Journal of Research Administration
Society of Research Administrators International

THE EFFECT OF NUMEROSITY PERCEPTUAL LOAD ON MORAL LEXICAL TASK

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ABSTRACT
Moral decision process is influenced by various distractors is an interesting topic today. Massive online information spark this phenomenon. This study aimed to determine the dynamics of the moral decisions process at the semantic representation stage in manipulated cognitive-perceptual conditions in a lab setting. The data were analyzed with Bayesian ANOVA. In experiment 1, three cognitive tasks that induce high perceptual load were tested, including the flanker task (est = -604.32, l-95% CI = -658.96; u-95% CI = -552.38), the perceptual-letter task (est = -399.39, l-95% CI = -447.93; u-95% CI = -352.78), and the dot numerosity task (est = 2349.64, l-95% CI = 2296.59; u-95% CI = 2403.25). The analysis results showed that the dot numerosity task took the most reaction time and the majority of subjects stated that the task requires greater concentration. In Experiment 2, an perceptual load intervention using dot numerosity task was applied through lexical moral-word decision task. Strong evidence results were found in the main effect moral word reaction speed, with negative moral word have longer respons times, folowed with netral word and positive word. Numerosity effect also was found to stimulate accuracy model in high load group. Further discussion is discussed below.
Keywords: Moral Decision, Lexical Decision Task, Perceptual Load, Cognitive Task

INTRODUCTION
Moral decisions can be characterized as an individual's capacity to assess the extent to which a stimulus aligns with standards of morality—the process of making decisions that are ethical or involve various cognitive functions. The cognitive process should possess the ability to maintain its effectiveness even when it is disrupted by extraneous information or irrelevant stimuli (Li et al., 2018). The rapid advancement of social media inundates our cognitive processes with a constant stream of both pertinent and extraneous information. The simultaneous processing of stimuli, along with the process of decision-making in the presence of both relevant and irrelevant stimuli, has an impact on memory performance and cognitive state (Craik, 2014; Varao-Sousa et al., 2018). Ultimately, cognition, serving as the locus of executive function, is necessary for the ability to adjust to various changes in tasks and stimuli encountered in the surrounding environment.
The process of decision-making is carried out within an individual's cognitive abilities, as discussed Jin et al., (2019). Theoretical implications suggest that distractions have the potential to impact the performance of moral decision-making, specifically in relation to cognitive processes such as working memory. In a study conducted by Paxton, Ungar, and Greene (2012), it was

observed in the initial experiment that participants who were administered a Cognitive Reflective Test (CRT) exhibited a greater acceptance of utilitarian moral judgments in the personal-switch condition compared to those who did not receive the test. The increase in cognitive activity caused by CRT leads to a utilitarian moral conclusion. Korner and Volks (2014) also emphasized the significance of employing interventions that enhance cognitive capacity as it regards the ethical considerations of utilitarian decision-making, such as the decision to end another person's life. Similarly, the utilization of sleep deprivation conditions (Tempesta et al., 2012) and the impact of alcohol (Duke & Bègue, 2015) yielded comparable outcomes. Alcohol and sleep deprivation were found to influence executive functions (as CRT did in the preceding case). The moral decision-making process is controlled by the executive function when it is subjected to a significant load (Landy & Royzman, 2018). The aforementioned research findings indicate that cognitive factors play a significant role in shaping moral decision-making. Consistent with the study, as mentioned earlier, within a controlled laboratory environment, factors that hinder ethical decision-making can manifest as the modification of external stimuli before the focal point. Empirically, this manipulation has been observed to elicit heightened cognitive processes that impede the decision-making process (Li et al., 2018).

However, it is still uncommon to assess the perceptual load on the performance and accuracy of moral decisions, despite the fact that cognitive processes have been shown to influence moral judgments. In reality, the digital age exposes people to a greater amount of perceptual overload due to things like advertising and other multimedia content (Fisher et al., 2019).

According to perceptual load theory (Lavie, 2005), the increase in the cognitive-perceptual load, is defined as information that is processed when the subject responds to various target stimuli. The high cognitive-perceptual load when focusing on target (selective attention) from distracting stimuli can increase the individual's likeliness to miss some focal points (intentional blindness) (Lavie et al., 2014). This condition occurs because the working memory resource is approaching the capacity limit for processing a lot of information (Konstantinou et al., 2014). In several cognitive tasks involving high perceptual load, it was reported that only 10% could report in detail regarding the color and shape of the stimulus, whereas 55% reported being able to detect it at low perceptual load (Macdonald & Lavie, 2011). These findings underlie the priming method used in this present study. Conceptually, priming can act as a treatment in an experiment because it can change the target response (response interference). For example, subjects who are first exposed to the word “cat” stimulus will respond to the word “dog” faster than those who do not get “cat” word priming (Heyman et al., 2017). As previously explained, the level of the perceptual load will impact the subjects' response so that the target that subsequently appears will receive different responses from subjects with high perceptual loads and subjects with low perceptual loads. The use of priming, more precisely, can affect working memory performance through spatial attention (Kim & Humphreys, 2010).

In order to examine the impact of perceptual load on moral decision-making, various cognitive tasks are implemented as interventions to manipulate perceptual load. These tasks include the flanker task, perceptual letter task, and dot numerosity task, which serve as perceptual load tasks.

Additionally, the lexicon determination task (LDT) is applied, with changes made to incorporate moral-related words. The Lexical Decision Task (LDT) is widely used in the field of psycholinguistics to investigate word recognition and word meaning (Jiang, 2013). Lexical decision tasks have the ability to distinguish between the target (language) and non-target (non-language) categories by utilizing lexical representation (Dijkstra et al., 1999) and semantic representation (Yap et al., 2015). In their research, Gantman and Jay van Bavel (2014) highlighted the moral-pop-out effect in the lexicon decision task with moral words and non-moral words. The study found that related moral words are processed faster than non-moral words, so it can be concluded that the semantic representation of words related to morality has a higher priority. However, unlike the research by Gatman and Jay van Bavel, the researchers in this present study used conscious priming (Breitmeyer et al., 2005; Goller et al., 2017) in the form of cognitive-perceptual tasks to manipulate the perceptual load conditions of participants.

Experiment 1

Currently, three cognitive tasks related to perceptual load have been validated. Based on a comprehensive analysis of relevant literature and theoretical frameworks, it has been determined that three cognitive tasks serve as the fundamental components of perceptual load, specifically the modified flanker task (Stins et al., 2008), perceptual load task (Lavie et al., 2014), and the dot numerosity task (Feigenson et al., 2013a). These three task serve the purpose of addressing the distraction component within the load theory framework, and it is hypothesized that they impact the perceptual-cognitive system when transitioning from low to high perceptual load.

The Flanker Task

The flanker task was initially presented by Barbara Ericksen and Charles Ericksen in the year 1974. The flanker task is centered around the cognitive abilities of attention, specifically the capacity to concentrate on the intended target, whether it is relevant to the task at hand or not, while simultaneously inhibiting any distracting stimuli. The individual flanker task score, which represents the average disparity between the congruent stimulus and incongruent stimulus (referred to as distraction), is commonly known as the flanker effect (Buetti et al., 2014). The flanker task, which first utilized directional arrows as stimuli, has undergone several revisions in order to gather more diverse and accurate data from numerous sample groups, including youngsters (Johnstone & Galletta, 2013; McLean et al., 2014; Xie et al., 2017).

The Perceptual Letter Task

The perceptual letter task used a matching system paradigm and was originally adopted by Nilli Lavie to examine the impacts of low perceptual distractors and high perceptual distractors. The perceptual letter load tasks, as delineated by Khetrapal, (2010) and Lavie, (2005) often involve a configuration of letters positioned around a central point of focus, known as fixation. Within this configuration, there is a single letter positioned to the left. The objective of the participant is to ascertain whether the letters inside the cluster of visual stimuli correspond to the letters adjacent to them. In addition to employing the unaltered form, the perceptual task will be subject to modification through the inclusion of letter distractors and pair distractors.

The Dot Numerosity Task

Regarding the dot numerosity task, the researchers conducted a planned assessment of mathematical ability using the paradigm and description of the approximate number system (ANS) as outlined by Libertus et al., (2013). The approximate number system (ANS) is a cognitive-perceptual ability that enables individuals to estimate the quantity of a combination of stimuli by generating numerosities. The process of ANS functioning involves a combination of cognitive and intuitive guessing, as described by (Cai et al., 2018). One commonly employed activity within the widely utilised approximation number system involves the assessment of numerosity through the usage of yellow and blue dots.

METHOD

The initial sample for this study comprised 30 college students who were subjected to three perceptual-cognitive tasks. Participants were provided incentives for their attendance at the experimental laboratory. Participants did not have any visual impairments and were in a state of good health. The results were gathered via two laptops 15.5 inch within the laboratory setting. Each participant was positioned in front of the laptop, with a distance of 30 cm between them and the laptop screen. During the initial stage, the cognitive task that exhibited either low or high perceptual load was identified using a repeated-measures ANOVA. Following the completion of the cognitive tasks, the participants were interviewed to ascertain their perception of the perceptual-cognitive load associated with each task and determine which task they considered to have a more substantial perceptual load. During the three cognitive activities, participants were provided with instructions to prioritise both speed and accuracy in their responses. The perceptual load assignments were two primary blocks, each containing 16 stimulus trials. The initial block was indicative of a condition characterised by low perceptual load, while the subsequent block was representative of a condition characterised by high perceptual load.

The inter-stimulus interval lasted for a duration of 1 second. Additionally, during the transition period from block 1 to block 2, the participants were provided with fresh instructions, necessitating a waiting period of up to 15 seconds. The second block exhibited an identical paradigm to the previous block, however with an increased quantity of distractors. In the context of the flanker task, the level of interference was heightened during the subsequent block. The stimuli comprised various combinations of alphanumeric characters, such as "66866" and "RRBRR". Regarding the perceptual letter task, the objective was to establish correspondence between the letters shown in a circular configuration centred around a fixation point. Specifically, the letters positioned on the left side of the arrangement were comprised of pairs of two letters, such as "BG" or "RB." In the dot numerosity task, the researchers introduced four targets that exhibited a range of 5 to 20 variations in the number of dots across trials. The dot numerosity encompasses various combinations of dot stimuli, spanning from a minimum of 10 dots to a maximum of 100 dots. The participants were provided with the option to select a time interval between successive tasks. The stimulus presentation employed the staircase approach in a block-wise fashion, as described by (Leek, 2001). The data analysis was carried out using R (R Core Team, 2016).

RESULTS

The existing body of research and empirical evidence indicates that the application of the normal distribution is highly inappropriate for the analysis of reaction time (Lindeløv, 2019; Masson, 2011). To address this issue, we use bayesian repeated measure ANOVA from brms package (Bürkner, 2017). In addition to the decision-diffusion model, the ex-Gaussian distribution has been found to be a reliable method for assessing reaction time (RT) data, as demonstrated by (White et al., 2016). Based on the analysis conducted using four chains and 2000 iterations, it was observed that the dot numerosity task exhibited superior performance compared to the other two perceptual tasks. The lower bound of the 95% confidence interval (CI) for dot numerosity was estimated to be 2296.59, while the upper bound of the 95% CI was estimated to be 2403.25.

According to Stanton, (2018), statistically meaningful confidence intervals are those that do not include the value of zero. In addition, the chi-square analysis conducted on the accuracy data yielded moderate evidence (Bayes Factor = 9,122; $p < 0.001$). Meanwhile, the chi-square for accuracy data was also in moderate evidence (BF = 9,122; 0%) (Morey et al., 2018). The Bayes factor (BF) interpretation adheres to the guidelines established by Robert Kass and Adrian Raftery (1995). The findings of the current study indicate that the dot numerosity task exhibited the longest reaction time, accompanied by moderate accuracy.

In contrast, the flanker task demonstrated the shortest reaction time, along with the lowest accuracy. The perceptual letter task, on the other hand, displayed moderate reaction time and the highest level of accuracy. Detailed information can be found in Tables 3 and 4. Tasks that exhibit the highest perceptual load are characterized by longer reaction times and lower levels of accuracy, ideally. In order to verify this, a process of cross-checking interviews was conducted with the research participants to inquire about the cognitive task that demands the greatest level of concentration and effort to accomplish (refer to Table 1). The dot numerosity task, also known as the Approximate Number System (ANS), was found to demand the highest level of focus among the majority of participants (n = 22). Based on the researchers' empirical observations, it has been noted that tasks such as the flanker task possess a certain vulnerability wherein the stimuli presented tend to exhibit discernible patterns that may be readily inferred and acquired by the participants, hence leading to trial learning.

Conversely, trial learning may be attained in instances where the distractor exhibits malfunction, leading to the inference that the flanker task fails to meet the subject's elevated perceptual load. Moreover, perceptual load refers to the cognitive load that is intended to facilitate optimal decision-making. If the available information is adequate for making a decision, it will be accomplished irrespective of the level of task difficulty. A complex task may not be completed due to its failure to induce a high load state, as indicated by the mean accuracy in Table 2. Conversely, a simple task that requires a continuous or gradual load may be automatically executed until reaching a high load position.

Table 1. Total reaction times and accuracy

Statistics	Reaction Time (ms)	Accuracy
Min	318	0
Max	28225	1
Range	27907	1
Median	1416.5	1
Mean	2063.46	0.76 (76%)
SD	1684.916	0.42

Table 2. Mean and SD of Loading Task

Type of Task	Mean of reaction times	Mean of Accuracy	Minimum reaction times	Maximum reaction times	SD of reaction times
Flanker Task	975.35	0.69 (69%)	318	3091	304.40
Letter Perceptual Task	2025.2	0.85 (85%)	564	28225	1726.30
Dot numerosity Task	3189.94	0.75 (75%)	828	14078	1730.02

The dot numerosity task exhibits a greater degree of variety compared to the other two tasks. Nevertheless, these variances do not inherently increase the level of difficulty associated with accomplishing this activity. The perception of numerosity is influenced by both visual inspection and perceptual abilities, as well as intuitive abilities (Feigenson et al., 2013b). The discrimination of the stimulus gradation presented by five dots is a considerable challenge in terms of perceptual differentiation, while simultaneously demanding minimal cognitive load on working memory. In the context of dot numerosity, the cognitive and intuitive task resources, specifically the number and numerosity sense, collaborate to ascertain the numerosity of several stimulus groups. The ability to differentiate between quantities of dots within the range of 25 to 30 (referred to as low dot) can be rapidly achieved by cognitive processes. However, the task becomes more challenging when attempting to discriminate between quantities ranging from 70 to 75 (referred to as high dot). Table 5 demonstrates that an increased quantity of dots and reduced gradation have been observed to result in longer reaction times and diminished accuracy. At this juncture, the researchers have reached the determination that the participants did not employ intuition as a direct factor in their decision-making process regarding numerosity. Intuition is often employed as a cognitive mechanism when the cognitive faculties encounter their inherent limitations.

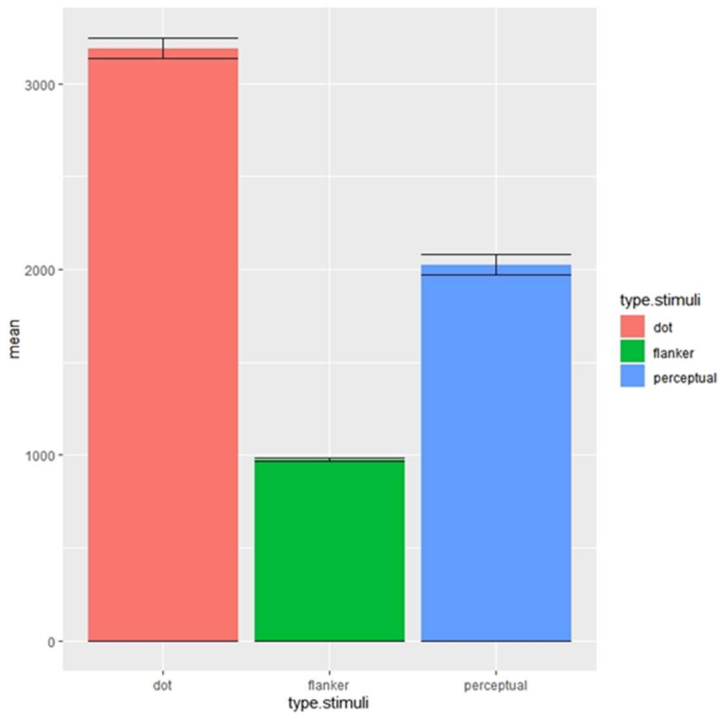

Figure 1. Barplot Error Mean RT

Table 3. Bayesian ANOVA

	Estimate	Est.Error	l-95% CI	u-95% CI	Rhat	Bulk_ESS	Tail_ESS
Intercept Dot	2349.64	27.38	2296.59	2403.25	1.00	1540	1884
Flanker	-604.32	27.28	-658.96	-552.38	1.00	1295	1859
Letter	-399.39	24.65	-447.93	-352.78	1.00	1103	1790

Table 4. Mean of Reaction Time in the Dot Numerosity Task

Magnitude	**Block#**	**Dot Magnitude***	**Mean of RT**	**Mean of accuracy**
gradation_10	block_1	high_dot	2838.533	0.48 (48%)
gradation_15	block_1	high_dot	2874.967	0.53 (53%)
gradation_20	block_1	high_dot	2891.000	0.70 (70%)
gradation_5	block_1	high_dot	2627.633	0.90 (90%)
gradation_10	block_2	high_dot	5686.883	0.48 (48%)
gradation_15	block_2	high_dot	4885.833	0.78 (78%)
gradation_20	block_2	high_dot	4884.200	0.40 (40%)
gradation_5	block_2	high_dot	4861.767	0.25 (25%)
gradation_10	block_1	low_dot	2394.949	0.78 (78%)
gradation_15	block_1	low_dot	2291.650	0.98 (98%)
gradation_20	block_1	low_dot	1698.933	1.00 (100%)
gradation_5	block_1	low_dot	1292.475	1.00 (100%)

gradation_10	block_2	low_dot	2249.590	1.00 (100%)
gradation_15	block_2	low_dot	3769.067	0.82 (82%)
gradation_20	block_2	low_dot	2681.350	1.00 (100%)
gradation_5	block_2	low_dot	3143.458	0.95 (95%)

*low_dot (>50 dot); high_dot (<50 dot), # block_1 = 2 target, block 2 = 4 target

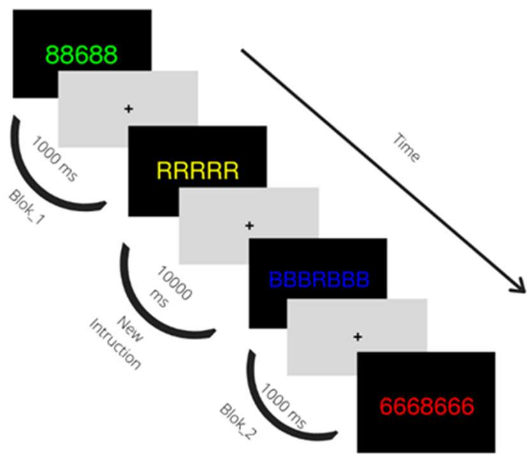

Figure 2. Flanker Task

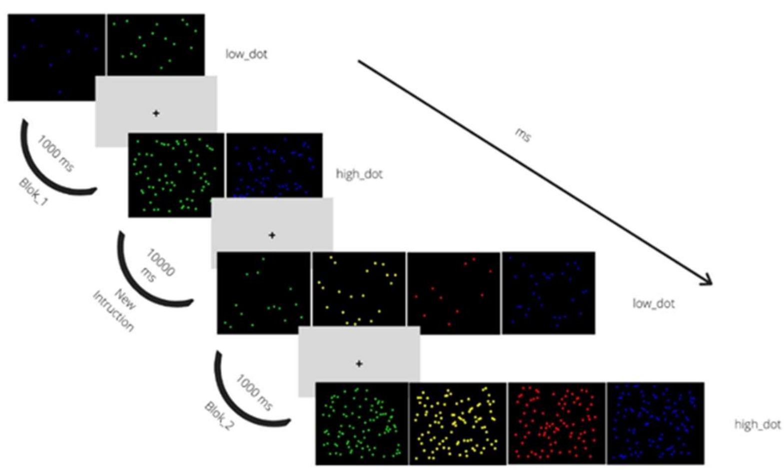

Figure 3. Dot Numerosity Task

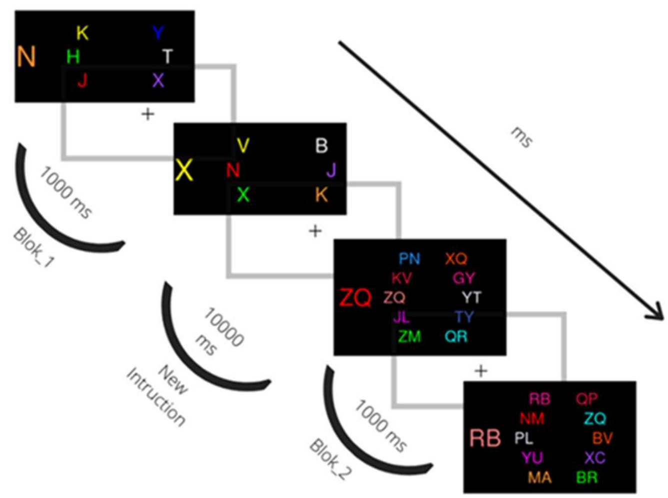

Figure 4. Perceptual Letter Task

Experiment 2

Following the identification of dot numerosity as a perceptual activity that exerts a significant impact and enhances perceptual load, the subsequent phase involved examining the lexical moral-word judgement task while incorporating dot numerosity as a deliberate interference. The term "high group" pertains to the experimental group that was exposed to four distinct forms of dot numerosity task, whereas the "low group" denotes the experimental group that was exposed to only two types of dot stimuli.

Lexical Moral-Word Decision Task

The stimuli for moral terms comprised words in the Indonesian language. Terms such as "stealing," "provocateur," and "bullying" are classified as negative moral descriptors, whereas phrases associated with positive moral connotations encompass terms such as "tolerant," "compassionate," and "caring." Neutral words encompass verbs and adjectives devoid of moral implications, exemplified by terms such as "moving," "contemplating," "calm," "spirited," and "crying." The stimuli underwent a validation process conducted by individuals who had expertise in their respective fields.

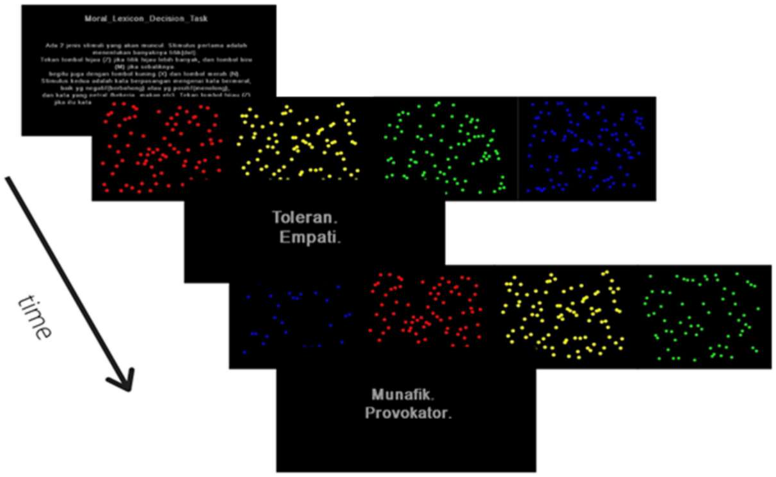

Figure 5. Moral lexicon decision task in high load group

METHOD

The research was conducted with a between-subjects design, specifically comparing a high load lexicon decision task with a low load lexicon decision task. The participants of the study were divided into two groups, with 17 individuals assigned to the high-load group and 16 individuals assigned to the low-load group. According to previous research conducted by Datta et al., (2019) and Lu et al., (2019) a sample size of 30 is widely regarded as sufficient for psychophysical experimental laboratory studies. The data were gathered utilising two laptops, whereby the individual was positioned in a sat posture directly facing the laptop, maintaining a distance of around 30 cm from the screen. The participants indicated that they did not have any visual impairments and utilised the Indonesian language for their regular communication. The participants engaged in a lexical moral-word judgement task comprising of two blocks, with each block containing eight trial stimuli. In this study, every subject's dataset consisted of 16 lines including reaction time data, specifically response latencies, measured in milliseconds (ms). The stimuli used in both the high-load and low-load groups were identical, and no difference was seen across the blocks. The data analysis was conducted with the R programming language, while the presentation of stimuli was facilitated through the utilisation of Expyriment (Krause & Lindemann, 2014).

Table 5. Bayesian ANOVA reaction times

No		BayesFactor	%	BayesFactor*	%*
[1]	Group	0.339	±0.06%	0.339	±0.06%
[2]	Moral Word	40.123	±0.02%	40.123	±0.02%
[3]	Group+Moral Word	13.382	±1.37%	13.505	±0.69%
[4]	Group + Moral Word + Group:Moral Word	0.755	±2.8%	0.756	±1.26%

*bayesfactor after montecarlo recompute and rescale bayes estimation

Table 6. Bayesian ANOVA accuracy

No		BayesFactor	%	BayesFactor*	%*
[1]	Group	44203.55	±0%	44203.55	±0%
[2]	Moral Word	1.99808	±0.02%	1.99808	±0.02%
[3]	Group+Moral Word	9.0012	±4.66%	8.6593	±0.4%
[4]	Group + Moral Word + Group:Moral Word	1.8834	±3.61%	1.8470	±0.52%

Table 7. Lexicon Accuracy and Mean Respons Latencies

Group	Moral Word	Accuracy	RT
High-load	Negative moral	0.82 (82%)	3454.295
Low-load	Negative moral	0.61 (61%)	3502.567
High-load	Positive moral	0.70 (70%)	2480.791
Low-load	Positive moral	0.75 (75%)	2583.142
High-load	Neutral	0.26 (26%)	2906.301
Low-load	Neutral	0.32 (32%)	3428.777

RESULTS

After excluding extreme reaction times (either below 300 ms or beyond 20,000 ms), a total of 1046 rows of data were obtained for the comprehensive data analysis. Following the removal of the outlier, the data underwent a conversion from milliseconds to seconds. The data analysis was conducted via the bayesfactor package. The findings from Bayesian ANOVA on response times data with an ex-Gaussian distribution revealed that the main effect of the moral word variable yielded a Bayes factor of 40, showing robust evidence against the null hypothesis. Additionally, the proportional error was determined to be below 1.5% (0.02) [2]. In order to mitigate any errors, we conduct a recompute and reanalyze process utilising a Montecarlo simulation with 50,000 iterations. Subsequently, we proceed to evaluate the outcomes obtained from different models. Subsequent examination revealed that positive moral statements had a faster response time compared to neutral and negative moral word. Anecdotal evidence suggests that there is a Bayes factor of 0.33, indicating a lack of significant variations in reaction times between the high and low-load groups. The interpretation of Bayesian interaction poses challenges, as it necessitates the division of the Bayes factor for the interaction's main effect of the two factors (model 4) by the Bayes factor for the combined main effect of the two factors (model 3). The obtained value of 0.055 suggests that there is no significant interaction between the group and the moral word.

The Bayesian ANOVA analysis yielded a Bayes factor of 4440.45 and a proportional error of 0% for the accuracy data (tabel 6). These findings provide robust evidence of significant differences in accuracy between the groups. The group with a higher perceptual load exhibits greater accuracy compared to the group with a lower perceptual burden. The Bayes factor analysis reveals that the moral word exhibits the lowest value, specifically 1.9 (+0.02). This indicates that the dot numerosity effect has only anecdotal evidence in terms of its impact on accurately identifying moral words as either good or negative. The phenomenon of priming numerosity dot appears to have an intriguing impact on individuals' ability to accurately differentiate between moral words categorised as good, terrible, and neutral. The Bayes factor for the interaction effect between group and moral word is 2.1 (+0.65), suggesting anecdotal evidence. This value was derived by dividing the Bayes factor received from model 4 by the Bayes factor obtained from model 3.

FINDINGS AND DISCUSSION

The findings related to significance in this study can be explained in terms of two point, the main effect reaction times and accuracy. First, in the priming numerosity effect individuals tend to drawn numerous and bigger number/dots, even when applied to something small (Bagchi & Davis, 2016). However, priming numerosity effect have no effect in moral word. People actually respons the positive moral world faster than the neutral and negative, not because the priming perceptual load. In accordance with the findings, Gantman et al., (2020) also found that words affiliated with morality meaning were responded faster than neutral words. However, Gantman et al. did not distinguish between positive and negative moral words. However, research from McHugh et al., (2023) explains that cognitive load can impact cognitive activity when making moral decisions, which results in a decrease in reasons-giving answer. This means that moral decisions can be influenced by cognitive loading, not perceptual loading. For example, thinking about the answer to a difficult question (e.g. cognitive reflective test), has a different level of cognitive activity from just comparing and estimating how many dots there were. Following Murphy & Greene, (2017), state that perceptual load and cognitive load have distinct operational mechanisms.

Similar to the results for reaction time, the best model in accuracy data was between group accuracy. However, it cannot be concluded that the positive moral, bad or neutral word were more accurate. This finding underlines that the higher the priming perceptual load, the higher the accuracy. This phenomenon occurs because individuals increase attentional activation on the objects target to process, and because do not require calculations, they are mandatory. This finding emphasizes that the higher the priming perceptual load, the higher the accuracy. This result is consistent with previous research indicating that perceptual and cognitive load have distinct working mechanisms. This activity originates in the anterior insula, which is responsible for attention burden and categorizing distractors and target stimuli. When this region is active, it will influence the attentional process. According to load theory, under high load conditions, individuals will reduce distractor processing, which causes the effect of load on accuracy.

Another significant finding in the field is that selecting a task with the highest reaction time alone cannot serve as the primary criterion for determining the effectiveness of an intervention for perceptual load. It is essential to consider several additional factors, such as qualitative interview data and participant observations.

ACKNOWLEDGEMENTS

This research was supported by BPP-DN Scholarship from Direktorat Riset dan Pengabdian kepada Masyarakat, Kementerian Riset dan Teknologi, Republik Indonesia.

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