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Inclusive Connecting Trigger in Cognitive Science of Creativity

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Abstract This research paper presents the cognitive scientific and neuro-scientific knowledge of creativity. It goes on to develop and propose an Inclusive Connecting Trigger (ICT) to improve the generation quality and generation time of candidate solutions. It also develops a preliminary mathematics for selecting the ICTs and the methods of choosing ICTs. It discusses the scope of ICT to a variety of creative domains. The Inclusive Connecting Trigger is demonstrated and supported by experiments performed and documented is this research paper.

Keywords: *inclusive connecting trigger, involuntary memory, remote association, alternate uses, fluency, originality, creativity, intelligence*

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1. Theory

Most of grow up with traditional concept of Intelligence Quotient (IQ) originally developed by Alfred Binet, with the understanding that intelligence is inborn and immutable and verbal and mathematical reasoning are the requisites or must-haves of intelligence. Also, genes, it is known, account for 48% of IQ and the environment and learning accounts for the remaining 52% [1]. Today, it is understood that we possess at least 7 different measurable intelligences. The interaction of these intelligences, the domains available for study and mastery within a culture and the judgement rendered by the field that is deemed competent within a culture entails emergence of creativity [2]. This research paper develops a technique to generate more (fluency) and novel (originality) ideas.

The mathematician, Poincare felt that he could state that "to create consists of making new combinations of associative elements which are useful. The mathematical facts worthy of being studied….are those which reveal to us unsuspected kinships between other facts well known but wrongly believed to be strangers to one another. Among chosen combinations the most fertile will often be those formed of elements drawn from elements drawn from domains which are far apart" [3]. Creativity is indeed a recombination of seemingly unrelated concepts in contiguity to produce novel, useful ideas**.** Clearly, creativity does not happen in intellectual vacuum. Creativity, both spontaneous and deliberate is a function of time, breadth of knowledge, meshy-ness or messiness of the networks or number of synaptic interconnections, disinhibition of the left prefrontal cortex [4] which censors activation of association cortices in the occipital, parietal and temporal cortices.

The Figure 1 depicts 3 unrelated concepts as black, blue and green. The ICT creates and overlap and inclusion, connecting the 3 concepts into 1 associating concept. The more the proliferation of the ICT in the memory networks, the greater the chance of "inclusion" and "connection" of seemingly unrelated concepts leading to novel ideas. *This is the main theme of the research paper.*

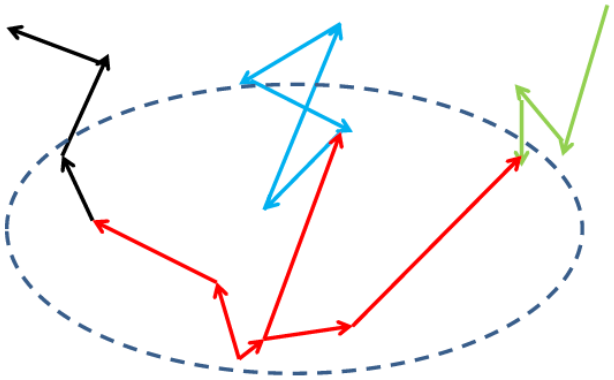

Figure 1. Inclusive Connecting Trigger

2. Involuntary and Voluntary Memory

When a cue is presented, past memories can be evoked without deliberate effort. The contexts can be those that occur in everyday life, involuntary (we will focus on this trigger for the scope of this paper) and voluntary triggers evoking other memories as by-products and during psychiatric illness such as Post Traumatic Stress Disorder

(PTSD) [5]. Voluntary memories, as defined by Hermann Ebbinghaus, founder of experimental study of memory, are memories which appear in consciousness when we search for them while involuntary memories appear spontaneously. In case of involuntary memory, the memory fragment "pops" into our awareness without any apparent conscious attempt to evoke it. So, involuntary memories are explicit, episodic and unintentional [6]. Hippocampus and areas around medial temporal cortex, evoke a previous conscious experience by activating the network which was originally used in perception of the previous conscious experience [7].

At least in the first context, in everyday life, involuntary memories occur about 3-5% of the day especially in the "diffused" state of attention [8]. If that is the case, involuntary memories should be evoked more frequently than those evoked in everyday life. Once evoked, these voluntary or involuntary memories will start a cascade of involuntary memories which may form novel connections. This cascade of activation can occur in autobiographical memory as well as between semantic and autobiographical memory [5]. For involuntary memories, even though the cues can be external (senses), internal (thoughts) or mixed (both senses and thoughts) the experiment presented below used internal cues for evoking involuntary memories. Linguistic or abstract thought cues were found to be frequent as compared to sensory or physiological/ emotional cues [9]. Even within the rear sensory cues, auditory cues are more common [10]. It has been suggested that involuntary recall can be triggered when voluntary triggers are presented [11] and [12], a process known as chaining [13] and [14].

When a memory is evoked in the autobiographical memory system, these activations may trigger other memories. If these activated memories are strong enough they may become conscious otherwise, they may result in associative priming whose effects may be seen after some time [5] – page 63. The abstract triggers produce more memories than sensory triggers, in the case of involuntary memories [9]. There is an interaction between trace information (information stored in the person's brain) and retrieval information, which is a necessary condition of all memory phenomena [15].

Contextual binding theory, going further posits that not only is the trace information interact with retrieval information but the context (spatial, temporal and other details) in which both occurred is also associated with them [16]. These contexts should overlap with many other memories and contexts creating an inclusive network for novel idea.

3. Procedure

Consider the Remote association (RA) of 3 words Broom, Book and Scar again. "Hold" the 3 words visually and semantically in your mind without attempting to process the commonality or similarity of the 3 words by trial and error, though deliberate creativity can be used as well. The 3 unrelated words will trigger 3 different ensembles of neurons in your long term memory. If there is no obvious overlap for the 3 words the novel solution will not be generated readily.

An Inclusive Connecting Trigger is a set of words which are very commonly used in everyday life by most human beings. Example – {Mom, Food, Sleep, Talk, Play, Money, Stone, Colour, Children, Rain, Hospital, Love….}. We grow up learning these simple, common words or concepts. The idea is to find words that will trigger many networks increasing the probability of identifying a solution to the RA. As the triggers above are common to many concepts and words, they should trigger many original solutions. These triggers or cues should be preferably concepts than general events as it is known that conceptual associations occur more commonly than event associations [9]. A numbered list of such ICT was written down on a paper and random number was used to choose and apply 1 ICT at a time. Multiple triggers can be tried, if the first random ICT does not give good results, in problem solving such as Alternate Uses (AU) or RA to generate more fluent and original ideas.

The Inclusive Connecting Trigger should be held in the mind in a "diffuse" or non-focused manner along with the original 3 words "Broom", "Book" and "Scar" one at a time. This will facilitate the recombination of unrelated words/concepts in a meaningful way. One recombination is to "Bind" or "Put Together" which may not seem like the best connection. The broom sticks and pages are bound together while the bandage covers the scars. If the trigger "Children" or "Book" is used, it is possible that the solution "Harry Potter" may be found.

Not limited to RA but Inclusive Connecting Trigger can be used for finding Alternate Uses (AU) or Complete the Incomplete Picture. Generalizing, the Inclusive Connecting Trigger should help in generating novel solutions in other areas as well.

4. Experimental Results

The RA test was offered to 8 subjects after generating random words from Random Word Generator. A same 2 RA tests of 3 words and a same 2 alternate uses test were given to each subject. The result was measured on 2 dimensions of fluency and originality. However, as the Inclusive Connecting Trigger is presented after the tests were presented without Inclusive Connecting Trigger, the fluency number would not be independent but the originality number will be independent. The subjects were trained for RA test and Alternate Uses test with couple of examples before experiment to ensure understanding of the test. Subjects were chosen for both genders and age varying from 10 to 70. A time of 90 seconds was provided to generate solutions. The fluency and originality of ideas after the ICT was presented includes the number of ideas generated before ICT was presented.

The Analysis of Variance (2 Factor with Replications) table for fluency and originality are shown below.

Table 1. A p value of 0.102 was found for improvement in the originality of solutions after presenting the Inclusive Connecting Trigger. The variation remained insignificant across the samples of different gender and age

ANOVA (Originality of RA Solution)						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Sample	3.875	7	0.553571	1.47619	0.244485	2.657197
Columns	1.125	1	1.125	3	0.102495	4.493998
Interaction	0.875	7	0.125	0.333333	0.927044	2.657197
Within	6	16	0.375			
Total	11.875	31				

Table 2. A p value of 0.054 was found for improvement in the fluency of solutions after presenting the Inclusive Connecting Trigger. The variation remained insignificant across the samples of different gender and age

ANOVA (Fluency of RA Solution)						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Sample	22	7	3.142857	0.897959	0.531194	2.657197
Columns	15.125	1	15.125	4.321429	0.054083	4.493998
Interaction	12.375	7	1.767857	0.505102	0.817455	2.657197
Within	56	16	3.5			
Total	105.5	31				

Table 3. A p value of 0.044 was found for improvement in the Originality of Alternate Uses (AU) solutions after presenting the Inclusive Connecting Trigger

ANOVA (Originality of AU Solution)						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Sample	22.21875	7	3.174107	5.97479	0.001511	2.657197
Columns	2.53125	1	2.53125	4.764706	0.044296	4.493998
Interaction	3.71875	7	0.53125	1	0.466275	2.657197
Within	8.5	16	0.53125			
Total	36.96875	31				

Table 4. A p value of 0.002 was found for improvement in the Fluency of Alternate Uses (AU) solutions after presenting the Inclusive Connecting Trigger

ANOVA ()						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Sample	93.96875	7	13.42411	6.411514	0.001041	2.657197
Columns	26.28125	1	26.28125	12.55224	0.002707	4.493998
Interaction	23.46875	7	3.352679	1.601279	0.205603	2.657197
Within	33.5	16	2.09375			
Total	177.2188	31				

Correlations of Originality RA, Originality AU both before and after the test were found negligible.
Pearson correlation of Originality RA and Originality AU = -0.027 and p-Value = 0.884
Correlations of Fluency RA, Fluency AU both before and after the test were found significant.
Pearson correlation of Fluency RA and Fluency AU = 0.699 and p-Value = 0.000

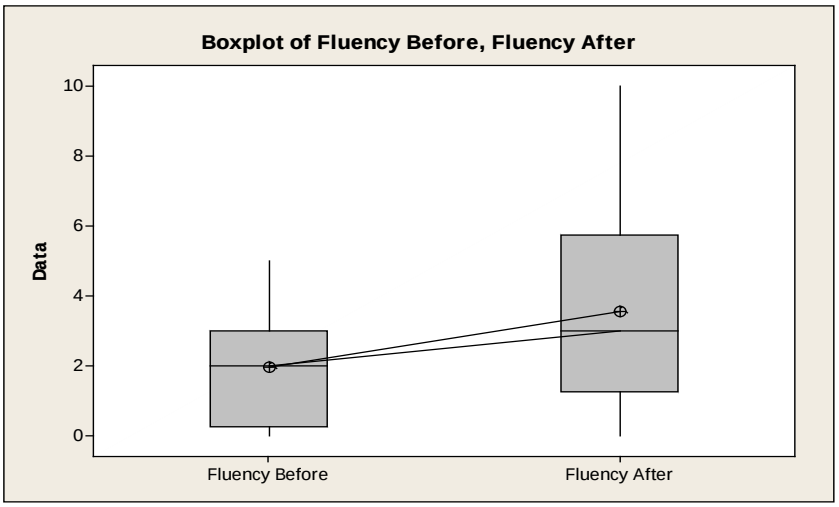

Figure 2.

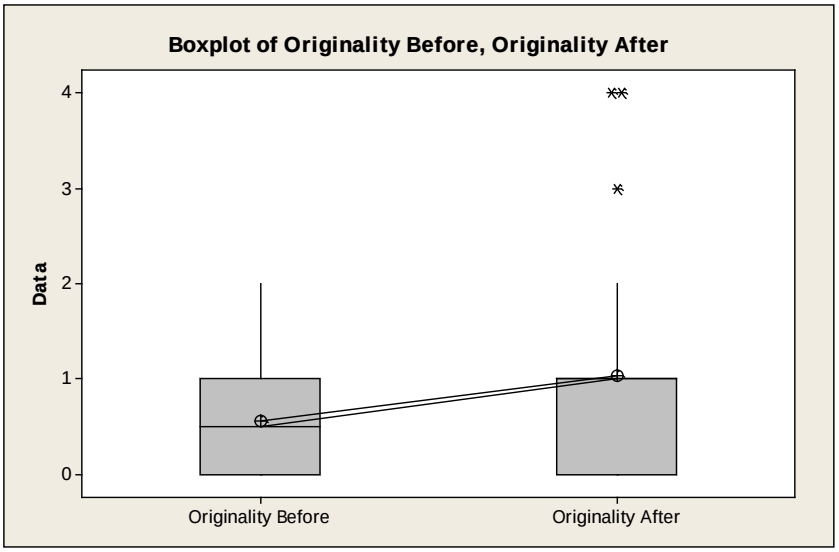

Figure 3.

The Box plots above show gain in both originality and fluency scores for both before and after ICT trigger is presented. The change in both mean and median values was found as shown in figures above.

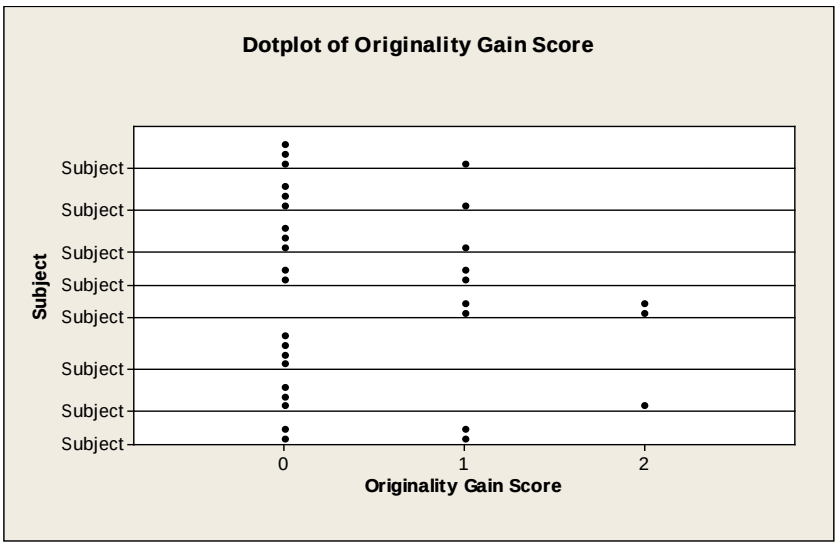

Figure 4.

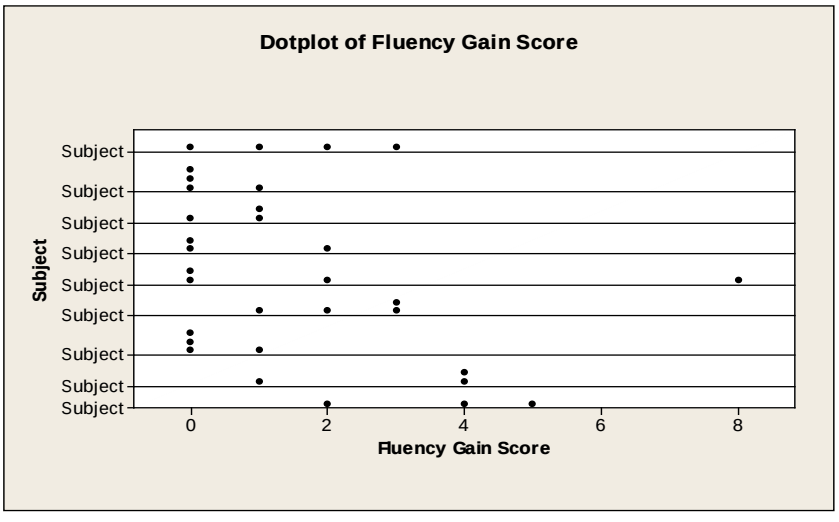

Figure 5.

The dot plot shows the amount of gain in originality and fluency scores after the ICT was presented. The gain impacted the fluency scores more than originality scores.

5. How to choose an ICT?

ICT is a set of primordial or widespread concepts with the ability to trigger as many involuntary memories as possible creating a possibility of inclusion. It can connect unrelated ideas, concepts or semantics into a novel idea. It should preferably be a concept more than an event and should be "held" in mind in a diffuse and unfocused manner. Kvavilashvili and Mandler [17] suggested that wider and faster activation of memory networks occurs during diffuse attention states while [18,19,20] suggested that the executive control system that monitors which autobiographical memories eventually reach awareness is less vigilant during times of diffuse attention and therefore unexpected retrievals will occur. The set mentioned in this paper earlier is just an example and not exhaustive. {Family, School, Country, Government, Number, Water, Book, House, Health, Animal, Blood, Sun…..} are few more examples of very common triggers which can inspire at least divergent thinking or remote association. Even a phrase can be used instead of a word to retrieve involuntary memories and trigger novel ideas. 1 ICT should be used at a time and many such trigger words should be used until satisfactory solution is found. After an involuntary memory is evoked, it can also be held in diffuse memory to trigger more chained memories as it is known that subjects mostly report 2 or 3 chained memories [9,14,21]. However, evoking a memory into consciousness may not be necessarily required and the cascade can happen only in the subconscious. Adjective, verbs, adverbs or other parts of speech can be used other than nouns. Abstract cues (voluntary) will trigger, probably, more memories than sensory cues just like involuntary memories (analogy drawn from research paper by [9]).

There is a strong recency effect in both voluntary and involuntary memories [22]. The ICT or memory cue is voluntary and strategically used to generate creative solutions however the memories evoked after subsequent chaining is involuntary. This paper agrees that involuntary memory is evoked by a cue that matches a corresponding characteristic aspect of retrieval environment [23] as opposed to perfect match between cue and central feature of autobiographical memory [17].

Consider 2 concepts, a "shoe" and a pair of "glasses". The concept of shoe is made up of sub-elements such as {heel, toe, walking, leather, polish, lace…….} and the concept of glasses is made up of sub-concepts such as {frame, lens, vision, colour, eyes…….}. Let us assume that you are trying to solve the problem of frequently slipping and breaking of glasses. If you hold both shoe and glasses in your mind, you can, by recombination of elements, borrow the concept of lace from the shoe to glasses to create a lace or lanyard for glasses to solve the problem. After all creativity is recombination of old ideas into novel ideas.

Here the sub-concept of frame can be broken down into sub-sub-concepts {black colour of frame, shape of frame….}. Let us call all the concepts including the combinations of sub-concepts and sub-sub-concepts as N,

N_{max} (t) = $\sum_{r \text{ from } 1 \text{ to } n}$ (r $^{n}c_{r}$ $(x)^{t}$) where N_{max} (t) is the maximum of total number of all concepts that can be generated in time t and x is the number of connections per element and a combination of r elements fired from all available n memory neurons.

N_{ict} is the number of all concepts fired by an ICT. The ICT are words with a high value of N.

$N_{nict} < N_{ict} < N_{max}$ where N_{nict} is number of all concepts fired by a non-ICT.

x does not remain constant for every branching and hierarchy of network and hence average value should be considered. N is also, of course, culture specific and knowledge dependent. The strength of neuronal connections varies across individuals and depends on many factors such as activation of ion channels, concentration of calcium ions, various other secondary messenger molecules etc. So, the number N may vary according to the strength of neural connections.

If shoe = {a, b, c, d, e} and glasses = {i, j, k, l, m} where sub-concept e is the subset of shoe then to fire all i, j, k, l, m and e, one of the ICTs with high N value should be used. If ICT triggers all i, j, k, l, m and e then it is possible that a novel combination of glasses with laces is formed similar to Figure 1.

A practical way to qualify a concept as ICT is by using word association to create the branching and hierarchies. A strong ICT will have extensive branching and hierarchies with ability to "include" many unrelated concepts. Of course, the memory network fired will be a lot more extensive than association which manifest in the consciousness. However, word association will give a rough idea about the possible ICTs.

Although reasoning brain is the seat of convergent thinking, it can also solve open-ended and ill-structured problems [4]. Both, the deliberate (trial and error search for novel solutions) and spontaneous creativity can be improved by an ICT trigger.

6. Scope of ICT

We have seen that ICT improves the creative output in Alternate uses and Remote Association. The article proposes that ICT should also help musical creativity. Playing musical instruments according to written notes, I think, is a kinaesthetic intelligence and understanding that music as a pattern is musical intelligence. This understanding of music (pitch and rhythm) can be further used by combine existing ideas and emotions in composing music. Playing musical instrument is definitely a skill but understanding and composing music requires musical intelligence and creativity, respectively. Composing music requires both musical intelligence and creativity. Switching the fingers, while playing violin and reading musical notes, with the non-dominant hand and its coordination with the stable bowing dominant hand is bodily skill which can be developed through practice. An ICT will generate patterns and emotions which should assist any musical instrument composition. Since hippocampal activity has been related to associative retrieval [24], it is probable that retrieval of an emotional context by an ICT activates a more extensive and inclusive network of information than does the retrieval of a neutral context. Hippocampus is involved not just in binding recently encodes events but also remotely encoded events [24]. An ICT like "birthday" can trigger a

cascade of mostly happy memories and emotions which can "include" or combine unrelated ensembles in the neural networks leading to novel composition. The converse that music can trigger ideas (based on interviews in book by [25]) in other domains seems to be true as well. This is however conceptual and needs to be empirically verified.

In another instantiation, the ICT can also connect unrelated elements (memories) in homonymity, rhyme, structure and rhythm of words which can exploited in creative writing (based on "similarity" concept by Mednick, Sarnoff A, 1962). Also, ICT should work optimally in creative writing (or any field) with only the requisite information in the field because high "associative strength" due to more than requisite knowledge will steepen the creativity [3].

Visualization and Semantics of the problem areas should both be used while using ICT as some problems are better solved visually while others verbally [3]. In divergent thinking, a positive mood will help see relations between concepts [26].

A rough sketch of a painting can be done in a busy restaurant, museum, art gallery or a studio which can be later transformed into a canvas painting. While even a mundane place can trigger novel idea accidently, more time would be required than required with ICT. Better than random perceptual triggers a strategically placed ICT should trigger more and original ideas.

Not limited to the few creative domains discussed above, ICT can be applied for improving the originality and speed of idea generation in practically any domain including academics, architecture, advertising, performing arts, sculpture, embroidery or even something as remote as ornamental plastering or ceramic art etc. However, ICT will work effectively if the minimum requisite preparation is done in the concerned domain [27].

7. Conclusion

The highlight of the experimental finding is that with ICT, not only does the probability of finding a novel solution increase but the number of novel solutions found also increase. It would be interesting to see the improvement in fluency and originality with this trigger confounded with other triggers such as using the non-dominant hand or sleep (test performed immediately after sleep) to write the Alternate Uses and Remote Associations while searching for solutions.

The fluency and originality scores after the ICT is presented are not completely independent of the fluency and originality scores before the ICT is presented. Further controlled tests need to be devised for independence of scores. The same experiments can be run with a fully randomized Design of Experiments (DOE) for independence of fluency and originality values before and after the ICT is presented.

The elaboration and flexibility scores can be considered as a more comprehensive form of above experiment is designed. The originality and fluency scores are subjective and a more objective scoring method can be employed.

The technology for measuring the N (t) discussed in section 5 is currently not available but the formula can be further developed and the value can be obtained to develop a list of best ICTs. The practical method suggested will suffice in the unavailability of right technology. Hence, the continuation of this research is the experimental study to develop the set of ICTs facilitated simple word association.

References

[1] Devlin, Bernhard. Daniels, Michael. Roeder, Kathryn. (1997). The heritability of IQ. Nature, 388 (6641): 468-471.

[2] Gardner, Howard. (1983). Frames of Mind: The Theory of Multiple Intelligences. New York: Basic Books.

[3] Mednik, Sarnoff A. (1962). The associative basis of creative process. Psychological Review, 1962, Vol 69, No 3, 220-232.

[4] Carson, Shelley. (2010). Your Creative Brain: Seven steps to maximise Imagination, Productivity and Innovation in your life. Harvard University, Published by JosseyBass. A Wiley Imprint.

[5] Mace, John H. (2007). Involuntary Memory, Wiley-Blackwell. ISBN 978-1-4051-3638-9.

[6] Berntsen, D, & Hall, N H. (2004). The episodic nature of autobiographical involuntary memories. Memory & Cognition, 32, 789-803.

[7] Moscovitch, M. (1995). Models of consciousness and memory. In M. S. Gazzaniga (Ed.), The cognitive neurosciences (pp. 1341-1356). Cambridge, MA: MIT Press.

[8] Berntsen, Dorthe. (1996). Involuntary autobiographical memories. Applied Cognitive Psychology, 10, 435-454.

[9] Mace, John H. (2004). Involuntary autobiographical memories are highly dependent on abstract cuing: The Proustian view is incorrect. Applied Cognitive Psychology, 18, 893-899.

[10] Berntsen, Dorthe. (1996b). Moments of recollection: A study of involuntary autobiographical memories. Unpublished PhD dissertation, Department of Psychology, Aarhus University, Denmark.

[11] Ebbinghaus, Hermann. (1885/1964). Memory: A contribution to experimental psychology (H. A. Ruger and C. E. Bussenius, Trans.). New York: Dover.

[12] Linton, M. (1986). Ways of searching the contents memory? In D. C. Rubin (Ed.), Autobiographical memory (pp. 50-67). New York: Cambridge University Press.

[13] Mace, John. H. (2006a). Episodic remembering creates access to involuntary conscious memory: Demonstrating involuntary recall on a voluntary recall task. Memory, 14, 917-924.

[14] Mace, John. H. (2006b). Involuntary autobiographical memory cues: A content analysis. Manuscript submitted for publication.

[15] Tulving, Endel. (1974). Cue- Dependent Forgetting, The Society of Sigma Xi, 1974.

[16] Yonelinas, A. P. Hopfinger, J. B. Buonocore, M. H. Kroll, N. E. A. & Baynes, K. (2001). Hippocampal, parahippocampal and occipital-temporal contributions to associative and item recognition memory: An fMRI study. NeuroReport, 12, 359-363.

[17] Kvavilashvili, L & Mandler, G. (2004). Out of one's mind: A study of involuntary semantic memories, Cognitive Psychology, 48, 47-94.

[18] Conway, M. (2001a). Phenomenological records and the self-memory system. In C. Hoerl & T. McCormack (Eds.), Time and memory: Issues in philosophy and psychology (pp. 236-255) Oxford: Clarendon Press.

[19] Conway, M. (2001b). Sensory-perceptual episodic memory and its context: Autobiographical memory. In A. Baddeley, J. P. Aggleton, and M. A. Conway (Eds.), Episodic memory: New directions in research (pp. 53-70). London: Oxford University Press.

[20] Conway, M. & Pleydell-Pearce, C. (2000). The construction of autobiographical memories in the self-memory system. Psychological Review, 107, 261-288.

[21] Mace, John H. (2005b). Priming involuntary autobiographical memories. *Memory*, *13*, 874-884.

[22] Berntsen, Dorthe & Rubin, D. C. (2002). Emotionally charged autobiographical memories across the life span: The recall of happy, sad, traumatic and involuntary memories. Psychology and Aging, 17, 636-652.

[23] Conway, Martin A. (2005). Memory and the self, Journal of Memory and Language, 53, 594-628.

[24] Yonelinas, Andrew P. Ranganath, Charan. Ekstrom, Arne D. Wiltgen, Brian J. (2019). A contextual binding theory of episodic memory: systems reconsolidation reconsidered. Nature Reviews Neuroscience, 20, 364-375 (2019).

[25] Krysa, Danielle. (2014). Creative Block. Get Unstuck, Discover New Ideas. Advice & Projects from 50 Successful Artists. Chronicle Books LLC.

[26] Murray, Noel, Sujan, Harish, Hirt, Edward R, Sujan, Mita. (1990). The influence of mood on categorization: A cognitive flexibility interpretation. Journal of Personality and Social Psychology. 59 (3): 411-425.

[27] Wallas, Graham. (1945). The Art of Thought. C.A. Watts & Co Ltd.