information is retained for a short duration of time (of the order of 10-15 sec). Also known as Brain's Sticky Note, STM holds a limited capacity of objects ranging from 5 to 9. This is attributed to the 7 ± 2 's magical prowess cited in the paper by G. A. Miller. Cases where STM is commonly used include memorizing a phone number, translating languages, comprehending the meaning of a sentence, etc. Divide and conquer approach can be used to pair digits of

3, 3 and 4 to memorize a 10 digit mobile number. Translator should retain the newer piece of information to be translated while speaking the translated version of the earlier piece. Sentence comprehension occurs by holding the former part while reading on the subsequent words^{5,6}.

1.1.3 Long Term Memory

The LTM is very flexible on the period as well as amount of storage. It allows huge amounts of information to be stored indefinitely, at times even throughout life. This state is achieved by repeating the information over and over again or associating it with typical meanings or sounds, etc. People remember their names, planets, directions, colors, important dates and a lot more with a conscious effort to retain it. However storage in LTM occurs more through the semantics i.e. the meanings and associations, in contrast to STM where auditory information lasts longer than the visual one. Forgetting takes place in LTM stores when interference with older memory results in either dilution of older knowledge or superimposition of newer one over its older counterpart.

1.2 Classification of LTM

1.2.1 Declarative Memory

Declarative memory is the memory to have the defined facts or occasions and can be recollected consciously. It is a subset of implicit memory, and can further be classified in two more categories enumerated as under:

1.2.2 Episodic

The memory which deals with specific period of time wherefrom we can re-build our events at any point of time and that essentially centers the person himself/herself is called as episodic memory. Since it's a first-person account one can not only remember the date or time but even the emotions of happiness, gloom or fear or whatever it may have been.

1.2.3 Semantic

This is a better off memory in terms of the structure of facts, figurines, wisdom about external world along with the space and time it took place on. It involves less of a first-hand account but rather uses simple knowledge such as the stops between one station and the other, cognizance of Mathematical principles, traditional rites and rituals, different cuisines, meanings of words in a language, to name a few.

1.2.4 Procedural Memory

The involuntary memory which deals with skills or expertise in performing a task is called as procedural memory. Such skills become so deep-seated in our memories, after years or months of practice that we are no longer sentient of their existence. Stitching a button, tying a tie, knitting the batter of dough are some cases that involve procedural memory^{7,8}. Table 1 describes the Comparison of short term memory and long term memory.

2. Memory Loss and Memory Problems

Human beings, however gifted they may be, tend to forget things. And it's not a sin to disremember things one knew a moment ago. Almost anyone and everyone face a lapse of memory from time and again. It may vary from forgetting a person's name you just met, inability to recall where you kept your spectacles, forgetting what you had at lunch are few of the multitude instances that daily happen with us. As long as this forgetfulness doesn't hinder your work, one need not seek medical attention. A succinct description for a memory disorder would be conditions that stem from harm to neuroanatomical structures which hamper the storage and reminiscence of memories. Disorders could build up over a period of time

or could be sudden due to some mishap. The causes for memory disorders have been elaborated in Section III.C after having thrown light on some of the major disorders that challenge mankind^{9,10}.

2.1 Major Memory Disorders

Few of the most popular disorders have been taken into consideration and discussed about in this section. The list is presented in lexicographic order and does not serve to debase the gravity of any other memory disorder. The details include how the disease stems from and what it affects, so that the readers have a gist of the major characteristics of the disease.

2.1.1 Alzheimer's Disease

Alzheimer's disease popularly abbreviated as AD is the condition where synapses and neurons of cerebral cortex and brain's subcortical regions are lost, which leads to shriveling of the affected areas. The disease is characterized by the incompetence to gain new memories or recall newly noticed facts. AD doesn't affect all memory stores equally. Short-term stores are first to rupture, episodic and semantic memory follow suit and in due course of time even procedural memory caves in. With the progression of AD, portions of memory that were sound before too become upset¹¹.

2.1.2 Amnesia

This mental abnormality stems from damage to hippocampus or medial temporal lobe and deteriorates memory and learning amidst other cognitive abilities in a normally alert patient. This condition is a disturbance whose impact is greater than everyday forgetfulness or muddle-headedness. Lesions to brain from physical injuries, stress of various sorts or psychic defence mechanisms are potential candidates that cause the trouble we know by the name "Amnesia". Amnesia is of 2 types: Anterograde amnesia, in which the knack to memorize new things is compromised and Retrograde amnesia, in which person may remember new things but already existing memories can't be recalled. If both types of amnesia co-exist in a person, he/she is said to be suffering from global amnesia¹².

2.1.3 Autism

The condition that arises from compromised social interaction of children at an age where they should be expressing themselves freely had to prove itself to be

Table 1. Differentiating STM and LTM

Parameters	STM	LTM
Kind of recall	Temporary	Permanent
Amount of information stored	Around 7 items or even less	Unlimited amount of information can be stored.
Duration of knowledge	Short period of about 10-15 sec	Indefinite periods around the person's entire lifecycle
Encoding of information	More through auditory and less via visual	Semantic encoding guided by meaning and links
Changes in neural connections	Temporary and unstable	Stable and permanent
Repetition and recalling	Converts STM into LTM	Improves the LTM further but doesn't convert it to STM
Forgetting	Rarely occurs, that too in case of abnormalities	Decay does occur

classified as a disease because scientists would deem to be the case of “neurodiversity”. Autism affects movement, balance, visual cognition besides causing blockades to memory¹³.

2.1.4 Dementia

This is not just a single disease but a wide class of disorders that encapsulates lot many memory dysfunctions. Besides tampering a human’s ability to think and remember, it also affects emotion, moods, balance, perception, acquired language skills and problem solving. Dementia is a step further than MCI (Mild Cognitive Impairment) because the memory loss in former is more severe as compared to the latter. This severity is amalgamated by one or more of Aphasia, Apraxia, Agnosia or Executive dysfunction¹⁴.

2.1.5 Huntington’s disease

This disorder is a hereditary progressive ailment of the brain which beginning from slurring or deceleration of speech to deterioration of intellectual faculties, frenzied movements and eventually incarceration to bed. Few symptoms of this disorder are laziness, irritation and depression. This disease is called hereditary because if any of the parents for a child suffers from Huntington, the newborn has 0.5 probability to have that as an innate disease. Striatum (largest area of Basal ganglia) is the chief affected region in this disease¹⁵.

2.1.6 OCD

Obsessive Compulsive Disorder is a condition where the person has uncontrollable urges (“compulsions”) to reduce the penetrating thoughts that produce anxiety (“obsessions”) despite putting efforts to ignore them. OCD is viewed as the disharmony between Long term and Short-term memory stores. The patient may be stuck in mental loop (with LTM being Brain’s controller) so much that the sufferers’ reactions are based with entirety on memories, regardless of the input. Certain obsessions include keeping the surroundings tidy and pin-perfect, being hygienic at all times, distaste for odd prime numbers¹⁶.

2.1.7 Parkinson’s Disease

This disorder is a protracted, progressively deteriorating condition which affects the Central Nervous System (CNS), thereby harming motor skills which brings with

itself tremors, muscle rigidity and instability in postures. Its onset is in about 96% of cases, after the age of 50. Unlike other disorders whose causes are uncertain and yet under debates, but Parkinson’s is known to be caused by paucity of Dopamine (a neurotransmitter), its formation and action in substantia nigra that affects the Basal ganglia’s stimulation of the motor cortex¹⁷.

2.1.8 Schizophrenia

Schizophrenia is a condition branded with atypical social behavior and person’s fiasco to fathom reality. Turbid thoughts, vague beliefs, hallucinations, dearth of emotions, speech, motivation, etc. are few of the symptoms that mark Schizophrenia. Potentially its cause is accrued to environmental factors like age of parents, being brought up in a town, ill-nutrition of mother during pregnancy, etc. substance factors like consumption of Cannabis, alcohol, etc., and genetic factors like the first degree relative having Schizophrenia¹⁸.

2.1.9 Tourette Syndrome

This is a neurological condition noticed in childhood, where repetitive, stereotypical, involuntary utterances and movements called “tics” occur. The CNS is so affected that the sufferer keeps repeating others’ words or doing socially objectionable actions. Similar to Huntington’s disease, this disorder involves altercations in the way Striatum interacts with its composite Basal Ganglia. Tics could be facial smirking, voluntarily eye-blinking, throat-clearing, hopping, jumping etc. and tics come and go over time, besides their variation in type, frequency, intensity and location.

2.1.10 Wernicke-Korsakoff’s Syndrome

Brain disorders are not always innate, but could be due to our own habits of consuming more alcohol than food. This disorder stems from privation of thiamine and leaves a person unable to form new memories as in the case of anterograde amnesia, loose existing memories and forsaken from empathy and apathy. The brain areas that are mainly affected by Vitamin B’s thiamine deficiency are thalamus and hypothalamus¹⁹.

2.1.11 Memory Loss Causes

Apart from diseases mentioned in Section III A, there exist other factors too that facilitate loss of memory. Such causes have been mentioned below:

- Medication

Pills like antidepressants, stress-releasers, sleeping pills, antihistamines and tranquilizers deter the brain to effectively retrieve what it stored.

- Alcoholism

Alcohol interferes with brain chemicals and reacts with normal medication, resulting in thiamine deficiency.

- Dehydration

Low levels of fluid in the body, also contribute to faintness in memory.

- Depression and anxiety

The extreme ends of bipolar disorder too leave the brain incapable of making decisions and this oscillation between the 2 phases is a stimulant for forgetfulness.

- Stress

This pressure situation gets in the way of focus, attention and does not let a person concentrate with conviction, thereby the ability to remember suffers.

- Infections

Infection in respiratory system, urinary tract or diseases like herpes, syphilis, etc. causes reduced alertness that potentially results in memory loss.

- Lack of oxygen to brain

With lack of oxygen, the level of consciousness drops which in turn lowers the level of alertness and the brain is thus not able to recollect things at a normal rate.

- Malnutrition

Lack of essential vitamins impede the steadiness of memory. For instance reduced thiamin leads to Karsakoff's syndrome.

- Sleep deprivation

Quality and quantity of sleep are vital for memory's efficient consolidation and retrieval. Getting too little sleep leads to fatigue which in turn affects the memory in a negative sense.

- Thyroid glands activity

Lack of thyroid glands activity leads to people not being able to think clearly because the processing of nutrients to create energy for cells is lessened thereby inducing forgetfulness.

- Smoking

This cause is engulfed by the other cause that says lack of oxygen to brain results in declined memory activity. Studies mention that smokers are unable to recall names for faces of people they already knew.

- Head injury

Accidents that physically affect the head are bound to cause some affects to Long-term and/or Short-term memory storage and retrieval.

2.1.12 Symptoms of Memory Loss

Few indicators of memory problems find mention.

- ✓ Confusion.
- ✓ Petulance.
- ✓ Feeling lost even in familiar places.
- ✓ Misplacing items in inappropriate places.
- ✓ Erratic mood-swings for no particular reason.
- ✓ Language issues, such as mingling of words.
- ✓ Confabulation.
- ✓ Forgetting facts, places, people, events.
- ✓ Repeating same stories again and again.

3. Memory Associated with Aging

Effect of age on memory is attributed to 2 solid and 1 debatable frameworks, listed below:

- Inadequate Processing Resources

Based on the assumption that with age, resources present to store information into or recall from memory are limited. Hence lack of resources hinders normal memory functioning

- Diminished Processing Speed

Limited time mechanism: The relevant tasks are not even successfully executed when confined time period is given due to already degraded cognitive performance.

Simultaneity mechanism: Even for unlimited period of time, if person is able to finish tasks of early stage, he/she may not be able to hold that output for completion of task coming at next stage.

- Reduced Inhibitory Functioning

This is the most discussed and debated hypothesis which claims that aged people are more susceptible to distractions that hinder the encoding and retrieval, which in turn affects memory²⁰⁻²².

3.1 Effect of Age on LTM and STM

3.1.1 STM

- Primary Memory

Memory span, viz. a metric for determining memory capacity, is affected by aging. Memory span is the longest sequence of un-correlated items a brain can remember,

and this span has been proven to be lower for higher age groups as compared to youth.

- Working Memory

To assess the Primary memory of STM only retrieval was tested, but in working memory along with Recall, the Processing is also taken into account. Instances include asking subjects to alphabetically list out their friends' names. Studies reveal that with more age, working memory is also hampered.

3.1.2 LTM

- Semantic vs. Episodic Memory

Episodic memory is affected more in high aged individuals than semantic, but the latter is not spared as the speedy retrieval is scarred and these frustratingly time-consuming failures in retrieval also deteriorate Semantic memory.

- Implicit vs. Explicit Memory

Implicit memory is not affected by age, whereas explicit memory shows a vigorous debility in memory with the advancement of age²³.

4. Affect and its Types

Affect is the experience of feeling or emotion. It's an essential component of how a human being responds to the stimuli

because it depicts the visceral reaction to the stimulus before cognition starts for the formation of a more complex emotion. The time at which Affect occurs is still debatable. Some suggest it happens before the beginning of any cognitive processing, others suggest it after the processing of certain information²⁴. Affect has been known to spread in different dimensions: Positive, Negative and Neutral. The most popular measure is PANAS (Positive and Negative Affect Schedule) that contained 20 single word items describing emotions in different dimensional spaces. I-PANAS-SF is an irredundant version of the former and is characterized by reliability, stability and inter-cultural invariance²⁵. Silvan Tomkins in his book "Affect Imagery Consciousness" describes Affect as the biological share of feelings viz. pre-coded in our systems which on elicitation precipitate a known pattern of events²⁶.

4.1 Types of Affect

The 3 classes which encompass 9 types of Affect, the low-high reactions corresponding to the Affect along with its biological expressions is summarized in the Table 2.

5. Measure of Memory

As has been discussed, an accurate and a fool proof method for measuring the memory of an individual is not

Table 2. Affect, response and expression

Class	S. No.	Affect	Low intensity response	High intensity response	Accompanying expression
POSITIVE	1	Joy/ Enjoyment	Reaction to success	Impulse to share	Smile lips wide out
	2	Interest/ Excitement	Reaction to new situation	Desire to attend	Eyebrows down, eyes tracking, closer listening
NEUTRAL	3	Surprise	Response to erratic change	Resets the impulse	Eyebrows up, eyes blinking
NEGATIVE	4	Anger	Reaction to threat	Impulse to attack	Frown, red face
	5	Disgust	Reaction to bad taste	Impulse to abandon	Lower lip raised and protruded Head forward and down
	6	Dis-smell	Reaction to foul smell	Impulse to evade	Upper lip raised Head pulled back
	7	Distress	Reaction to loss	Impulse to mourn	Crying, sobbing, arched eyes, mouth lowered
	8	Fear	Reaction to danger	Impulse to run/hide	Pale face, numb limbs, erect hair, sweat all over
	9	Shame	Reaction to failure	Impulse to review behavior	Eyes lower, head down, blushing.

formalised. Memory of an individual can be measured under four characteristics. These can be listed as Recall, Recognition, Re-learn and Re-construct. For children of age group 10–15 measure of re-learn and re-construct will be cognitively challenging task. Thus we restrict the scope of the paper to recall and recognition. A typical experimentation will consist of giving the subjects a set of items for be memorised within a specified time limit after which a pause buffer time is left. Once the buffer time is completed questions are presented to the subject at which point they are expected to answer. Our primary focus is the reaction time of the subjects which is a measure of time from the time the question is presented to the subject and the point at which the subject answers the question. It is a passive measure of the time taken by the subject to recall the memory which was just encoded before the given buffer time. A novel mathematical model has been proposed for passively measuring this recall time of the subjects being experimented.

6. Mathematical Modelling

The novel mathematical model can be represented as:

$$M_{\text{recall}} = f(n, t_b, c, t_r) \quad (1)$$

where M_{recall} is the characteristic memory constant of the subject under experimentation, n is the number of items presented in the trial, t_b is the buffer time between when the items are presented and the questions are asked, c is the number of questions answered correctly and t_r is the average reaction time of a subject for a set of trials specified by n .

To derive the model, the proportionalities between the variables and the outcome should be fitted so that the desired result is got. The relation between t_r and c is sufficient in giving an idea of how good the memory of the subject is. It is to be noted that a lower t_r value means the subject took a lesser time to react to the questions and thus a faster recall but not sufficient enough to passive suggest whether the memory is good or not. If the t_r values is less with high c it suggests a very good memory of the subject, where as a high t_r with low c is an implication of very bad memory of the subject. The exceptions can be stated as one with a low t_r but a low c which can be an implication of wrong memory encoding and one with a high t_r but still a high c might implicate difficulty in recalling though with good memory encoding. This can be figuratively represented in Figure 1. To further

understand the relation between t_r and c a plot of c^{tr} is also represented Figure 2.

As the value of c increase the steepness of the curve increases. In the represented Figure, $c_4 > c_3 > c_2 > c_1$ and thus the steepness of the curve varies with c too.

To arrive at the formula first the intervariable proportionalities is analysed.

$$t_r \propto n$$

$$t_r \propto t_b$$

$$t_r \propto t_b n$$

$$t_r = k_1 t_b n$$

$$\frac{1}{k_1} = \frac{n \times t_b}{t_r} \quad (1)$$

The proposed model of M_{recall} can be analysed as a proportionality with the given parameters as follows:

$$M_{\text{recall}} = f_2(n, t_b, c, t_r)$$

$$M_{\text{recall}} \propto c$$

$t_r \backslash c$	high	low
fast	Very Good Memory	Bad Memory
slow	Good Memory	Very Bad Memory

Figure 1. Relationship between t_r and c and its suggestions on the memory of the participant.

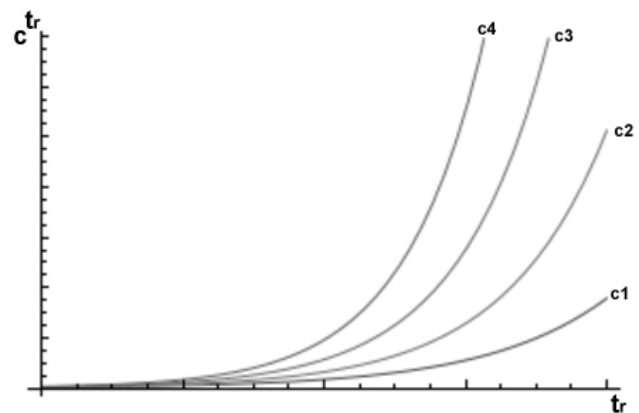


Figure 2. Represents the variation characteristics of c .

$$\begin{aligned}
M_{\text{recall}} &\propto \frac{1}{tr} && \text{given } c \gg \\
M_{\text{recall}} &\propto n && \text{given } c \gg \\
M_{\text{recall}} &\propto t_b && \text{given } c \gg \\
M_{\text{recall}} &\propto \frac{n \times tb}{tr} && \text{given } c \gg \\
M_{\text{recall}} &= k_1 \frac{n \times tb}{tr} && \text{given } c \gg \\
M_{\text{recall}} &= \frac{k_1}{k_2} && \text{from (1) (2)}
\end{aligned}$$

where $\frac{1}{k_1}$ is derived from Equation 1 and k_2 is modelled as a function of c which can be given by:

$$k_2 = f_1(c) \quad (3)$$

where f_1 can be given as an exponential or logarithmic function of c which fits the condition of n , t_b and t_r .

Thus, the model can be given as:

$$M_{\text{recall}} = f_1(c) \frac{n \times tb}{tr} \quad (4)$$

where $f_1(c)$ can be given by:

- $a \log_{10}(c)$
- $\log_{10}\left(\frac{c}{n-c}\right)$
- $\log_{10}\left(\frac{c}{n}\right)$
- $g_1(c); \text{ if } c \geq \Theta$
 $g_2(c); \text{ if } c < \Theta$

where Θ is the threshold set.

7. Discussion

As discussed in the mathematical model, Equation 1 to Equation 4 helps us deriving the required formulation to arrive at the subjective M_{recall} . The characteristics of the model can be discussed as follows. The reaction time of a subject will be directly proportional to the number of items represented in the set and the buffer time given in between set display and the questions displayed. Thus we derive Equation 1. The proposed model M_{recall} should be directly proportional to the number of questions answered correctly. Thus, it will be inversely proportional to the reaction time, number of items/set and the buffer time given that the number of correct answers is high. An exponential function should be given for f_1 under Equation 3, since even a small change in c should have a

larger impact on M_{recall} . Moreover, the difference between M_{recall} given for lower c should be lesser than when given for higher c . This can be represented as:

$$dM_{\text{recall}}(n_i - n_{i-1}) > dM_{\text{recall}}(n_j - n_{j-1}) \quad (5)$$

Where i is a set of $n = 8$ and j is a set of $n = 4$.

Thus, an exponential function is chosen for Equation 4. Another possibility will be the choice of a threshold function with the threshold as Θ which can be further divided as g_1 and g_2 .

8. Conclusion

In this paper, a novel mathematical model for passively measuring the recall memory of children is formulated. This method can be easily implemented in a functional manner and also to other cognitive abilities too. The initial experimentations and results have given reliable outputs which have helped in trying about different Numerical fittings for the proposed functions.

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