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The effect of interactive storytelling with emotionally charged and neutral word-quests in working memory: An experimental approach

Ladas, V., Mamo, H.I., Mamidi, A., Mirasgendi, E., Korovesi, D., Afentouli, P. & Louka, P.

Mediterranean College, Greece & University of Derby, UK

Abstract

Recent studies on WM [working memory] capacity have recognized the advantage of interactive storytelling and emotional loads**,** such as threatening words in recall outcomes. Yet, the combination of the priming technique, which is directly related to the deep semantic process, with the above remains understudied. The purpose of this study is to explore the effect of IPSFP [Interactive Participation of Story Formation through Priming] on WM. Due to the COVID-19 pandemic, the experiment was facilitated with online methods. Out of 108 recruited participants, 54 took part in the experimental IPSFP task. A typed story of 30 sentences ending with a blank word, was provided to them. Each sentence containing 12 words before the blank word, that semantically implied a target-word (15 threatening / 15 neutral) to fill in the blank. After detecting the target-words and filling in the blanks, the participants were asked to recall them. Data were analyzed using 2 (type of story presentation) x 2 (type of stimuli presented) Mixed ANOVA. There is a significant effect of type of presentation on recall where more words were recalled in the priming condition. However, the interaction between type of story presentation and type of stimuli is not statistically significant. Statistical significance, power and effect sizes validate the great influence of priming on WM. In conclusion, the active role of the individual in memory tasks appears to produce higher scores in recall, in contrast to the individual having a passive role. This finding might have implications in teaching techniques and learning methods.

Keywords: Working memory; Recall; IPSFP; Story formation; Priming; Audiovisual; Threatening stimuli; Neutral stimuli;

Corresponding author: V.Ladas, Mediterranean College, Greece & University of Derby, UK, V.Ladas@mc-class.gr

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Introduction

Memory constitutes a well-researched object and its main forms consist of sensory, STM [short-term memory] and LTM [long-term memory] [1]. External stimuli that occur in the individual 's environment are held in the sensory memory. The information attended by the individual passes to the STM and afterwards, though rehearsal, the information is established in LTM [2]. However, this model appears to be rather oversimplified, since a distinction regarding the importance of the information processed and stored is not made [3]. It has been observed that mnemonic duration of loads varies when cognitive factors such as interactive storytelling [4], emotional words [5] and priming [6] are involved, and therefore alter loads memory representations. According to the unitary-store model, LTM [long-term memory] consists of "representations of loads perceived" [7, p.198] via repeated STM activations. STM is the capacity for a readily available memory state of holding up to seven (+/-2) random chunks of information [8]. Baddeley and Hitch [9, 10] argued for the existence of another function, the WM, which allows for the manipulation of this temporarily stored information in STM, with four components: the CE [central executive] an attentional system; the PL [phonologic loop] that briefly transforms information to phonological forms; the VSS [visuo-spatial sketchpad] for temporary visuospatial stimuli; the EB [episodic buffer] that links the temporary visuospatial and phonological traces [11] with LTM. However, the recency effects in a task of free recall are not considered in this model [12].

Eysenck [13] suggested that If two different tasks activate different WM components, i.e. emotional loads and audiovisual feedback stimulate the PL and the VSS respectively, then these tasks can be performed profitably. Yet, if they utilize the same component, memory representations will be weak [13]. According to Craik and Tulving [14] there are three levels of processing that critical determine how the information will be forwarded to LTM. The third level of these, is called "deep semantic" [13, p. 230] and refers to the decision making about words filling-in-blanks in sentences, where recalling of the chosen words can give twenty chunks of information [13]. This deep semantic process amplifies and forces the CE, which actually determines the WM process by allocating data to the subsystems, to enter a mental solving-problem mode [15]. This strategy produces mentally embodied solutions and thus, imprints clearer memory representations [16]. The priming technique utilizes a similar semantic process [17] in which the exposure to a stimulus that affects a response to a subsequent stimulus without conscious guidance or intent [18, 19]. Regarding to mental solving-problem, Ohlsson [20] argued that insight is actually primed by the non-solutions. Therefore, if one task such as IPSFP activates WM components by engaging cognitive functions such as SM, WM function may improve [21]. Henry [17] suggested that priming of paired representations in a story of paired items, can stir EB to a "novel episode" (p.1610). EB is assumed to connect WM, LTM and SM, in a way that they share details about sequential information such as the memory of a story [22]. Baddeley [12] suggested the capacity of the EB is approximately four words. But if EB and the other WM components are utilized in a deep semantic task such as priming and in other cognitive processes such as SM and writing, a long-lasting effect on LTM can emerge [23]. The effect of semantic priming in memory is associated with the effect of the context and the relations of the meaning [24]. The process underling sematic priming is spreading activation [25], through which semantic networks that consist of nodes are searched. The process of retrieval appears to engage both semantic and lexical (orthographic and phonemical, [26]) networks. Since attention is drawn to mean making [27], in recognition tasks, target words are identified faster, when the context in which they occur is meaningful rather than unrelated [28]. Also, target words embedded in a meaningful context are more probable to be recalled and recognized, in contrast to words embedded inconsistently. Research indicates that the former elicits a larger event related action potential than the latter [29]. At the same time, semantic priming that is facilitated in sentences contributes to better facilitation of target words in memory than word pairs [5]. Also, writing the target words embedded in sentences appears to produce better retention than learning them from word lists [30].

Interactive storytelling includes a multidimensional process of cognitive loading [31] and predicts a better recall out-

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come, in contrast to passive elaboration. It is also suggested that interactive storytelling can stimulate participants' interest and reasoning. Thus, storytelling reinforces target-words mnemonic status by framing them semantically [4]. Another study, investigating the differences between passive and interactive learning in a web-based environment, yields consistent findings, with interactive learning contributing to better learning outcomes than passive learning. Interactive learning is considered to be more enjoyable, probably contributing to better learning outcomes [32]. At the same time, multisensory stimuli are considered to produce great benefits in the learning process. More specifically, better recall is observed when two types of stimuli presentation are congruent and appear to produce better recall than when presented separately [33, 34]. Ventrolateral prefrontal cortex appears to play a major role regarding processing and retainment of audiovisual information [35].

The type of the stimuli seems to also play an important role in recall and memory processes. Stimuli linked to emotional cues is suggested to produce better recall scores than neutral stimuli [36, 37]. Consequently, threatening words may be more easily recognized than neutral words [38], since threatening stimuli capture attention, even without perceptual awareness [39]. Also, this may occur due to the fact that threatening representations are processed in greater detail within the EB allowing for a better consolidation [40]. However, threatening stimuli may produce impairment resulting in poor recall outcomes in highly anxious individuals [41]. However, regarding to a story created from threatening stimuli, the resulting attention and interest minimizes the negative effect of the stimuli [42] operating all the WM components and the SM [43].

Stories have been used as a context to embed target words. The study of Vaahtoranta and colleagues [4] demonstrates that interactive storytelling can result in the best long-term consolidation of information. It appears that interactive participation in tasks leads to better retention of information and inculcation of stronger memory traces by activating a wider range of WM components. The same seems to apply for writing the target words embedded in sentences. Semantic priming can be a mean though which interactive participation is achieved. On the other hand, audiovisual presentation of target words is argued to be beneficial regarding memory outcomes. However, it constitutes a method underlined by passivity. At the same time, emotionally charged stimuli appears to produce better recall outcomes than neutral stimuli. Hence, an unaddressed spectrum arises. The novelty of the present study lies in the integration of the story component with the IPSFP [4,17], and the type of target words (threatening and neutral), in order to observe differences between the effect of the above and audiovisual presentation in recall ability [5, 17, 38, 41]. During the SARS-CoV2 pandemic mitigation phase, involving physical distancing and strict restrictions to public movement, communication turned to digital platforms. Despite the criticism on conducting research online, Campell et al. [44] validated that reliable results with statistical significance can be achieved through digital environments. Therefore, this study used Google Forms, an online tool for data collection. Thus, it appears that this study is the first to investigate the unaddressed spectrum of priming in a general basis let alone Greek population.

Three hypothesis are tested in the present study; type of story presentation will have a main effect on WM recall ability, whereas IPSFP is expected to produce higher recall scores than audiovisual presentation; type of stimuli will have a main effect on WM recall ability, whereas threatening words are expected to produce higher recall scores that neutral words; type of presentation and type of stimuli will have an interaction effect on WM recall ability, whereas threatening stimuli in the IPSFP condition are expected to produce higher recall scores (one-tailed).

Methodology

Design

In this experimental design, mixed measures (2 x 2 Mixed ANOVA) were used. Type of story presentation is the independent-between variable that consists of two levels; IPSFP, the experimental task, and story audiovisual presentation, the control group task. Type of stimuli represents the re-

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peated-within variable of two levels: threatening and neutral words-quests. Words-quests recall (WM) signify the dependent variable, measured by how many words-quests the participants were able to recall.

Participants

G*Power estimated a total of 90 participants yet, 108 students, 42 males and 66 (females mean=30,21 years old, std dev.= 9,79) of various human science studies constituted an opportunity sample recruited using snowballing sampling technique. Inclusion criteria referred to age above 18th year. Exclusion criteria referred to dyslexia, audiovisual impairments and heightened fear or anxiety towards stories including threatening stimuli, which all participants reported as absent.

Materials

Google forms were used to facilitate the study. Two links were created for the priming and audiovisual presentation of story. The link for the former included a story with gaps and for the latter it included a video, in which the story was told, and the target words were presented. In both conditions the same story was presented. The story was formulated by the researchers including standardized 15 threatening and 15 neutral words, that were taken by word banks existing in studies. In the end of the tasks, participants given access to the answering form**.**

Procedure

Participants were recruited via email and SNS [social network services]. The link to the digital platform for the IPSFP task was randomly shared with 54 of them, whereas the other 54 received the link to the audiovisual presentation task. In total, 108 personal sessions took place during audiovisual communications via SNS. Firstly, they were given access to the briefing and consent forms. During the IPSFP task the story was provided in a text form with 30 sentences ending with a blank word. Each sentence contained 12 words, before the blank word, that semantically implied one target-word - e.g. "There were glasses on the floor, implying that the window glass was _______ [broken]". The estimated time of reading the story and filling-in-blanks was ~4 minutes. In the control group task, the story was presented in audio form on a video screen of a white background. A cross was displayed in the center of the screen to stimulate attention. Each time the target-word was heard was simultaneously projected in a lexical form for 1.13 seconds. The total duration of the audiovisual feedback was 4 minutes and 15 seconds. Afterwards, they were given access to the answering form, in order to recall as many target-words as they were remembering within 3 minutes. In the end of the tasks, they had access to the debriefing and wishes form, where they were informed about the purpose of the study.

Ethical considerations

The present study was conducted with the ethical considerations proposed by BPS Code of Ethics and Conduct in 2018. In order to ensure that the participants are comfortable with the nature of the story, they were informed about it, so the possibility of emergent anxiety and fear upon reading or hearing the story could be reduced. Regarding confidentiality, the data of each participant were converted by one researcher into the numbers of words recalled and distributed to the others. The researchers were the only ones having access to their computers, were the database existed. To endure anonymity participants were asked to create a unique personal code. Participants were also informed both in the debriefing form and verbally about their right to withdraw their data from the study.

Results

All parametric assumptions were met, except for a concern with normality. Therefore, and because hypotheses were formulated as one-tailed, a parametric test was conducted on a stricter significance level - a=.01 - [45]. Table 1 shows the mean, SD and totals of story presentation and type of stimuli.

The means and SDs show that the IPSFP task as well as the use of threatening target-words in contrast to neutrals, yield better performance in recalling. At the same time, it can

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Table 1: Totals, Mean and SD of ESSPRF and audiovisual presentation in both Threatening and Neutral words.

	IPSFP	Audiovisual	Words totals
Threatening	6.18 (2.26)	3.92 (1.89)	5.05 (2.36)
Neutral	6.03 (2.18)	3.62 (2.12)	4.83 (2.45)
Story totals	6.11 (2.21)	3.77 (2.00)	

be noted that performance in IPISF demonstrates a greater difference to audiovisual, rather than the performance concerning threatening opposed to neutral words. Moreover, concerning further results, it is noted that in the IPSFP condition there are cases 18-20 words were recalled in total, demonstrating the potential of IPSFP in expanding the storage capabilities of WM.

Data were analyzed using a 2 (Type of story presentation) x 2 (Type of stimuli) mixed ANOVA. Effect sizes and power analysis were also performed. There is a significant effect of story presentation on word-quest recall ($F(1,106) = 48.5$, $p = .0005$, $\eta^2 = .23$, $\omega^2 = .10$, power = 1.00) where IPSFP yields better performance that audiovisual presentation. There is no main effect of the type of stimuli on word-quest recall ($F(1,106) = .909$, $p = .171$, $\eta^2 = .01$, $\omega^2 = -.01$, power = .47). Finally, there is no interaction effect between type of story presentation and type of stimuli in word-quest recall ($F(1,106)= .101$, $p = .375$, $\eta^2 = .00$, $\omega^2 = -.02$, power = .09).

Discussion

The primary aim of this study was to investigate whether type of stimuli presentation effects recall outcomes and the results yielded that IPSFP produced higher recall scores than audiovisual presentation of the story; stressing out that priming utilizes a wider range of WM function. This finding is consistent with previous research. The IPSFP is suggested to activate the SM, in this case the memory of a story [22] and potentially reinforces the representation and consolidation of words-quests in LTM [21]. Considering that the IPSFP can force the CE to progress in a mental solving-problem mode, stronger memory representations of target-words were created [16]. EB stimulated by the of memory of the story [22] -, proceeds to a novel episode in which the highest capacity arises. Especially considering that deep semantic level of processing which occurs during reading and filling-in-blanks results to recalling of twenty items of information [13]. The maximum of twenty recalled target-words in the IPSFP task of this study corroborates this theoretical aspect and emphasizes the need to further explore the mechanism of WM and how its capacity can be expanded through different functions, such as IPSFP. The role of the participants in the audiovisual condition is passive, whereas in the IPSFP condition the participants engage in the story formation. Previous research indicates the superiority of the conditions in which the individual has an active role regarding learning outcomes and thus recall ability. In contrast, the conditions in which the participant has a passive role produce poorer outcomes [4, 32]. An important component is the reported enjoyment, when the individual is given an active role in tasks [32]. Likewise, in the present study participants reported enjoying the priming condition more that the audiovisual condition. Additionally, research proposes that increased memory retention occurs upon writing the target word, especially when the target word emerges through mechanisms forced by priming techniques, rather than simply being given the word [13] as it is done in the audiovisual condition. Thus, the above unfold the factors probably underling the superiority of IPSFP, in contrast to audiovisual type of presentation.

The type of stimuli (threatening and neutral) was found not to have a main effect on recall, which is inconsistent with most of the previous research [36, 37, 38]. This is a finding that needs to cautiously be addressed, since the non-statistical effect may derive from the fact that there were normality issues. An alternative explanation may be that the nature of the story produced anxiety and consequently impairment that resulted in poor recall ability [41]. At the same time, the effect of the priming condition on recall might have contributed to not detecting any differences regarding threatening and neutral words. A fourth explanation could be that the sample size was small, since a sample size of 2062, according to G*Power estimations, would be adequate in order for a statistically significant difference to emerge.

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Regarding the effect sizes and statistical power, concerning [45] standards, the powerful influence of IPSFP is being clarified. The high percent of η2 (.23) explains that magnitude effect of the priming technique was enough to influence participant-WM in a positive manner. Furthermore, an also high percent of ω2 (.10) reveals IPSFP's substantial nature and validates the secure generalization of this statistical significance (p = .0005), while stressing out a potential positive magnitude effect on the population. Therefore, IPSFP may be considered as an enhancing tool, not only for the better functioning of WM, but possibly for educational processes. By achieving perfect statistical power (1.00), this statistical substance is being confirmed and any possibility of statistical error is eliminated. However, the moderately low percentages of effect sizes and statistical power of the type of stimuli ($\eta^2 = .01$, $\omega^2 = -.01$, power = .47) – as well as of the interaction effect ($\eta^2 = .01$, $\omega^2 = -.01$, power = .47) - bring to the fore their failure to meet the normality criteria, turning the research interest to the limitations that potentially prevented the achievement of positive statistical results.

In the present study it is attempted to investigate an unaddressed component in the literature, regarding WM. The above findings provide support for the studies which propose that interactive participation in tasks leads to better retention of the information in memory, which might have applications regarding learning (teaching and learning techniques). Furthermore, the standardized procedure followed to create the story and the video reduces bias regarding effects of extraneous variables in the recall process. Nevertheless, the words used in the IPSFP task to make the semantic impressions around the 30 implied target-words in some cases led participants to identify synonymous words to the requested ones, which may demonstrate a component overlooked in the process of creating the story. Also, a problem regarding normality occurred while analyzing the data, thus, the above results must be interpreted with caution. At the same time, google forms were used to facilitate the study rather than in vivo facilitation of the experiment. In order to reduce the bias of conducting a web-based experiment private session were facilitated. Simultaneously, research yields that there is no statistical difference between the two methods concerning the results they produce [44]. Thus, in this time that web-based research is mandatory, it is proposed that private sessions with the participants via online platforms may be a way to facilitate a study, reducing the bias of web-based studies.

Future research is needed to provide support for the results yielded. Future studies could address if there is a long-lasting effect of the priming condition on recall. This could be investigated though requesting the participants to recall the words a day or days after their participation in the experiment. It could also be investigated if there are any differences regarding the type of words (threatening and neutral) recalled after the initial experiment. In order to investigate if trait anxiety constitutes a confounding variable, an anxiety scale could be distributed, with anxiety constituting a variable of the study. Also, in the process of story creation researchers could choose words that produce better semantic priming to the target-words. According to the G*power's, a sample of 2062 participants should be recruited, so possible differences in type of stimuli conditions could be observed. In addition, in order to test for the differences or similarities in the effect of IPSFP between physical or virtual research, an experimental design of three groups is proposed: IPSFP via online, in-person and in-person with the use of virtual reality glasses. Online priming has the power to influence the WM of participants and to expand its storage capacity and therefore, in-person IPSFP combined with virtual reality is expected to uncover a greater performance of memory abilities.

Conclusions

The active role of the individual in memory tasks appears to produce higher scores in recall, in contrast to the individual having a passive role. The type of stimuli appears not to have a statistically significant effect on recall which, among others, might be attributed to the effect that interactive participation, though priming, has in memory. When cognitive loads proceed through multidimensional processes, such as the IPSFP, WM components are entering to a multifunctional operation where stronger memory traces may inculcate, and therefore the ability to recall extends.

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