# Combined effects of Selective attention and repetition on event-related potentials of Arabic Words Processing

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DOI: http://dx.doi.org/10.7358/neur-2018-023-tari Tarik@kfupm.edu.sa

ABSTRACT

*It has been debated whether, word repetition effect (N250r) is affected by selective attention. Therefore, attention was manipulated due to Lavie's perceptual load theory by increasing the number of letter-words (e.g., 3 letter-words; 6 letter-words & 9 letter-words). An immediate (S1-S2) repetition priming paradigm was used, and the participants were instructed to decide whether both S1&S2 were identical or not. S1 was presented for short time intervals (200 ms), while S2 was presented for long time intervals (1800 ms). Results showed that there is an early repetition effect (N250r) on both hemispheres for 3 letter-words, while this effect appeared in the left hemisphere for 6 letter-words; nevertheless, this effect is vanished for 9 letter-words. These findings suggested that an early repetition effects which occur around 250 ms strongly depend on selective attention.*

*Keywords: Repetition; event-related brain potentials; N170; N250r*

## 1. Introduction

Word processing in arabic language is unique, because the features of the arabic words which is that most of the letters are connect mandatory to each other. Hence, these letters change their form due to the location in the word (i.e. begining, middle or end), suggesting that words are processed in an unique manner compared to other objects. Evidence for the uniqness of the word processing compared to object processing is that words can be named more quickly than they can be categorized, whereas objects are categorized more quickly than they can be named (Potter & Faulconer, 1975). However, Nelson and Reed (1976) showed that words phenomic access is direct, with no need for perior semantic processing, while objects phenomic access is indirect with a requirments of semantic processing, suggesting that there are different stages for word processing compared to objects processing. Many models suggested that written words lead to the development of the mental orthographic lexicon that allow for efficient recognition of words (Coltheart, 2005; Ehri & Snowling, 2005).

Event-Related potentials (ERP) studies on word processing and recognition showed that there are many of neuro-cognitive components which processed simultaneously when words are presented in the sensory system (Adamo & Ferber, 2009; Allison, McCarthy, Nobre, Puce, & Belger, 1994; Ashby, Sanders, & Kingston, 2009; Bechtereva, Abdullaev, & Medvedev, 1992), suggesting that the sensory system processed words in a different stages as shown in the model of Nelson, Reed and McEvoy et al. (1976). This process includes; Pictorial encoding, orthographic encoding, word recognition units (Logogens), semantic representation, and memory encoding. ERPs studies showed that each of the above-mentioned stage is connected to specific ERP components which respond effectively for a specific cognitive component, such as pictorial encoding which is related to a positive going peaks around 100 ms, and termed P100 that responsible for the main properties of words, such as length, contrast and luminance. Additionally, ERPs studies showed that orthographic coding is connected to neurocognitive compenets with negative peaks around 170ms and termed N170 (Taha, Ibrahim, & Khateb, 2013). Prior studies showed that this component is responsible for word detection. In the study of Taha, Ibrahim and Khatheb (2013) the authors examined the effect of orthographic connectivity on the time course of early brain electrical response (N170) during visual word recognition. Findings showed that torthorgraphic stages seem to impact positively the reading process during the early stages of word recognition.

Forgoing studies have shown that there are two ERPs components related to the effect of word repetition. The first component is peaks negativitly a round 250 ms and termed N250r. Moreover this component is related to word recognition units (Logogens), and N400 which is related to semantic representation, and occurs around 400ms (Allison, McCarthy, Nobre, Puce, & Belger, 1994; Bentin, 1987a; Bentin, Kutas, & Hillyard, 1990). Most of the recent studies showed this effect of repetition modulation on central parial lobe in the time range of N400 (i.e., Massol, Grainger, Dufau, & Holcomb, 2010).

In the study of Massol, Grainger, Dufau, and Holcomb (2010) the authors conducted two experiments to examine compared effects of repetition primes with effects of primes that were high-frequency orthographic neighbors of low-frequency targets (e.g., faute-faune [error-wildlife]). Results showed that repetition primes generated more positive-going waveforms than unrelated primes, in the time window of 350-550 ms and termed N400. Similarly the study of Eddy, Grainger, Holcomb, Mirta and Gabrieli (2014) examined the time-course of reading single words in children using masked repetition priming. Results showed that children had larger amplitude N250 effects than adults for both shorter and longer duration primes. The overall similarity in the children's repetition priming effects to adults' effects is in line with theories of reading acquisition.

According to perceptual load theory, visual perception is capacity-limited, but when we increase the number of the words this process occurs mandatory unless all capacities are engaged by task-relevant target stimuli. I assume that when 9 letter words were presented these words will exhaust the whole capacity of the attentional system, without any capacity left for perceiving other stimuli (Lavie, 2005). Any spare capacity left was not required for the processing of task-relevant information "spills over", and the irrelevant information are processed. This process occurs routinely in the sense that it cannot be voluntarily withdrawn. Thus, for effective filtering to occur it is necessary that an attended task consumes all attentional capacity.

Overall there is long-term argument about word processing. Therefore, I aimed to reassess the potential selectivity of early repetition modulation of the N250r with attentional load using attentional load manipulation in the context of perceptual load theory by increasing the number of letter- words (i.e., 3 letters word; 6 letters words; 9 letters words). I presented words in 2 conditions of repetition and non- repetition. Participants were instructed to detect the repetition of words and ignore the length of these words. I assumed that this repetition effect could occur for 3 letter words but it could be disappeared for 6 letters words or 9 letter words. In the current study, I focus on the effect of load manipulation and repetition on the processing of Arabic words. In addition, I aimed to replicate the findings of word repetition effect which observed for children in the study of (Eddy et al., 2014), and replicated the same findings on adults. I would expect that N250r for words amplitude may be influenced under high load as compared with medium or low load. So I assume that this effect of repetition will be clear when there is more capacity left the attentional system, so I can expect that this effect of word repetition will appear for three-letters words and could be this effect extend to 6letters words. In contrast, I assume this effect of repetition will be vanished when 9- letters words are presented, because these words will exhaust the whole capacity in the attentional system leaving no capacity left for detecting this repetition effect.

## 2. Method

### *2.1 Partecipants*

22 students (11 female), aged between 19 and 28 years old (M = 23.78, SD = 2.67) contributed data to this study. All participants were right handed, which specified by Edinburgh Handedness Inventory.Participants have normal or corrected-to-normal visual acuity. They all gave written informed consent. The study was conducted in accordance with the declaration of Helsinki.

### *2.2 Stimuli*

I used a set of 90 Arabic words which consist of (30 three-letter words; 30 six-letter words; 30 nine-letter words). All words in each of these categories were rated for frequency by the participants (Nr.22), using Likert scale (from 1 for non-frequent to 5 highly frequent). However, the average frequency for each item in each category was then computed and values were statistically compared using one-way ANOVA with the three categories. Results showed that the stimuli did not differ in terms of word frequency $F\,(2, 87) = 1.13$, $p = 0.09$.

All of the stimuli were presented in a block design, which are counterbalanced randomly. All words were presented in a repetition priming paradigm which has been adopted from the study of Mohamed, Neumann, and Schweinberger (2009, 2011).

### *2.3 Procedures*

Participants were seated in a light- and sound-attenuated room. Viewing distance was 90 cm. During each experimental trial, an initial display for 500 ms of black fixation stimuli. Which followed by (S1) stimuli for short time interval for 200ms , which followed by an inter-stimulus interval of 1300 ms. A second stimulus (S2) was displayed for 1000 ms followed by an inter-trial interval of 1000 ms. Participants were made choice response to the second stimulus presentation by pressing one button if both stimuli (S1 and S2) were identical, or another button, if both stimuli were not identical. The experiment consists of 360 trials which included 3 blocks. Each block includes 120 trials and the time duration is 8minutes. The total time of the experiment was 24 minutes.

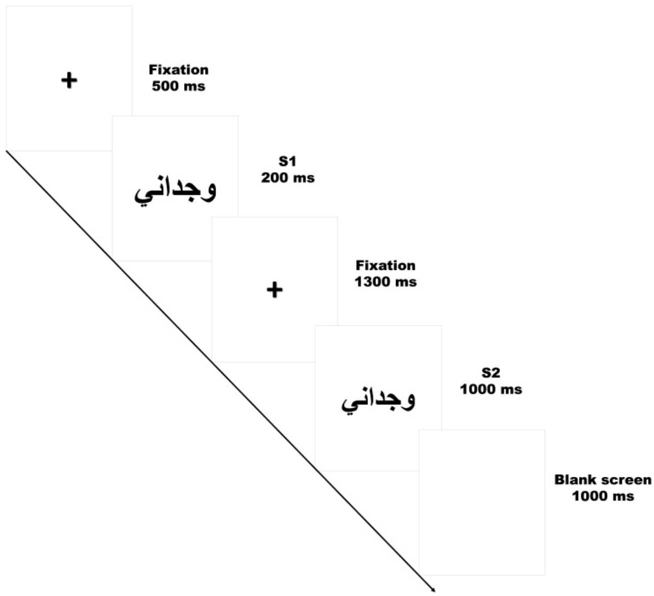


*Figure 1. Examples for the stimuli. Participants had to perform two-alternate choice responses ("Identical" or "Not Identical") to Words are presented in S1-S2 Paradigm*

### *2.4 Apparatus*

With a 30 electrodes (10-20 standard set-up) mounted in an elastic cap. EEG was recorded at Fz, FCz, Cz, CPz, Pz, POz, F3, F4, FC3, FC4, C3, C4, CP3, CP4, P3, P4, PO3, PO4, F7, F8, FT7, FT8, T7, T8, TP7, TP8, P7, P8, PO7 and PO8, and sampled at 500 Hz, using two mastoid references. Cz was used as ground electrode. Data were re-referenced offline to a common average reference. ERP epochs were quantified for 800 ms (-200 ms pre-stimulus baseline). Eye movement artifacts were excluded by algorithm of independent component analysis (ICA) as implemented in Brain Vision Analyzer 2.0. Data were filtered with a band pass at of 0.5-35 Hz. Trials with eye movements or EEG artifacts exceeding 50 µV were omitted from further analyses.

### 2.5 Data Analysis

Repeated measure analysis of variance (MANOVA) was calculated for analyzing effects of Word length "Load" (3 categories), and Repetition (repeated vs. non-repeated). P1 was quantified in the time segment 80-120 ms at occipital temporal electrodes (PO7, PO8), with an additional factors of Hemisphere (right vs. left). N170 was quantified at the time segment 120 to 200 ms at occipital temporal electrodes (P7, PO7, P8, PO8) with additional factors Electrode Position (P7/PO7 vs. P8/PO8) and Hemisphere (right vs. left). N250r was assessing the same factors. Epsilon corrections for heterogeneity of covariance were always performed using the Huynh–Feldt method, where appropriate.

## 3. Results

### 3.1 Behavioral Results

Repeated measure ANOVAs were conducted on factors, Load and Repetition on both Reaction Times (RTs) and Accuracy (ACC). RTs analysis revealed main effect of Repetition $F$ (1, 21) = 26.796, $p$ < .001 with longer RTs for Non-repeated words vs. repeated words ($M_{diff}$ = 44.313 ms). No other main effects or interaction were observed. ACC analysis does not show any main effects or interactions all *ps*> *0.30*. These findings showed that there is no effect of attentional load occurred for the processing of Arabic words. However, Perceptual loads were not successfully manipulated.

### 3.2 Event-Related Potentials Results

#### 3.2.1 P1 (080-120 ms)

An initial analysis on the region of interest (ROI), with the factors of Hemisphere, Load and Repetition does not reveal any main effects or interactions, all *ps*> *0.30*. For P1 latency, repeated measure ANOVA does not show any main effects or interactions all *ps*> *0.40*

### *3.2.2 N170 (120-200ms)*

An initial analysis on the Region of interest (ROI), with the factors of Hemisphere, Sites, Load and Repetition revealed an interaction of Hemisphere by Load $F$ (2, 42) = 7.02, $p < .01$. No other main effects or interactions all *ps> 0.10* were reported. To solve this interaction, I conducted additional analysis for each hemisphere. Further analysis showed a main effect of load $F$ (2, 42) = 7.02, $p < .01$ on the left hemisphere with largest negativity for 3-letters words (*M*= 7.88 µV), compared to 6-letters words (*M*= 7.03 *µv*), or 9-letter words (*M*= 6.68 *µv*), while this effect does not exist on the Right Hemisphere $F$ (2, 42) = 0.99, $p >$ .30. For N170 latency Repeated measure ANOVA does not show main effects or interactions all *ps> 0.10.*

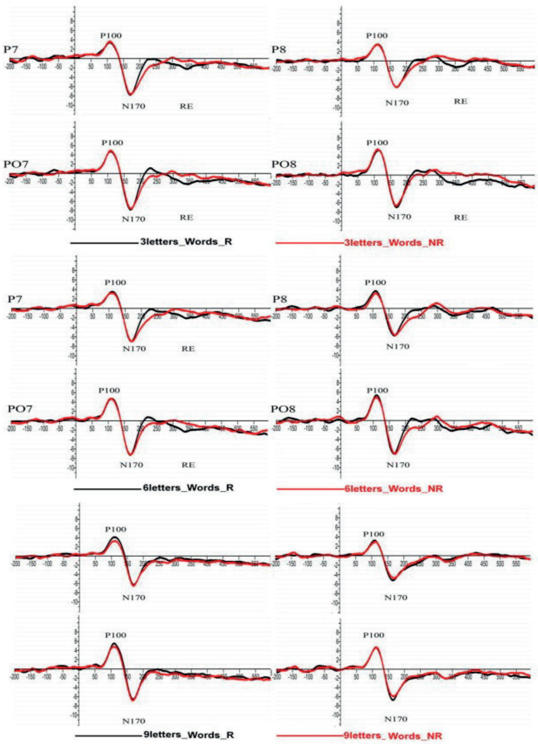


*Figure 2. Grand average event-related potentials (ERPs) for occipital-temporal sites of interest, across 22 observers. Upper part Results of three-letters words. Middle part results of 6 letters words. Bottom part for 9 letters words*

*3.2.3 N250r (240-350 ms)*

N250r mean amplitudes analysis showed two-way interactions of Sites by repetition $F\,(2, 42) = 7.58$, $p < .01$; and four-way interactions of Hemisphere by Sites by Load by Repetition $F\,(2, 42) = 3.72$, $p < .05$. To solve-up these interactions, I conducted additional analysis for each hemisphere. Left hemisphere analysis showed that there are interactions of Sites by Load by Repetition $F\,(2, 42) = 13.04$, $p < .001$, Sites by Repetition $F\,(1, 21) = 5.05$, $p < .05$. I conducted additional analysis for each sites and findings showed main effects of repetition on both P7 and PO7 which qualified by attentional load, for both 3 letters words and 6 letters-words, $F\,(1, 21) = 8.14$, $p < .01$; $F\,(1, 21) = 4.98$, $p < .05$; $F\,(1, 21) = 6.14$, $p < .01$; $F\,(1, 21) = 3.59$, $p < .05$ consequently. For the Right hemisphere there is an effect of load by repetition $F\,(1, 21) = 4.01$, $p < .05$, which appears only for 3 letters words $F\,(1, 21) = 3.85$, $p < .05$.For N250r Latency showed main effect of Repetition $F(1, 21) = 12.93$, $p < .005$ with longer longer latency for Non-repeated words vs. repeated words ($M_{diff} = 17.06$ ms). No other main effects or interactions, all *ps*> 0.33

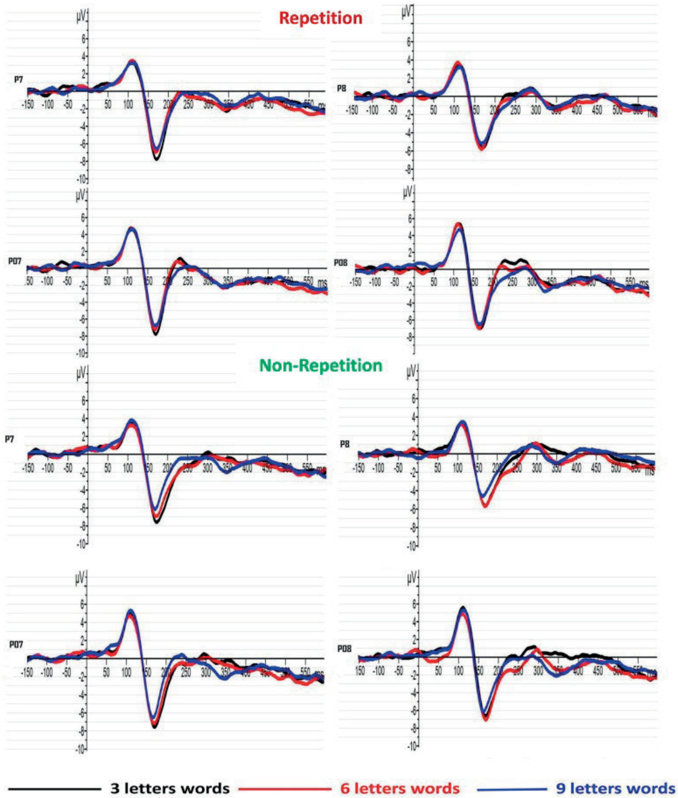


*Figure 3. Grand average event-related potentials (ERPs) for occipital-temporal sites of interest, across 22 observers. Upper part for repetition effects with different length. Bottom part for non-repetition effects for different word length*

## 4. Discussion

The Present study investigated the combined effects of attention and repetition on the processing of Arabic words. Attention was manipulated by increasing the number of word letters sequentially (i.e., 3-letters words, 6-letters words, 9-letters words), due to Lavie's perceptual load theory. Hence, I measured a repetition related modulation in ERPs which elicited by S2 stimulus, in a sequential matching task on (S1-S2) paradigm, while no task was performed to associate with the presence of S1 stimulus. Here, I noticed the most prominent repetition related ERP modulations N250r component in an occipito-temporal area for Arabic Words. Considerably, those repetitions modulations were powerfully qualified by attentional load of S2-presence. In particular, I observed N250r component for 3-letters words in both hemispheres, while this effect appears for 6 letter-words on the left hemisphere, in contrast this component does not appear in both hemispheres for 9-letters words. It's obvious that word selectivity N250r is massively depending on selective attention (Forster & Lavie, 2007; Lavie, 1995; Lavie, 2005).

However, these findings is consist of (Brand-D'Abrescia & Lavie, 2007), which showed that the RTs were increased when the number of words is increased (i.e. 3-letter words vs. 9-letters words). Interestingly, N250r findings of Arabic words could be interpreted due to attentional capacity, when 3-letters words are presented the attentional system has a spare capacity, which spill over and perceive these words, and detect the repetitions. Consequently, not only on the left hemisphere (Allison et al., 1994; Arguin, Fiset, & Bub, 2002; Ashby et al., 2009; Barnea & Breznitz, 1998; Bechtereva et al., 1992; Behrmann & Plaut, 2013) is responding to these words but get a kind of support from the right hemisphere which is responsible for the meaning of these 3-letter words. In contract, when 6-letter words were presented, so there is no capacity left on the attentional system because these 6 letter words engaged the whole capacity. Consequently, the only specialized hemisphere (Bentin, 1987b; Bentin, 1989; Bentin & Ibrahim, 1996) will respond to the repetition of 6 letters words. Moreover, when these 9-letters words were presented, the both hemispheres could not respond to the repetition of these words, because the attentional capacity could not perceive these words, because the attentional system is engaged to the processing of these 9-letters words. Therefore, there is no capacity left in the attentional system to perceive repetition effects of the 9-letters words.

I realize of course, that my interpretation is speculative. In Nelson et al. (1976) model of word recognition Word Recognition Units (WRUs) are thought to be not only responsible to store the structural information of words, but also allowing the identification of words to specify these letters are words or not. Here, I presented an evidence that words can be elicited the repetition modulations N250r, if the attentional system has ability to perceive these words.

Another new finding related to the N170-ERP component of Arabic words. N170 is thought to be related to the structural encoding of Arabic words. Here we did not report a repetition effect on the N170, but there is an effect of attentional load. It is not clear why this effect was reported. In conclusion, the findings of the current results showed that ERP Repetition for Arabic words is strongly depend on selective attention.

## 5. Conclusion

The current study investigated the Combined effects of selective attention and repetition on the early repetition effects of the Word Processing (N250r). Results showed that N250r for word processing is strongly depending on selective attention for word processing.

## Aknowledgment

This work is supported by Start-Up research grant SR151013 provided by Deanship of Academic Research "DSR" at King Fahd University for petroleum and minerals "KFUPM"

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