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Research Paper

Comparative Investigation of the False Memory Paradigm in COVID-19 Recovered Patients and Unaffected Individuals: Using the DRM test

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ABSTRACT

People who have experienced COVID-19 have reported several psychophysiological effects following their recovery from the illness. Some of the psychological complications seem to stem from a phenomenon named brain fog which might interfere with the psychological processes that underlie the process of memory encoding and recall (Hellmuth et al., 2021). Memory is one of the most fundamental cognitive neuropsychological processes that aid human function. This paper presents data from a sample of 80 participants aged 18-26, which includes 40 participants who have been exposed to COVID-19 and 40 unaffected individuals, to examine the differences in their performance in the Deese-Roediger-McDermott paradigm between the participants from the two groups, testing the extent of false memory in them. The data from the two groups would be subjected to tests of mean difference after testing for normality and SPSS-20 would be used for the statistical analysis for this study. Results would be discussed in the full-length paper and the findings will help us understand whether there is a contribution of COVID-19 infection to the formation of false memories and the respective direction. Knowing and understanding this phenomenon might make healthcare providers and other people more understanding of the long-term complications post-recovery.

Keywords: *False Memory, DRM Paradigm, COVID-19, Cognitive Psychology, Brain-Fog*

The Deese-Roediger and McDermott task is a false memory paradigm in which subjects are presented with lists of semantically related words at encoding. After a delay, the subjects are asked to recall or recognise these words (Pardilla-Delgado & Payne, 2017). The subjects are then asked to remember previously presented words as well as related but never presented words called critical lures/. These critical lures are recognised with a high probability and with great confidence. Many productive years of DRM research

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indicate that multiple and often opposing psychological processes cause even the most basic false memories (Gallo, 2010). The combined effects of social distancing among people during COVID-19 (Zhang et al., 2020) and sustained sub-clinical cognitive impairments are common complications after recovery from COVID-19 in young adults, regardless of the clinical course of infection (Woo et al., 2020). In other contexts, it has been found that emotional associations and individuals with a history of trauma and or depression are at risk for producing false memories when they are exposed to information that is related to their knowledge base (Otgaar et al., 2017).

Ageing is associated with normative changes in a host of cognitive abilities. Declining memory skills are perhaps the most obvious and most studied changes that occur in later life, with age differences being most evident in situations involving episodic memory. This has been attributed to declines in basic cognitive and cortical mechanisms (Hess et al., 2012).

Within the context of COVID-19, it became apparent that healthcare planners and policymakers had to prepare for the eventuality of controlling for the heavy health burden and socioeconomic costs that recovery in COVID patients might incur (Ellul et al., 2020) and among COVID patients, a combination of attention deficits, concentration deficits and short-term memory deficits have emerged. These place a significant burden on the individual themselves and their families and healthcare providers as they help the individual recover in entirety (Woo et al., 2020; Rogers et al., 2020) and reintegrate into their life once again.

Recent research suggests that affective and motivational processes can influence age differences in memory. Positive mood states can impact older adults' information processing and potentially increase underlying cognitive age differences (Emery et al., 2012). It has been shown that human memory is not a literal reproduction of the past but instead relies on constructive processes that are sometimes prone to error and distortion (Schacter, 2012) where certain distortions reflect the operation of an adaptive cognitive process that contributes to the efficient functioning of memory itself. This finding has several clinical and applied implications. Within the biomedical field, as soon as COVID began manifesting itself with long-term neuropsychological outcomes, the application of over three decades of neuroHIV research allowed researchers and clinicians to focus on challenges in survivors with neurocognitive deficits following COVID-19 illness (Levine et al., 2020). Some correlations were found between verbal memory and frontal functions and the degree of functional impairment at admission and subsequent improvement (Di Pietro et al., 2021; Alemanno et al., 2021) highlighting the need for adequate cognitive evaluation and rehabilitation post-COVID-19. Findings across the board demonstrate that cognitive impairments exist even in patients who recovered from COVID-19 and might be linked to underlying inflammatory processes (Zhou et al., 2020). However, more recent research demonstrates that individuals who had undergone COVID-19-related procedures following the use of Extracorporeal Membrane Oxygenation showed long-term anxiety, depression and post-traumatic stress but not cognitive impairment (Rajajee et al., 2021). Thus the current study attempts to compare the presence of false memories between participants who have tested positive for COVID-19 and those that have not tested positive.

METHODOLOGY

Objectives

To compare the presence of false memories between participants who have tested positive for COVID-19 and those that have not tested positive.

Hypothesis

H_{01}: There is no significant difference in the incidence of false memories between participants who have tested positive for COVID-19 and those that have not tested positive for COVID-19.

Operational definitions

- ***False memories***: False memories are memories of events that did not happen or are altered in their content.
- ***DRM test:*** The Deese–Roediger–McDermott (DRM) paradigm is a procedure in cognitive psychology used to study false memory in humans.

Sample

The 58 participants [Males (N=33), Females (N=25)], belong to the age range of 18-26. The participants were divided into two groups based on the presence and absence of COVID-19. Group 1 consisted of COVID-19 recovered patients and group 2 consisted of unaffected individuals. Purposive sampling was used and informed consent was obtained from each participant for the study.

Research design

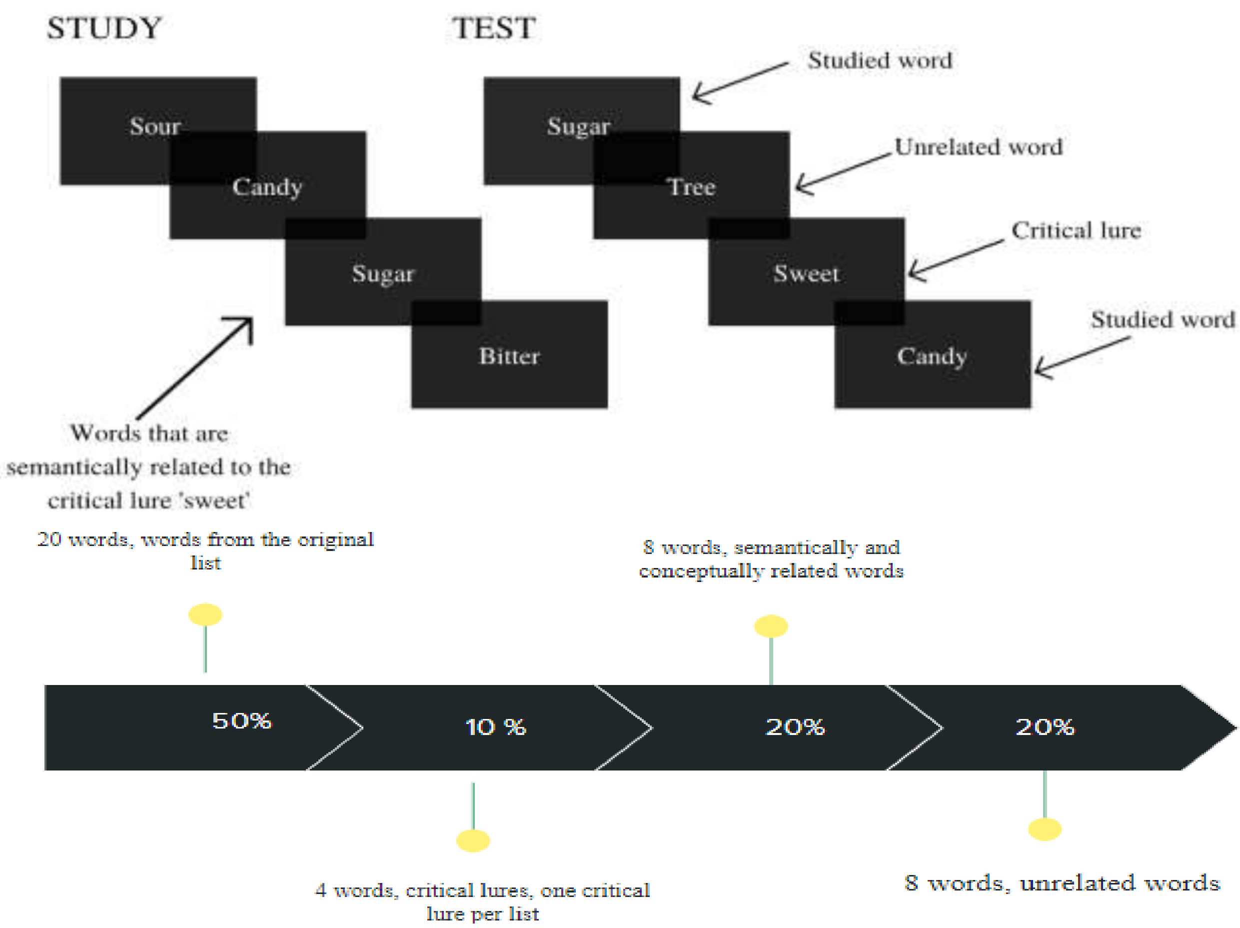
A quasi-experimental between-group research design was adopted for the study where the extent of cognitive impairment was assessed for the two aforementioned groups.

Measures

The Deese, Roediger, and McDermott (DRM) task, devised by James Deese (1959), Henry. L. Roediger III and Kathleen McDermott (1995), were used for this study (Pardilla-Delgado & Payne, 2017). This task is popularly used to test false memories in the laboratory and has appropriate reliability and validity (Blair et al., 2002). Usually, in this task, the subjects are presented with lists of semantically related words (*e.g.*, nurse, hospital, *etc.*) at encoding. After a delay, subjects are asked to recall or recognize these words. In the recognition memory version of the task, subjects are asked whether they remember previously presented words, as well as related (but never presented) critical lure words ('doctor').

Data Collection

For this study, 4 lists of semantically related words with a total of 40 words were used. Each word was shown to the participant for a duration of 2 seconds and a 12-second break was given between lists. A break of two minutes was given after showing all 4 lists. Then the participants were asked to recall the words within a time limit of 3 minutes following which they were asked to recognise the original words from a recognition list of 40 words. Out of the total number of words in the recognition list, 50% (20 words) comprised words from the original lists, 10% of the words were the critical lures (4 words; 1 per list), 20% comprised semantically and conceptually related words (8 words) and the remaining 20% comprised of filler or unrelated words (8 words).



Analysis

Statistical Package for Social Sciences (SPSS-20) was used to analyze the data.

RESULTS

The data received from the sample were analyzed using Statistical Package for Social Sciences (SPSS-20). The Shapiro-Wilk test was used to test normality. Based on the normality of the data, the Mann-Whitney U test was used to identify any significant difference between group 1 and group 2.

Table 1.0 Showing the descriptive statistics

	Covid					Non-Covid				
	M	**N**	**SD**	**Minimum**	**Maximum**	**M**	**N**	**SD**	**Minimum**	**Maximum**
R1H	18	29	5.16	7	28	18.6	29	4.72	10	33
R1WR	1.48	29	1.55	0	7	0.79	29	1.18	0	4
R1CL	2.07	29	1.31	0	4	1.86	29	1.19	0	4
R2H	14.1	29	3.78	2	20	14.8	29	2.13	10	19
R2M	4.83	29	3.30	0	13	5.14	29	1.88	2	10
R2CL	2.55	29	1.18	0	4	2.45	29	0.95	0	4
R2RW	0.62	29	1.12	0	4	0.38	29	0.56	0	2
R2F	0.41	29	1.02	0	5	0.17	29	0.46	0	2
R3	2.17	29	2.05	0	10	1.24	29	1.53	0	7

Note. R1H is the number of hits in the recall round, R1WR is the number of words wrongly recalled, R1CL is the number of critical lures recalled, R2H is the number of hits in the recognition round, R2M is the number of misses in the recognition round, R2CL is the number of critical lures recognised, R2RW is the number of related words recognised wrongly, R2F is the number of unrelated words recognised wrongly and R3 is the composite measure of R1WR, R2RW and R2F

Table 1 shows the mean, standard deviation, minimum and maximum of the sample divided on the basis of Covid-19 contraction.

Table 2.0 Shapiro-Wilk Test for Normality

S NO	Variable	Statistic	df	Sig.	Distribution
1	R1H	0.973	58	0.217*	Normal
2	R1WR	0.778	58	0.000	Not normal
3	R1CL	0.914	58	0.001	Not normal
4	R2H	0.892	58	0.000	Not normal
5	R2M	0.953	58	0.026	Not normal
6	R2CL	0.900	58	0.000	Not normal
7	R2RW	0.629	58	0.000	Not normal
8	R2F	0.417	58	0.000	Not normal
9	R3	0.790	58	0.000	Not normal

Note. *indicates normal distribution of data

From Table 1.0, it is clear that the correct number of hits from the recall (R1H) and recognition (R2H) rounds and the misses from the recognition round show the normal distribution for which the parametric test was done. As shown in the table, all the other areas do not follow a normal distribution and hence non-parametric statistics were computed for the same.

Table 3.0 Results from the Mann-Whitney U test computed for the variables

Variable	N	Mean		U value	Sig.
		Covid	Non-Covid		
R1H	0.973	18	18.6	375	0.477
R1WR	0.778	1.48	0.793	290.5	0.033*
R1CL	0.914	2.07	1.86	381.5	0.533
R2H	0.892	14.1	14.8	409.5	0.862
R2M	0.953	4.83	5.14	360.5	0.345
R2CL	0.900	2.55	2.45	395	0.679
R2RW	0.629	0.621	0.379	417.5	0.954
R2F	0.417	0.414	0.172	376	0.310
R3	0.790	2.17	1.24	282.5	0.027*

Note. *indicates significance at the 0.05 level. R1H is the number of hits in the recall round, R1WR is the number of words wrongly recalled, R1CL is the number of critical lures recalled, R2H is the number of hits in the recognition round, R2M is the number of misses in the recognition round, R2CL is the number of critical lures recognised, R2RW is the number of related words recognised wrongly, R2F is the number of unrelated words recognised wrongly and R3 is the composite measure of R1WR, R2RW and R2F.

Results from the t-test show no trend of significance for the variables, thus indicating no difference in the correct number of hits made in the recall round (R1H). However, results from the Mann-Whitney U test show significant differences in R1WR between group 1 and group 2, as shown in table 3.0. Figure 1 shows a graphical representation of the same.

Figure 1 Graphical representation of the differences in R1WR and R3 between the two groups

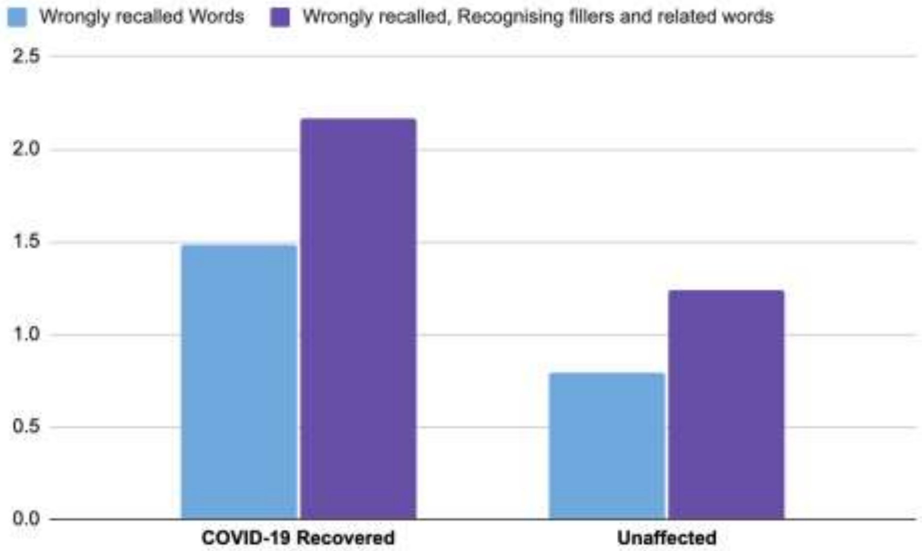


Table 4.0 Results for correlation of significant relations with the screening variables

		SOS
R3	Spearman's rho	0.299
	Sig.	0.02*

Note. * indicates significance at 0.05 level. SOS stands for severity of symptoms which the participants indicated on a likert scale.

As shown in table 4, a positive correlation between severity of symptoms and the composite measure (R3), within COVID-19 recovered individuals ($p<0.05$) was observed.

DISCUSSION

Memory is a strange tool. It is often believed that memory works as some kind of detached recording device, the content of which can be reviewed whenever the individual desires and in an exact manner that the information was supposedly put away. The problem here is that all mechanisms lie to the brain from how the image is perceived up until memory itself emerges from the perception of the image. Memory is susceptible to illusion in the form of false memories. There are several affectual, behavioural and cognitive processes that the individual is aware of and unaware of that contribute to the formation of memory. One study shows that the negative affective states promote item-specific processing which reduces false memories in a similar way as using an explicitly guided cognitive control strategy (Storbeck & Clore, 2011).

A false memory is a semantic or autobiographical memory that did not occur. The existence of false memories provides a challenge not only to our self-perceived ability to record the truth and report it according to some objective standard, but also raises questions of nonconscious motivations (Mendez & Fras, 2011). For neuroscientists, a potential source of understanding false memories is confabulation which is a result of brain disease (Mendez &

Fras, 2011). Confabulations are seen to be false statements without a conscious effort to deceive occurring in clear consciousness in association with neurological disease (Berlyne, 1972). Most confabulations seem to be provoked or momentary (Nahum et al., 2009). It is further believed that attenuations of an automatic, nonconscious sense of uncertainty, mediated by the ventromedial prefrontal cortex are associated with the production of the false memory itself (Mendez & Fras, 2011). The most commonly accepted experimental paradigm to measure false memory is that of the Deese-Roedinger-McDermott paradigm; with the response effect occurring in normal people and being influenced by many conditions including several list items, semantic relatedness (Brueckner & Moritz, 2009), attentional distraction (Peters et al., 2008), the medium by which the information is presented (Drowos et al., 2010) and the age and cognitive status of the subject (Dennis et al., 2008).

Keeping in line with results that have been emerging from the cognitive studies that have been happening on individuals who have recovered from COVID-19, Table 2.0 demonstrates that there is a significant difference between COVID and non-COVID participants concerning wrong words being recalled. This demonstrates that previous viral epidemics show similar cognitive difficulties in recovered patients (Hopkins et al., 2005; Filatov et al., 2020). This shows a demonstrated need to focus on the neuropsychological sequelae and impaired health states among survivors of SARS-related syndromes (Hopkins et al., 1999). Such memory-related changes may stem from hypoxic situations that are a common cause of neuropsychological changes observed in acute respiratory distress syndromes which are associated with cerebral atrophy and ventricular enlargement (Hopkins et al., 2006) which correlates to attention, verbal memory and executive functioning (Han & Mallampalli, 2015). This shows a need to involve practical rehabilitation strategies that allow individuals to cope once again with activities of daily living that are largely focused on the flexible use of these neuropsychological mechanisms.

Limitations and Future Directions

One of the limitations of the study lies in its cross-sectional nature. The data collection was done via online methods, hence the experimenters lacked complete control over the presentation of stimuli. Also since the study was conducted at different points of the day, we could not factor in the participant's circadian rhythms, general mood, appetite, or energy level which could have played a role in the outcome. Further, our study did not look into the specific types of content one would be interested in and how the type of content would relate to the false memory paradigm. Lastly, since the sample size was small, generalizability would be less for the study conducted. In the future, the researchers aim to understand the contribution of COVID-19 infection on the formation of cognitive impairment and the respective direction. Knowing and understanding this phenomenon might make healthcare providers and other people more understanding of the long-term complications post-recovery.

CONCLUSION

The phenomenon of false memories is complex and multi-determined. This work may have been able to reflect a portion of that complexity, by showing how different contextual and individual variables interact dynamically to end up in a complex result.

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Conflict of Interest

The author declared no conflict of interests.

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