**Title: The influence of anxiety on Distractor Filtering during two distinct phase of visual working memory process- Encoding & Retention.**

**Abstract**

Previous study has suggested stress and anxiety generally impair filtering efficiency at a visual working memory capability (VWMC). However, a distinction between efficiency of distractor filtering (DF) at visual working memory (VWM) encoding as opposed to during delayed maintenance has not been made. DF is associated with storage of relevant information while disregarding irrelevant items present during working memory (WM) process. The assumption made in many studies is that they rely on the same neural mechanism. Previous studies have also demonstrated unique contribution of DF during two different phase of WM process. - at encoding as well as during delayed maintenance. The assumption made in many studies is that they rely on the same neural mechanism. In our study, we wanted to find support of previous study and directly compare the role DF at a VWMC. Also, how self-reported stress and anxiety may affect DF differently. In order to test our hypothesis, a one-way repeated measure ANOVA was performed for a VWM task performance, with distractor present during encoding or during retention phase, while controlling for action in trials when distractor was absent. We also analysed self-reported anxiety score (STAI) influence on DF for the two distinct phase of working memory process. Our result indicates a main effect of set condition and significant interaction of anxiety score with DF during the two phase of memory process. Although, we have not been able to control for other external factors, such as sleep, ageing or existing medical condition which could also memory performance, within our limited condition we’ve been able to show significant interaction between anxiety score and DF for the two distinct phases of working memory process.

**Introduction**

Working memory is critical to nearly everything we do. In fact, it is so crucial to our daily functioning that William James (1911) called it the primary memory, while everything we now called long term memory as secondary memory. He further claimed it is that part of our cognition that we are most familiar with and a way to interact with our metal world. Memory is in lot of sense who we are, but working memory is who we’re right now. That includes everything from whatever specific information we’re holding in our mind to how we’re managing attention. Brain study has shown many areas across the cortex can be activated in support of working memory depending on the specific task. The pre-frontal cortex is especially important as it is generally associated with working memory process in terms of maintaining information and avoiding distraction. Thus, as Baddley and Hitch’s model suggested the three main components to working memory process (the phonological loop, visuospatial sketchpad, and the episodic buffer), its functioning is determined by the pre-frontal cortex.

Research on individual differences in working-memory capacity has been critical in psychology as WMC differences show its wider impact on other cognition. An important determinant of working memory capacity (WMC) has been identified is distractor-filtering (DF) (McNab & Nolan, 2014). It is associated with ability to disregard irrelevant items or situation that interferes during encoding (simultaneous presentation of target and distractor), or during retention interval (sequentional presentation of target and distractor) of memory. Equally, studies have also demonstrated this dichotomy where, short term activation of the stress response enhancing working-memory capacity, while chronic stress doing just the opposite (Berggren, et al 2016). Thus, in order to understand how working-memory operates, it’s also essential to understand other factors that may affect WMC.

In the domain of psychology, the operation of working-memory can be interpreted at different levels i.e., at a behavioural level, in terms of whole section of the brain, at an individual cell level, or as part of a neuro network model. The aim of this study is to understand the role of distractor filtering (both at encoding and during retrieval) for a visual working-memory task performance, at each of this level of interpretation.

**Memory as a Behavioural Phenomenon:**

At a behavioural level, there is no single thing called memory. There is a whole list of taxonomy that tries to differentiate different types of memory. But one important differentiation, in terms of looking at memory as a behavioural phenomenon, is the dichotomy between implicit vs explicit memory. Explicit memory is sometimes referred to as conscious memory of facts that can be expressed explicitly. For example, time of the next meeting or date of colleague’s birthday, which can be expressed declaratively, and then act upon those knowledges. In contrast, there are different types of implicit memory. One example of would be a type called, fear conditioning. This is a type of association memory that we learned without having the conscious knowledge of it. That is, our body learns to the fear conditioning without having the declarative knowledge to express it explicitly.

The reciprocal link between stress & emotion on memory has been demonstrated by many studies. Findings from these studies usually supports the idea that, while short-term activation of stress and emotion response enhances WMC, long-term activation of these systems may impair top-down attentional control and negatively impact WMC. In one study, researchers wanted to find out how these findings can be interpreted at a visual working-memory capacity (VWMC) level (Berggren, 2014). In order to test their hypothesis, participants had to encode the orientation of four simple shapes, or eight shapes, or four shapes while filtering out four irrelevant shapes. Before memory performance, participants were either exposed to a neutral or threating stimulus (e.g. an angry face). Findings from their study clearly supported the idea that, while short-term activation of fear response (exposure to threatening stimuli before task performance) enhance VWMC, long-term activation (correlated with self-reported anxiety) negatively impacts VWMC. What is not clear from the study was the role of DF in VWMC. Their study concluded stress & anxiety generally impairs DF during visual working memory performance.

**Memory as a Brain Mechanism:**

The part of the brain that is usually associated with memory formation is hippocampus. This part of the brain can form certain type of memory which does learning for you, called declarative memory. This has been demonstrated by many brain imaging study, where learning a new fact in a declarative way lights up this part of the brain. Study from patients who has damaged to this part of the brain has also demonstrated this case. One of most cited patient in memory study, known as HM (Henry Gustav Mollison), has been pioneering in our understanding of different types of memory. HM had this rare form of epilepsy generating from his hippocampus. Doctor surgically removed his hippocampus to cure him of this disease, but he was left with severe memory deficiency. HM couldn’t form any new declarative memory, but his procedural memory was intact. He had this 30 second memory span where by engaging his attention he is able to keep things in memory, but any distraction would then disrupt his memory transfer from short term to long term memory and vice versa, as he didn’t have any hippocampus to take that role.

What this patient demonstrate, DF is not only important during memory encoding (when we engage our attention long enough to be transferred to long term memory) but also during delayed maintenance. That is, when the stimuli is no longer present but held in mind long enough to make a response, before the doors of perception is closed.

**Memory at an Individual Cell level:**

**Memory as part of a neuro network model**

**Participants**

All members who took part in the study were recruited via gorilla.sc (online psychology research platform). They were either friends or colleagues of the researchers. We control for only a few eligibility and exclusion criteria, e.g. normal to corrected vision. Online informed consent was taken prior to the main experiment. The study was conducted solely via online and approved by Birkbeck College Ethics Committee. Of 37 participants who took part in the study, only results from 30 participants was taken into consideration (mean age = 32, SD= 7.88; Male=17, Female= 20; Left-Handed =2, Right-Handed=35). 5 were rejected because they had a negative k-value, indicating they either fail to understand task condition. Another 2 participants were rejected because their k-value was 0, indicating they were guessing far above baseline. In order to minimise any conflict of interest, no financial reward or course credit was given for their participation.

**Experimental design and task**

In our experiment, we investigated the role of DF in VWMC. As VWMC is limited, we hypothesized there will a main effect of set condition (4, 4E & 4D) and some interaction for task condition. We also predict, self-reported anxiety will interact with DF for the two distinct phase of visual working memory capability.

In order to test our hypothesis, we performed a one way repeated measure ANOVA for main effect of set condition with three levels – no distractor, with distractor present during encoding and distractor present during delayed maintenance. Participants VWMC were measured using K value for each of this set condition. Also, ANCOVA was performed to find any interaction between set condition and anxiety score.

**Results**

Result indicates main effect of set size and also significant interaction.

**Discussion**

**Notes (Bergen)**

1. It is a widely observed phenomenon, stress and anxiety interacts.
2. Highly stressed individual and people with anxious personality show attentional bias towards negative information.
3. However, more generally it is accepted long term activation may impair top-down attentional control and WMC.
4. In current study we investigate the influence of emotion and anxiety may interact at level of VWMC.
5. Participants were required to encode the orientation of four simple shapes, or eight shapes, or four shapes while filtering out the other 4 irrelevant shapes from memory.

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**Abstract**

Previous study has suggested stress and anxiety generally impair filtering efficiency at a visual working memory capability (VWMC). However, a distinction between efficiency of distractor filtering (DF) at working memory (WM) encoding as opposed to during delayed maintenance has also been made by similar study. DF is associated with storage of relevant information while disregarding irrelevant items present during WM process. The assumption readily made in many studies is that they rely on the same neural mechanism. But recent studies have demonstrated unique contribution of DF during two different phase of WM process (encoding vs retention). In our study, we wanted to find support of previous study and compare the role DF at a VWMC. Also, we wanted to find if DF is influence by self-reported anxiety score (STAI) differently for the two distinct phase. In order to test our hypothesis, a one-way repeated measure ANOVA was performed for a VWM task performance, with distractor present during encoding or during retention phase, while controlling for action in trials when distractor was absent. Participants had to encode the orientation of four simple shapes (red bar), while filtering out distractor item (blue bar), present during encoding or during retention phase. Memory performance decreased with demand characteristics of the set condition, while the effect was absent for the control condition. We also found STAI’s score influence on DF. Memory performance seems to be negatively associated with STAI’s score only when the distractor was present during retention interval but not during encoding, suggesting separate mechanism may be involved.

Thus, our result indicates a main effect of set condition and significant interaction of anxiety score with DF for the two distinct phase of memory process as predicted. Although, we have not been able to control for various external factors, such as sleep, ageing or existing medical condition which could also affect memory performance, within our limited condition we’ve been able to show disassociation between encoding and delay distractor filtering.

**Introduction**

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