Impact of intrinsic cognitive load and extraneous cognitive load over emotions

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Abstract- This paper offers an understanding of how cognitive load can interfere with the emotions of the person. Exposure to cognitive load at any level can be challenging for the task in hand. Conducted over 60 participants, this experimental design used the stroop test initially to measure the attention deficits of the participants, who were then subjected to the experimental conditions (with neutral and emotional stimulus). Convenience sampling was used as the sampling technique for this study and Independent t-test was used for the analysis. Results showed partial differences in the emotional and neutral processing of participants.

Index Terms- Cognitive load, Emotions, Extraneous and Intrinsic cognitive load

I. INTRODUCTION

There are times when it seems very hard to not just comprehend our emotions but also understand and manage other people's emotions. This may primarily be because of the various information that poses as a distractor in doing so. Such issues in processing can be either due to the way information has been presented or the content of the information. Cognitive load refers to the mental effort imposed on the working memory (here, we are considering 'load' as the excessive effort put in. Hence, cognitive load is the excess demand of the mental resources and capacity by the task in hand). Because of the limited capacity of the working memory, in both capacity and duration, it is likely to interfere with the tasks in hand. Cognitive load being of three types- a) Intrinsic load, which refers to the inherent level of difficulty associated with a specific instructional topic. It is more to do with the nature of what is being learned. b.) Extraneous load, referring to how information is presented. Unlike the intrinsic load, this can be controlled. It is not entirely necessary to reduce the extraneous cognitive load to help to learn. There is evidence that moderate extraneous load in some cases can benefit the learner. c.) Germane load, is the use of techniques, which can help to consolidate and organize the information for lasting learning. With repeated practice and exposure, behavior can become effortless and would require less effort for learning. CLT theories often focus on the presentation of the material, to study the limited capacity assumption, primarily to develop an understanding of the learning processes (Brünken, Plass & Leutner, 2004). There are few options in hand when it comes to cognitive load assessment- physiological measures such as eye movement (Klingner, 2010) and EEG responses (Haapalainen, Kim, Forlizzi & Dey, 2010), task-based performance measures (Gwizdka, 2010; Cerdan, Candel, & Leppink, 2018) and subjective or self-report measures, such as SWAT (Luximon & Goonetilleke, 2017), Pass Cognitive load scale (Pawar, Jacque, Deshpande, Pusapati & Meguerdichian, 2018) and NASA -TLX (Soria-oliver, López, & Torrano, 2017; Maestre, Gonzalez-cueli, Redondo-figuero, & Manuel-palazuelos, 2019; Nikulin, Lopez, Piñonez, & Gonzalez, 2019). Task-based performance is a more objective measure than the self-report measures, however, a physiological approach can provide evidence on the impact of varying task-based difficulties over biological and neural responses. The importance of measuring cognitive load has been considered vital for instructional designs, apart from the learning performance measures (Brunken, Seufert & Paas, 2010). It should also be considered that different measures of cognitive load tap different types of cognitive load , as mentioned above (Deleeuw & Mayer), that is, a particular measure tends to be more sensitive to a particular type of variable and hence, it should be taken into consideration before carrying out the empirical researches in CLT. Chandler & Sweller (1991) also suggest the importance of using the right instructional format with the type of information, for instance in the event of two or more sources of information an integrated instructional format would be more beneficial than the conventional one, as it would facilitate better mental integration.

Recent studies on cognitive load and emotions also point out the dilemma of the nature of emotions as an intrinsic load or an extraneous load. Even the nature of emotional elicitation stirs thoughts when it comes to the presentation of the material (Uhrig, Trautmann, Baumgärtner, & Treede, 2016). Films and pictures have been used in several past researches to understand which type of content comes to elicit what kind of emotion and their impact on performance (Uhrig, Trautmann, Baumgärtner, & Treede, 2016). However, an understanding of how both, intrinsic and extraneous cognitive load can interfere with the perception of emotions, can add to further exploration of cognitive load. Use of emotional expressions in studies to assess the impact of cognitive load on working memory also suggests that non- facial stimuli (neutral stimuli) and facial stimuli impact the working memory differently under different conditions like distractions (Ong & Chun, 2018) and attention and saccadic movements (Crouzet,Kirchner Thorpe, 2010).

Even though affect and cognition have been studied together in many studies as related concepts, it is important to consider that affective working memory and cognitive working memory seem

to be separate in their respective neural underpinnings (DeFraine, 2016). Applications of cognitive load and emotional experience has been tested in health care setting as well, where it was observed that even in an ICU setting, where environmental cognitive load is higher, a positive emotional environment can still be observed amongst people and hence, boost the learner ability (Pawar, Jacques, Deshpande, Pusapati, & Meguerdichian, 2018). Similarly, cognitive load effects on arousal have also been demonstrated and seen through pupillary response and heart rate; it is expected that such physiological measures can help to understand cognitive processing in an arousal condition thus, heightening the physiological measures (Sennersten & Lindley).
Seeking the dilemma of the past studies concerning the use of the nature of stimulus as well which type of cognitive load can have what effect over emotions, the current study aims to develop an understanding of which type of cognitive load can have what effect on the perception of emotions as well as its recognition.
Four hypotheses were constructed for this study-

Hypothesis 1: Reaction time of 'what is the item' will be more in emotional items than in neutral items.

Hypothesis 2: Response time of 'describe the item' will be more in emotional items than in neutral items.

Hypothesis 3: There will be no difference in the perception of physical attributes between emotional and neutral items.

Hypothesis 4: There will be no difference in the perception of functional attributes between emotional and neutral items.

II. RESEARCH ELABORATIONS

Participants

The sample consists of 60 male and female college students (19-25 years) from Pondicherry University. A 50-50 gender ratio was taken for this study. All these participants were Masters students in various disciplines. Out of these 60 participants, 30 were randomly assigned to neutral stimuli situation while rest 30 were subjected to emotional stimuli situation. Out of these 30 participants in each group, 15 males and 15 females participants were taken.

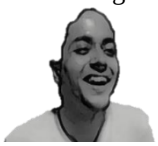
Inclusion criteria- None of the participants belong to the field of psychology, their participation is voluntary. It was also made sure that all the participants should score well on the Stroop test. Data was collected from all the participants in the psychology lab of the Institute. Informed consent was taken from all the participants beforehand.

Materials

To assess the attentional capacity, cognitive control, and non-conscious brain functions, all the participants were subjected to the Stroop test. Stroop test is a standard test to measure executive functions, such as working memory, inhibitory control and cognitive flexibility, and was thus considered apt to screen the participants, before subjecting them to the actual experiment. The errors and reaction time for both the congruent and incongruent color-word situations were noted. Demographic data sheet given to the participants asked about their name, age, course and year.

For the second phase of the experiment, slides were created according to the content of intrinsic and extraneous load. For each group, a set of 3 slides were created. To induce intrinsic cognitive load, human emotions were taken into account (Figure 1), for which volunteers from the performing arts department were asked to display three basic emotions- happiness, sadness, and anger. Photos of each of these emotions were clicked and used in the slides for the intrinsic cognitive load group. All the photos were black and white, to rule out any cognitive load being created due to color in the pictures thereby, letting participants focus only on the emotions.

Similarly, for the extraneous cognitive load group, all the features



being the same as in the intrinsic load group, more neutral pictures (Figure 2) were used. Hence, there were 3 slides with photos of a pen, a fan, and a bag.

Figure 1:Display of happiness (an emotion), as used for intrinsic cognitive load

Figure 2: Display of fan (a neutral image), as used for extraneous cognitive load

For the recognition task, a checklist of items was used (see Appendices B1 and B2). It was prepared keeping in mind that the functional and physical characteristics of the emotions/objects in the display, along with the characteristic items of other random emotions/objects. This was done to check their recognition for the right item, in spite of the load.

Procedure

After taking the informed consent of all the participants, the study was begun. This study took place in two phases. The first phase involved subjecting all the participants to the Stroop test (only color test), for which they were instructed and scoring was done. After this, the participants were given rest of five minutes. During this time they were asked to fill in their demographical datasheet. After this gap, the second phase of the experiment was begun. In this, participants were assigned to the intrinsic load group and extraneous load group. The former group was presented with a series of human emotions across the slides (such as happiness, sadness, and anger) while, the latter was presented with neutral item pictures (such as fan, bag, and a pen, across slides). After showing each picture, participants were asked two questions – what is this item? (for which reaction time was noted) and describe this item, (for which response time was noted). In 'describe the item', all the participants were given liberty to keep describing their slide for as long as they wish to. Thereafter, each

participant was given a checklist of statements and was asked to check those statements/items which they feel most adequately represented the items shown. Participants were finally thanked for their participation.

III. RESULT AND FINDINGS

The Independent t-test was used to analyze the 60 participants' data across all the hypotheses. All statistical analyses were conducted using IBM SPSS 20. For this study, analyses focused on four parts, as per the hypotheses. To control type 1 error, a p-value<0.05 was used for all the tables.

Mean and SD for reaction time, to test hypothesis 1 (60 participants; 30 in the emotional group and 30 in the neutral group) can be seen in Table 1. There was a 50-50 gender ratio for each group (emotional and neutral); gender differences were not taken into account. As can be seen in this table, for hypothesis 1, results were found to be significant between both, emotional and neutral groups about 'What' items ($\bar{X}$ EG[i] = 4.26 & $\bar{X}$ NG[ii] =1.39, t = 5.22) at .000 level. Hence, hypothesis 1 was accepted. The neutral group responded in comparatively less time when asked about what is the item, as compared to the emotional group indicating that the nature of the stimulus (inducing cognitive load) does contribute to our rate of perception of emotions.

Group	N	Mean	Std. Deviation	t value	Sig.
Emotional Functional	30	2.89	0.99	-5.98	.010
Neutral	30	4.17	0.61		

Table 1: Mean difference for the reaction of 'what' items between emotional and neutral groups.

Note p< 0.05

Group	N	Mean	Std. Deviation	t value	Sig.
Emotional Physical	30	2.56	1.08	-8.29	.001
Neutral	30	4.37	0.50		

For the next analyses, i.e. hypothesis 2, results were non-significant between both, emotional and neutral groups about 'describe' the items ($\bar{X}$ EG =28.09 & $\bar{X}$ NG = 46.05 , t = -4.00) at .099 level, as can be seen in Table 2. Hence, hypothesis 2 was rejected. However, it is worth noting that the mean value of response time for the emotional group is lower than the mean value for the neutral group (See Appendix A), indicating that emotional group couldn't describe at longer lengths about their slide, as compared to the neutral group.

Table 2:Mean difference for the reaction of 'describe' item between emotional and neutral groups.

Note p< 0.05

As coming to recognition context, within physical attributes, results were significant for hypothesis 3 ($\bar{X}$ EG = 2.56 & $\bar{X}$ NG = 4.37, t = -8.29) at .001 level, as can be seen in Table 3 (also, see Appendix A). Both, emotional and neutral groups differed in their perception of physical attributes about the stimulus. The mean difference indicates that, the perceived physical attributes were more for neutral items than emotional items. Hence, hypothesis 3 was rejected.

Group	N	Mean	Std. Deviation	t value	Sig.
Emotional RT What	30	4.26	2.91	5.22	.000
Neutral	30	1.39	0.71		

Table 3:Mean difference in the physical description of items between emotional and neutral groups.

Note p< 0.05

Recognition context in functional attributes (of the stimulus) also found similar results with differences between both, emotional and neutral groups. Hence, hypothesis 4 was found significant ($\bar{X}$ EG = 2.89 & $\bar{X}$ NG = 4.17, t = -5.98) at .010 level, as seen in Table 4. The mean difference indicates that the neutral group got more items of functional attributes right (about their stimulus) than the emotional group (see Appendix A). Hence, hypothesis 4 was rejected.

Group	N	Mean	Std. Deviation	t value	Sig.
Emotional RT Describe	30	28.09	15.40	-4.00	.099
Neutral	30	46.05	19.15		

Table 4: Mean difference for functional description of items between emotional and neutral groups.

Note p< 0.05

Discussion

This study aimed to suggest that how exposure to cognitive load can differ our perception towards understanding the emotions as well as in their recognition. This effect was tested by comparing both, intrinsic and extraneous cognitive load. A neutral stimulus, by definition, would mean, something which does not generate a response or does not hold any effect on the person. It can be a person, object or thing. Hence, how a neutral stimulus has been presented with matters and not its actual content. In these terms, it can be considered as an extraneous load. On the other hand, an emotional stimulus can be anything that carries an emotional valence and leads to emotional arousal within us; such information would require greater cognitive resources to comprehend and

manage the emotional state. This makes emotional stimulus relate to intrinsic cognitive load (Ojha, Ervas, Gola, 2017). According to the results, when subjected to both conditions, partial differences can be seen in how people perceive and react to the nature of the stimulus.

This falls in line with the prior studies which suggest that tasks with increased complexity also lead to an increase in the reaction time (Stroop, 1992). When asked to describe the item, it was hypothesized that participants might be able to associate with any memory related to that particular emotion and come up with describing a lengthy event or so, however, it was observed that the participants were moral vocal in the neutral slide group than the emotional group. It was also observed that the participants in the latter group took long pauses before coming up with the statements to describe the slide/emotion. A primary reason for this can be the fact that emotions are more likely to be challenging than any neutral stimulus since we internalize them. There is a greater element interaction involved when it comes to processing content with a higher mental effort, hence imposing a load on the working memory; these results can be supported by some prior studies which suggest the limited capacity assumption of the working memory (Sweller, Merrienboer & Paas, 1998).

Recognition of the physical and functional nature of the stimulus

When studying this scenario in the recognition context, we again see clear differences between the neutral and emotional group. Both the groups differed in their perception of the physical nature as well as the functional nature of the stimulus that was just shown. Results indicated that the perceived physical attributes were more for neutral items than emotional items and similar results were observed when perceiving the statements with functional attributes. This is most likely to be because of the high element interaction in the intrinsic cognitive load (which we can see in the emotional stimulus).

Although further work on this is needed to get an in-depth perspective on the effect of cognitive load over emotions, our findings indicate that emotionally loaded content (demonstrated through pictures here) requires more mental effort to process the content hence, such an information or data will entail more cognitive load when the same scenario is compared to an information group receiving a more neutral content (something which is mundane and does not evoke any emotions). We also see that not just while understanding the emotions, when it comes to picking out the correct information amongst a pool of information, about the said stimulus, recognition is better when presented with a more neutral stimulus, than emotional stimulus, Present results can add more value if conducted over a larger sample and with gender considerations; future studies can also examine similar effect in different emotional settings for a better understanding.

IV. CONCLUSION

Through this study we see that how can intrinsic and extraneous cognitive load influences the emotional and neutral stimulus differently in terms of the nature of the task and perception in terms of recognition. This study provides us with a clear picture of how cognitive load can affect our perception and recognition of stimulus and their characteristics. Hence, the contribution of this study is empirical, evaluating the effects of load on emotional control.

Even though the sample is quite less to generalize the findings, further studies with a bigger sample size and different emotional settings can add more to our understanding. Another limitation having to do with the intelligence of the participants and the kind of emotions used as the stimulus material could have acted as an extraneous variable (Ojha, Ervas, Gola, 2017). A third, drawback would be the assessment of the response of the participants. Since the responses are largely subjective, an objective mode of response assessment or subjecting the participants to a standard test situation may provide a varied picture, hence that should be taken into account by the future studies. Future studies around a similar understanding can add more value.

APPENDIX

Appendix A: Graphs representing tables

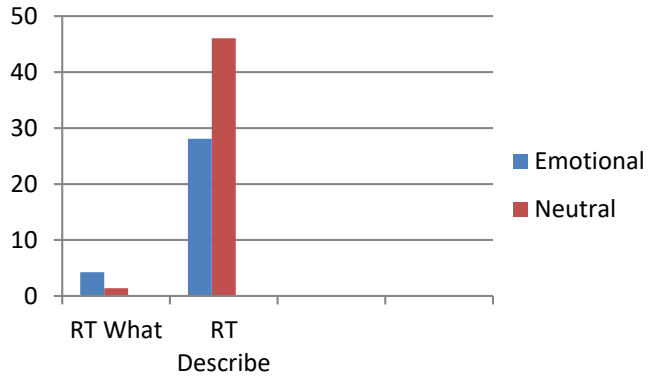


Figure A 1: Differences in reaction time and response time between emotional and neutral groups respectively. Note that response time for what is the item was less for the neutral group. When asked to describe the item, neutral group could describe the item for a longer duration.

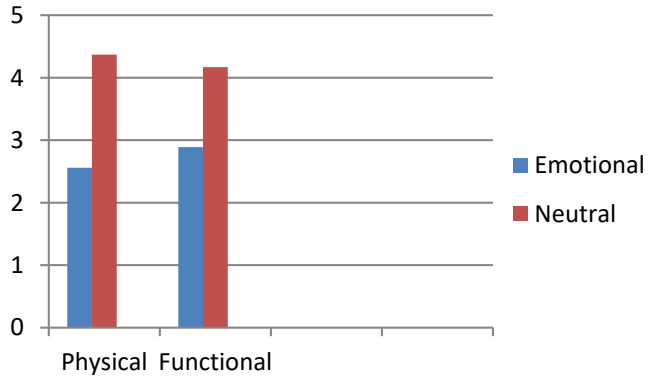


Figure A 2: Differences in recognizing physical and functional emotional and neutral groups respectively. Note that the

perceived physical attributes were more for neutral items than emotional items and similar results were observed when perceiving the statements.

Appendix B1: Checklist for Happiness

1. It is made of wool.
2. In this muscle around the eyes tighten.
3. It releases good hormones.
4. It has 8 legs.
5. It can be classified
6. Lip corners get raised in it.
7. It can be sliced
8. It has a fruity smell.
9. In this teeth can be seen, sometimes.
10. It is yellow in color.
11. It requires us to check our emails regularly.
12. There is no tension during this time.
13. It can be bought from local vendors.
14. It brings pupil dilation.
15. It has a strong outer covering.
16. It is an unpleasant thing.
17. It usually comes in a green packing.
18. It gives pleasure.
19. It can be awarded anytime.
20. It comes in many flavors.
21. In this cheeks are raised.
22. It should be done once a year.
23. It is a disorder.
24. It follows a step by step procedure.
25. It can be spread to others.
26. It has big semi-circle handles.
27. It can ignite fire.
28. It should be washed and cleaned properly.
29. It has a square shape.
30. We feel in a good state.

Appendix B 2: Checklist for fan

1. It can be refrigerated for a few days.
2. It needs to be recharged now and then.
3. It can be easily found in a garden.
4. It provides air circulation.
5. It can be used to break the ice.
6. It is an electrical device.
7. It can be used to give performances.
8. It sounds like a big thumping noise.
9. It is very fragile.
10. It creates a breeze that evaporates sweat on a person's skin.
11. It exhausts our potential.
12. It comes in one color only.
13. It gives off fumes which can harm people.
14. It is made of copper.
15. It hangs using a hook.
16. It is made out of cardboard.
17. Its temperature can be regulated.
18. It can be cut with scissors easily.
19. It has three blades.
20. It can be noted down for remembering.
21. It gives a cooling effect.
22. It is crockery often found in the kitchen.
23. It can only be used in bathrooms.
24. It should be preserved in oil for lasting effect.
25. It can be used on dry clothes in the rainy season.
26. It can be stored in jars.
27. It is fixed with the ceiling.
28. It requires constant refills.
29. It can be true or false.
30. It revolves in a circular manner.

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REFERENCES

[1] Brünken, R., Plass, J. A. N. L., & Leutner, D. (2004). Assessment of Cognitive Load in Multimedia Learning with Dual-Task Methodology : Auditory Load and Modality Effects. (Anderson 1983), 115–132.

[2] Brünken, R., Seufert, T., & Paas, F. (2010). Measuring cognitive load. Cognitive Load Theory, 181–202. https://doi.org/10.1017/CBO9780511844744.011

[3] Cerdan, R., Candel, C., & Leppink, J. (2018). Cognitive Load and Learning in the Study of Multiple Documents. 3(July), 1–7. https://doi.org/10.3389/feduc.2018.00059

[4] Chandler, P; Sweller, J. (1991). Cognitive Load Theory and the format of instruction. Cognition and Instruction. 8(4): 293-332.

[5] Chen, S., & Epps, J. (2015). Automatic classification of eye activity for cognitive load. *Computer Methods and Programs in Biomedicine*, *110*(2), 111– 124. https://doi.org/10.1016/j.cmpb.2012.10.021

[6] Crouzet, S. M., & Thorpe, S. J. (2010). *Fast saccades toward faces : Face detection in just 100 ms*. *10*, 1–17. https://doi.org/10.1167/10.4.16.Introduction

[7] DeFraine, W. C. (2016). Differential effects of cognitive load on emotion: Emotion maintenance versus passive experience. *Emotion*, *16*(4), 459-467.

[8] Deleeuw, K. E., & Mayer, R. E. (2008). A Comparison of Three Measures of Cognitive Load : Evidence for Separable Measures of Intrinsic Extraneous , and Germane Load. 100(1), 223–234. https://doi.org/10.1037/0022-0663.100.1.223

[9] Gwizdka, J. (2010). Using Stroop Task to Assess Cognitive Load.

[10] Haapalainen, E., Kim, S., Forlizzi, J. F., & Dey, A. K. (2010). Psycho-Physiological Measures for Assessing Cognitive Load. 301–310.

[11] Klingner, J. (2010). Measuring Cognitive Load During Visual Tasks by Combining Pupillometry and Eye Tracking, Ph.D. dissertation, Stanford University Computer Science Department

[12] Luximon, A., & Goonetilleke, R. S. (2017). Simplified subjective workload assessment technique. (June 2014). https://doi.org/10.1080/00140130010000901

[13] Maestre, J. M., Pe, L., Gonzalez-cueli, J. C., Redondo-figuero, C., & Manuel-palazuelos, J. C. (2019). EducaciónMédica death in the simulation lab. (xx), 5–7. https://doi.org/10.1016/j.edumed.2019.06.005

[14] Nikulin, C., Lopez, G., Piñonez, E., & Gonzalez, L. (2019). NASA - TLX for predictability and measurability of instructional design models : case study in design methods. Educational Technology Research and Development, 67(2), 467–493. https://doi.org/10.1007/s11423-019-09657-4

[15] Ojha, A., Ervas, F., & Gola, E. (2017). *An eye movement analysis of high and low intelligent individuals*. (October). https://doi.org/10.1109/CYBConf.2017.7985776

[16] Ong, Elsie; Chun, Rick Law Tsz (2018): *Emotional Facial Processing: Does Cognitive Load Make a Difference?*. SageSubmissions. Preprint.

[17] Pawar, S., Jacques, T., Deshpande, K., Pusapati, R., & Meguerdichian, M. J. (2018). *Evaluation of cognitive load and emotional states during multidisciplinary critical care simulation sessions.* 87–91. https://doi.org/10.1136/bmjstel-2017-000225

[18] Sennersten, C., & Lindley, C. (2018). Modeling cognitive load and physiological arousal through pupil diameter and heart rate.

[19] Soria-oliver, M., López, J. S., & Torrano, F. (2017). Relations between mental workload and decision-making in an organizational setting. https://doi.org/10.1186/s41155-017-0061-0

[20] Stroop. J.R. (1992). *Intereference in serial verbal reaction.* Journal of Experimental Psychology. 121(1), 15-23

[21] Sweller, J., Merrienboer, J. J. G. Van, & Paas, F. G. W. C. (1998). *Cognitive Architecture and Instructional Design*. *10*(3), 251–296.

[22] Uhrig, M. K., Trautmann, N., Baumgärtner, U., & Treede, R. (2016). *Emotion Elicitation : A Comparison of Pictures and Films*. *7*(February). https://doi.org/10.3389/fpsyg.2016.00180

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[i] EG- Emotional Group

[ii] NG- Neutral Group