Does Emotional Context Affect Subliminal and Supraliminal Priming?

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Objective: Emotions are complex psychophysiological changes experienced during the interactions of internal and external processes. The stimuli that have emotional value have processing efficiency both in encoding and retrieval processes with respect to the neutral stimuli. Processing advantage is present also for implicit memory. Priming effect does not require conscious recollection and leads to changes in responding due to previous exposure to the stimulus. In this study, it was aimed to investigate the effect of presentation type and different emotional contexts on the priming.

Method: Sixty-volunteered-university-students were (Female: n=40, Mean age =19.03±1.23; Male: n=20, Mean age =19.70±1.92) randomly assigned to the experimental conditions. Presentation type (Subliminal and Supraliminal) was between subject and Emotional Context (pleasant, neutral, and unpleasant pictures) was within subject independent variables. Dependent variables were Word Stem Completion score and completion latencies.

Results: Unpleasant emotional context had more capacity to create priming effect than the other emotional contexts. Both Subliminal and Supraliminal conditions favored the priming. Controversially to the transfer appropriate processing approach, the priming effect that was produced by supraliminal condition significantly higher than the priming created by the subliminal condition.

Conclusions: Unpleasant picture context produced more priming due to reason that evolutionarily important, i.e. thread-related, stimuli have processing priority and they capture the attention, utilize other cognitive resources easily. Even in priming, that is a phenomenon based heavily on data driven processes, concept driven processes are also effectual as indicated by levels-of-processing approach.

Keywords: Emotions, memory, repetition priming, subliminal stimulation

INTRODUCTION

Emotions are complex psychophysiological experiences that occur when an individual's mind is affected by internal (biochemical) and external (environmental) processes. In data processing stimuli that have emotional value, those that influence attention and memory, and those that cause emotional information are better coded and more frequently remembered than neutral stimuli (Bradley et al. 2003). This is called memory enhancement (Baran et al. 2014, Kensinger et al. 2002).

Memory enhancement is valid both in explicit and implicit memories. In the levels-of-processing approach, level of encoding (shallow, medium, or deep) influences explicit memory performance (Craik and Tulving 1975). According to this approach, data that is processed with respect to its physical (shallow) properties is forgotten more easily than data that is processed with respect to its semantic (deep) properties. On the other hand, according to the transfer appropriate processing approach, proposing that remembering will boost when the similarities between encoding and retrieving processes increase, priming is the basis of implicit memory (Blaxton 1989).

The priming effect, a phenomenon that does not necessitate conscious awareness, is defined as facilitation in the processing of a stimulus in response to previous exposure to the same

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or related stimulus before. This might occur as bedevilment during negative priming (Tulving and Schacter 1990, Voss et al. 2010). The stimulus that is presented to create priming effect is called "prime"; the stimulus on which priming effect is observed is called "target stimulus". The existence of priming effect is evaluated through responses given to the target stimulus; it is expected that the effects of priming on target is temporary (Janiszewski and Wyer 2014). A typical priming experiment consists of two stages: study and test. In the study stage, presentations of stimuli are done in various forms and in the test stage stimuli are usually tested by an implicit memory task consisting of uncompleted word or figure fragments (Tulving and Schacter 1990).

The priming effect suggests that stimuli are processed on the basis of their perceptual properties. In other words, stimuli processing relies on a perceptual representation system. More recent studies show that semantic priming also exists alongside perceptual priming (Taylor et al. 2012).

Perceptual priming is revealed through implicit memory tasks such as word identification, word stem completion and word fragment completion. During perceptual identification, stimulus words are presented to the participant very quickly, subliminally, with using tools such as a tachistoscope. Priming is defined as the increment in the number of correctly recognized words presented previously or decrement in the reaction time for identifying the previously experienced stimulus (Feustel et al. 1983). In word completion tasks, the participant is shown stems or fragments of words and asked to complete these with the first word that come to his or her mind (Akdemir et al. 2007, Kaynak and Cangöz 2010, Tulving et al. 1982). Here, priming effect is regarded as the participant's completion frequency of word stems or fragments with previously seen target words.

In comparison to neutral stimuli, negative stimuli cause more priming (i.e., emotional priming). This finding is valid even for patients with early stage Alzheimer Type Dementia (ATD) (LaBar et al. 2005). Höschel and Irle (2001) demonstrated the superiority of negative emotional priming over positive and neutral priming in both healthy and schizophrenic patients. In a study on emotional words, Giffard et al. (2009) showed that negative stimuli cause an increase in emotional priming in ATD patients. There are also some studies indicating that positive stimuli increase the emotional priming (Lamy et al. 2008, Luo et al. 2004). However, in a recent study Yang et al. (2012) used emotional faces in an emotional priming task and found that negative stimuli, independently from being supraliminally or subliminally presented, created a greater priming effect.

Cross-modal priming effect is defined as the priming effect of a stimulus (prime) in one sensory modality (e.g. auditory) on a stimulus (target) in another sensory modality (e.g. visual). Scherer and Larsen (2011) discovered that negative auditory primes increased the possibility of misclassification of the pleasantness or unpleasantness of a following positive target (i.e. incorrect classification of a positive word as negative when the prime was negative). Pecchinenda et al. (2006) demonstrated that emotionally balanced words increase the priming effect in healthy young adults.

Michael and Ehlers (2007) claimed that in post-traumatic stress disorder, experiences that belong to the traumatic moment make mind constantly busy and this might stem from the perceptual priming effect. In doing so, they showed that neutral pictures, which were presented before the negative context caused more priming effect than neutral pictures that were shown before the neutral context. This result draws attention to the importance of the survival property of the context, including danger. On the other hand, the same researchers suggest that the context of trauma, and the stimuli creating the trauma, are attributed to perceptual properties more than semantic ones. From this point of view, the priming effect is claimed to be stronger in perceptual priming tasks.

The aim of this research is to investigate the effect of the emotional context (pleasant, neutral and unpleasant) on priming effect (Word Stem Completion Task: WSCT score and WSCT reaction time) on the subliminal and supraliminal presentation levels. The hypotheses of the research are based on research findings of Michael and Ehlers (2007): (1) In accordance with Cross-modal priming effect, neutral words, which are presented subliminally and supraliminally in the emotional context (pleasant and unpleasant), are completed more and in a shorter time than neutral words that are presented subliminally and supraliminally in the neutral context. (2) The emotional priming effect of subliminal presented stimuli will be greater than supraliminal presented stimuli.

METHOD

Participants

Participants of the study included 60 volunteer university students (40 females and 20 males) between ages of 18 and 25 who study in different departments of Hacettepe University. Participants were randomly assigned to subliminal (SUBP, 22 females 8 males) or supraliminal (SUPP, 18 females, 12 males) conditions such that each condition had 30 individuals. There was no significant difference between participants in the two groups in terms of their mean age (SUBP: $\bar{X}$ = 19.37±1.81 and SUPP: $\bar{X}$ = 19.13±1.16), education year (SUBP: $\bar{X}$ = 12.37±1.81 and SUPP: $\bar{X}$ = 12.13±1.17), and level of depression (SUBP: $\bar{X}$ = 8.30±5.30 and SUPP: $\bar{X}$ = 7.20±5.80).

Individuals who obtained less than 17 points on the Beck Depression Scale (BDS) (Beck et al. 1961), individuals who

reported psychiatric or neurological sickness, and individuals who used drug(s) affecting cognitive skills were excluded from the research sample. Memory disorder, which is observed in depression, is actually a secondary memory problem caused by attention. This might influence memory performance independently from the analyzed variable. Therefore, BDS was utilized and participants that did not indicate depressive symptoms were selected. All participants provided informed consent. The data acquired from four participants, who reported that they had noticed the words during the study stage and completed missing words to reach these particular words in the test stage were excluded from the research.

MATERIALS and METHODS

Picture set that was used as a context: The pictures were selected from International Affective Picture Set (IAPS) (Lang et al. 2008). Accordingly, each emotional valence category (pleasant, neutral and unpleasant) consists of 8 pictures. In addition, one training picture was chosen and the number of pictures used in the set reached 25 in order to create emotional context. The number of IAPS pictures, average emotional value and average general arousal levels are presented in Table 1.

The difference between the emotional valence group averages (pleasant, neutral and unpleasant) is significant ($F_{(2, 14)}$ = 72.29, p < .001, η^2_p = 0.91). All of *post-hoc* paired comparisons concerning the three emotional categories are statistically significant (Bonferroni correction, pleasant>neutral, p = .001; pleasant>unpleasant, p < .001; neutral>unpleasant, p < .001). Additionally, the difference between general arousal level averages is also significant ($F_{(2, 14)}$ = 9.32, p = .003, η^2_p = 0.57). In *post-hoc* paired comparisons of general arousal averages of three groups, general arousal levels in the neutral group are different from the average of other two groups (Bonferroni correction, neutral<pleasant, p = .049; neutral<unpleasant, p < .001). There is no difference between general arousal levels of the pleasant and unpleasant picture groups.

Word Set: The study employed a 50-word set (list of studied words = 24 words and 1 training word; list of not studied words = 24 words and 1 training word) consisting of concrete and neutral words that are frequently used in Turkish (Tekcan and Göz 2005). Words were presented in "*Arial*" 52-point font size with white color on black background. Neutral words were presented in the context of three different emotional pictures with equal number of letters $F_{(2, 21)}$ = 0.46, p = .64, η^2_p = 0.04) and syllables ($F_{(2, 21)}$ = 1.82, p = .19, η^2_p = 0.15) (Table 2).

Word Stem Completion Task (WSCT): WSCT, which is an implicit memory task, was used in order to assess priming effect. Half of the words in WSCT were studied (S+) and the other half was not studied (S-). WSCT consisted of 50 words. Two of the words were training words (1 of 25 words from S+ list

Table 1. IAPS Numbers of the Pictures Used as Emotional Context, Means of Emotional Valence and General Arousal Level in American Culture

PLEASANT			NEUTRAL			UNPLEASANT		
*Pic. No	*E.V.	*G.A.	Pic. No	E.V.	G.A.	Pic. No	E.V.	G.A.
2000	6.51	3.32	2880	5.18	2.96	2301	2.78	4.57
2030	6.71	4.54	5471	5.21	3.26	2375.1	2.20	4.88
2302	6.43	3.64	7001	5.32	3.20	2399	3.69	3.93
2511	6.21	3.41	7058	5.29	3.98	2458	4.69	5.28
8001	6.50	5.60	7160	5.02	3.07	2710	2.52	5.46
8179	6.48	6.99	7182	5.16	4.02	3301	1.80	5.21
8200	7.54	6.35	7184	4.84	3.66	9041	2.98	4.64
8503	7.02	5.22	7186	4.63	3.60	9332	2.25	5.34
M±Std.	6.68±0.42	4.88±1.39	M±Std.	5.08±0.24	3.47±0.41	M±Std	2.86±0.93	4.91±0.52

*Abbreviations, Picture No: Pic. No; Emotional Valence: E.V.; General Arousal: G.A.

Table 2. Number of Letters and Syllables in the Words (Neutral) Presented in Three Different Emotional Contexts

PLEASANT Picture Context			NEUTRAL Picture Context			UNPLEASANT Picture Context		
Word	# of Letters	# of Syllables	Word	# of Letters	# of Syllables	Word	# of Letters	# of Syllables
KABLO	5	2	KARINCA	7	3	KAMYON	6	2
PARKE	5	2	TABANCA	7	3	KELEBEK	7	3
SANDIK	6	2	KAYISI	6	3	KAPI	4	2
PATEN	5	2	BORU	4	2	TAKSİ	5	2
MASA	4	2	BACAK	5	2	MEKTUP	6	2
MİNDER	6	2	BALKON	6	2	GAZETE	6	3
HAVUZ	5	2	TAHTA	5	2	PALTO	5	2
HEYKEL	6	2	ANTEN	5	2	FİNCAN	6	2
Mean	5.25	2.00	Mean	5.63	2.38	Mean	5.63	2.25
S.Deviation	0.71	0.00	S.Deviation	1.06	0.52	S.Deviation	0.92	0.46

and 1 of 25 words from S- list); so WSCT was implemented on 24 words in each list (in total 48 words). In Turkish there are at least three words starting with the first three letters of these words. In WSCT, S+ and S- words were arranged in random order.

In order to verify the existence of priming effect in implicit memory (WSCT) independent from experimental manipulation, words on the S+ list were mixed with words on the S- list in the test stage. The two lists were compared in terms of number of correct completions. Priming effect was determined by a significant difference in correct completions of the two word sets (S+>S-).

Procedure

Participants were individually tested in a normally illuminated and silent room. A 15" laptop computer was used for all experimental practices. Participants sat 60 cm away from the computer screen. For all participants, there were practice sessions before the experimental session.

During SUPP testing, stimulus pairs (the neutral target word and the picture providing emotional context) were presented for 8 seconds on the screen. Participants were asked to read out the seen word on the screen and then to look at the picture shown on the screen. In the next stage, participants were presented with a 9-Point Likert Scale, and asked to evaluate the word's emotional valence and then the picture's valence. The participant completed the WSCT task at the end of the session.

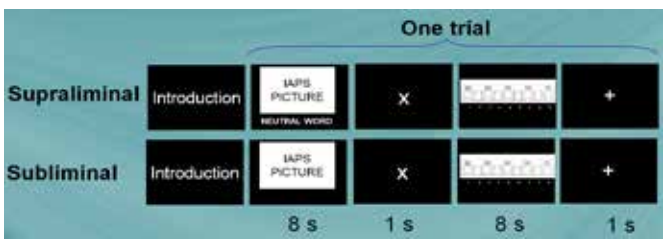

Figure 1. Application of Supraliminal and Subliminal experimental conditions. Each condition was manipulated according to between-subject design. At the end of each condition, word stem completion test was applied.

During SUBP condition, the picture was presented for 8 seconds. One second after the appearance of the picture on the screen, the word stimulus was presented for a duration of approximately 17 milliseconds. In the next stage, a 9-Point Likert Scale appeared and participants were asked to evaluate "only" the emotional valence of the picture. The participant completed the WSCT task at the end of the session.

The 9-Point Likert Scale, which was employed in both conditions, was previously used in a study by Lang et al. (2008) in order to evaluate emotional valence dimension. The values and their meanings on the scale are as the following: Values near to 1 refers to unpleasant, near to 5 refers to neutral, and near to 9 refers to pleasant categories. A schematic display of the procedure is shown in Figure 1.

In both SUBP and SUPP testing conditions, 24 words alongside 24 pictures (8 positive, 8 negative and 8 neutral) were presented. These 24 pairs belonged to the studied list in WSCT. WSCT was implemented as a paper and pencil test. The participant completed the missing word and the experimenter measured completion time by simultaneously clicking left button of the mouse and recording the time for each word after the word completed.

In order to demonstrate the existence of priming effect experimentally, it is expected that in WSCT the number of completed words from the studied list (S+) should be significantly greater than the number of completed words from non-studied list (S-) due to implicit memory. Additionally, the average completion time is expected to be significantly shorter for S+ list than S- list (see Table 3). WSCT consists of both the S+ and the S- wods together in a random order. ANOVA results are provided only for correctly completed S+ words and their reaction times.

RESULTS

The *t*-test results for SUBP and SUPP conditions are shown on Table 3. In both experimental conditions, the number of words that were completed correctly in S+ list was more than in S- list, and completion time in S+ list was shorter. These

Table 3. Means, Standard Deviations and t-test Results of Number of Correctly Completed Words and Reaction Times in Word Stem Completion Task for each Conditions

Presentation Type (N=60)	List Type	Number of Correctly Completed Words	p	Reaction Time of Correctly Completed Words (ms)	p (Reaction Time)
SUBP	S+	8.17 (2.05)	p=.033	2645.98 (828.70)	p=.031
	S-	7.23 (2.16)		2835.92 (864.38)	
SUPP	S+	14.37 (3.00)	p=.004	2502.95 (370.69)	p<.001
	S-	10.87 (2.86)		2839.45 (678.18)	

SUBP: Subliminal Presentation; SUPP: Supraliminal Presentation; S+: Studied list; S-: Non-studied list

findings indicate that priming effect occurred experimentally in both conditions.

The pictures used in both groups (SUBP and SUPP) were selected from IAPS according to their average emotional valence values. They represented three different categories (Emotional Valence of the Picture: Pleasant, Neutral and Unpleasant). Participants were asked to evaluate pleasantness and unpleasantness of the stimuli in order to encode picture and word pairs. For this reason, evaluation results of 9-Point Likert Scale for pictures and words were used as dependent measurements. To verify that the pictures used as background in the SUBP and the SUPP conditions were evaluated as similarly, a 2 (Presentation Level: SUBP and SUPP; between subject independent variable) x 3 (Emotional Valence of the Picture: Pleasant, Neutral and Unpleasant; within subject independent variable) mixed ANOVA was conducted. The main effect of Emotional Valence of the Picture was found to be significant ($F_{(2, 116)} = 746.89$, $p = .000$, $\eta^2_p = 0.93$). *Post hoc* comparisons indicated that the difference between the average of pleasant pictures ($\bar{X} = 7.02$, SE = 0.11) and the average of neutral pictures ($\bar{X} = 5.24$, SE = 0.07) was significant (p=.000). Additionally, the difference between the average of pleasant pictures and the average of unpleasant pictures ($\bar{X}$= 2.13, SE = 0.90) was significant (p = .000) and the difference between the average of neutral pictures and the average of unpleasant was also significant (p=.000).

The main effect of Presentation Level and the interaction effect of Presentation Level by Emotional Valence of the Picture were not significant. This non-significant interaction result showed that there was no difference between the valence evaluation scores of pictures under the SUBP and the SUPP conditions.

Table 4 presents the mean number of correctly completed words and completion durations (standard deviation in parenthesis) with respect to the experimental conditions. To test the hypotheses of the study, a 2 (Presentation Level: SUBP and SUPP) x 3 (Emotional Context: Pleasant, Neutral, and Unpleasant) mixed ANOVA was conducted on the number of correctly completed words. The main effects of Presentation Level ($F_{(1, 58)} = 87.29$, $p < .001$, $\eta^2_p = 0.60$) and Emotional Context ($F_{(2, 116)} = 31.40$, $p < .001$, $\eta^2_p = 0.35$) were statistically significant.

Table 4. Means and Standard Deviations of Completed Words and Reaction Times (ms) in the Word Stem Completion Task in SUBP and SUPP Conditions with Respect to the Emotional Contexts

Presentation Type	Emotional Valence of the Pictures		
(N=60)	Pleasant	Neutral	Unpleasant
SUBP	1.77 (0.22)	2.8 (0.23)	3.6 (0.3)
	2751.74 (747.57)	2704.04 (890.65)	2825.99 (806.40)
SUPP	3.77 (0.22)	4.9 (0.23)	5.7 (0.3)
	2353.59 (547.07)	2584.90 (475.44)	2482.70 (469.46)

SUBP: Subliminal Presentation; SUPP: Supraliminal Presentation

According to *post hoc* analyses, the number of correctly completed words was greater in the SUPP condition than in the SUBP condition ($\bar{X}_{SUPP} > \bar{X}_{SUBP}$, p<.001). The words presented under the unpleasant picture context were completed more than the words presented under the pleasant or neutral picture contexts (Unpleasant>Pleasant, $p < .001$ and Unpleasant>Neutral, $p < .01$). On the contrary, words presented under the pleasant picture context were completed less than under the neutral picture context (Neutral > Pleasant, $p < .001$).

The same 2 x 3 mixed ANOVA design as above was conducted for completion durations. Only the Presentation Level main effect was found to be significant ($F_{(1, 58)} = 4.43$, $p = .040$, $\eta^2_p = 0.07$). Words were completed faster under the SUPP condition than the SUBP condition ($\bar{X}_{SUPP} < \bar{X}_{SUBP}$, $p = .04$).

DISCUSSION

Discussion concerning Hypothesis 1: Regardless of subliminal or supraliminal presentation, more words were completed in the context of unpleasant pictures than pleasant or neutral pictures. The emotional priming effect was observed in both groups. Our study indicated an increased priming effect in the context of unpleasant pictures. This finding coincides with both the Yang's (2011 and Kempwheeler and Hill's findings (1992), which both suggested that negative stimuli result in a greater priming effect. This finding may be due to evolutionary characteristics of unpleasant stimuli. Unpleasant stimuli, particiularly dangerous stimuli, are identified and evaluated quickly, attracting more attention and increasing level of arousal. The results of our study support Scherer and Larsen's (2011) findings indicating that negative auditory cues are evaluated negatively and independently from the emotional value of the word. Scherer and Larsen (2011) indicated that in addition to emotional valence of words, general arousal level also impacts the priming effect. They emphasized that in comparison to positive words, negative words have a higher general arousal level. Similarly, our study identified that general arousal level of contextual pictures are different (see Table 1). However, we observed a difference between average arousal level of the neutral picture and average arousal level of both emotional categories (neutral<pleasant, p=.049 and neutral<unpleasant, p<.001). There was no significant arousal level difference between the pleasant and unpleasant picture categories. Therefore, the greater priming effect of unpleasant pictures is not only due to general arousal level. This

finding is an original contribution of the study to the related literature.

The height of arousal level of unpleasant pictures, although not significantly different from that of pleasant pictures, might have caused improved word encoding in both SUBP and SUPP conditions. This may have resulted in improved recall compared to positive pictures. One study which investigated latency of detection of spatial position of a dot after viewing emotional pictures found out that the detection time of dot position after the positive and the negative pictures were shorter than that of neutral picture (MacLeod et al. 1986). This result supports our findings only for negative picture context.

In previous literature, there is no evidence for an impact of emotional context on WSCT duration. Nonetheless, our averages show that the slowest reaction time was obtained from words that were presented in the context of unpleasant pictures whereas the quickest reaction times was obtained from words that were presented in the context of pleasant picture. It is expected that reaction times with unpleasant pictures are shorter for evolutionary reasons. This result, which is incompatible with the literature, might stem from the use of methodologically different tasks (cross-modality priming effect). On the other hand, the processing priority of negative stimuli in the perceptual system may be related to filtering of potentially threatening incoming sensory information. An automatic vigilance mechanism may cause to some interruptions in the flow of information, and that in turn may increase reaction times to negative stimuli (Algom et al. 2004, Wentura et al. 2000).

Discussion concerning Hypothesis 2: The study demonstrated that priming effect occurs more often in the SUPP condition than in the SUBP condition. In WSCT, which is a perceptual priming task, data driven processing is essential. WSCT performance is affected by perceptual (physical) properties of stimulus. Success in this task increases as long as the similarities between task demands during the priming and the test stages are high according to the transfer appropriate processing approach (Roediger and Blaxton 1987). If the WSCT has both perceptual and conceptual dimensions, then the transfer appropriate processing approach can be applied. This approach should be more effective in for SUBP than SUPP messages. In contrast to this expectation, the priming effect is higher under the SUPP than the SUBP condition. This can be explained with the help of *logogen* (units that are related to some properties of words such as sounds, visual appearance and meaning; and they have thresholds to be activated)(Morton 1979) and the associated concept of spreading activation approach. Connections between *logogen*s are concerned with visual, phonetic and semantic similarities. If one of the *logogen*s, whose meanings are similar, is active, the possibility of getting activated of the others (i.e. others that are semantically or physically associated/similar to the already activated one) increases, also.

Similarly, the "Spreading Activation" approach suggests the existence of a threshold value to activate related concepts (Collins and Loftus 1975). In WSCT during the priming stage, *logogen*s representing the presented words lead to activation. Thereby, these words are easily and rapidly selected during the test stage. Therefore, as longer and deeper processing occurs during priming in SUPP, it leads to a stronger activation than in SUBP. As a result, strongly activated words are completed more often and more quickly in the SUPP condition than in the SUBP condition in WSCT.

The completion differences between presentation levels in WSCT are associated with a disputable issue in the literature. Some researchers (Challis and Brodbeck 1992) take the "Levels of Processing" approach (Craik and Lockhart 1972), which claims that perceptual priming tasks (such as WSCT) can have not only perceptual but also conceptual components with respect to the encoding level (shallow to deeper, or shallow/physical, moderate/auditory, deeper/semantic). Accordingly, evaluation of stimulus during the priming stage might cause a deeper/semantic priming effect on WSCT during the test stage (Bowers and Schacter 1990). Furthermore, Weldon's (1991) research shows that in comparison with perceptual identification tasks, WSCTs have more conceptual components (concept oriented data processing). In addition, relatively longer exposure to the stimuli in SUPP conditions (i.e. the words presented for 8 seconds in SUPP and for 17 milliseconds in SUBP), as shown by Weldon (1993) in word fragment completion tasks, creates access not only to perceptual properties of the stimulus but also to conceptual properties such as meaning and context as well. Accessing both perceptual and conceptual processing levels depends on long exposure to the stimuli, as in this study. This may lead to the completion of more words in the SUPP condition than in the SUBP condition where only the perceptual properties of the stimuli are available (Mandler et al. 1990). Indeed, in the SUPP words are more deeply processed than in SUBP through evaluation of their emotional valences.

Therefore, research findings of this study are also important because they demonstrate "Levels of Processing" approach, which is suggested by Craik and Lockhart (1972) for measurements of explicit memory, and is also valid for measurements of implicit memory. As a matter of fact, according to Terry (2008) "*Data processing levels are actually not an independent theory; rather it should be considered as an approach that can be adapted to all theories of memory"* (p. 208).

Recent studies that are different from traditional priming paradigms (unimodal) show that a priming effect occurs also through cross-modal method (Carroll and Young 2005, Li et al. 2007). This study preferred the cross-modal method.

Therefore, the process of word completion in the WSCT task is influenced by both subliminally and supraliminally presented words (unimodal) and by emotional valences of the pictures (multimodal or cross modal). For this reason, current research findings are not expected to be compatible with the research findings that are obtained through the traditional paradigm.

Conclusion and Limitations of the Study

In summary, while the three different types of emotional pictures affected the number of correctly completed words in WSCT, they did not have an impact on completion time. On the other hand, SUBP and SUPP conditions affected both measurements. In WSCT, the highest numbers of completed words were obtained in the context of unpleasant pictures in the SUPP condition; the fastest reaction times, independently from the emotional context, were again acquired during the SUPP condition. The fashion in which reaction times were measured was a limitation of the study. The reaction times were not the direct response of participants by themselves, but instead a result of the experimenter pressing a button when the participant completed the word.

Emotional stimuli, particularly the emotional load of the stimuli, increased the priming effect. Particularly, negative stimuli were more effective at the priming effect than positive or neutral stimuli. Increased priming effect by the negative stimuli can be explained by brain structure. There are specialized structures in the brain that process threat related stimuli, even subconsciously. Areas such as the amygdala and sub-cortical neural circuits such as the thalamus-superior colliculus-pulvinar might be responsible for involuntary and automatic, rapid reactions (Liddell et al. 2005, Sweeny et al. 2009, Tamietto et al. 2012).

Small sample size is a limitation of this study. Another technical limitation is the inability to reduce stimulus' duration on screen below 16.67 milliseconds. In further studies, it would be beneficial to use special devices to decrease the presentation time in the subliminal presentation condition.

In both depression and anxiety, it is known that the negative stimuli may cause better remembrance in explicit and implicit memory (Harrison and Turpin 2003, Liu et al. 2012, Wittekind et al. 2015). In this study participant depression was determined with using the Back Depression Scale. Thus, healthy individuals with symptoms of depression were not selected for participation. Nevertheless, intensity of depression and anxiety was not controlled for, leading to another limitation of the study.

Author's note: This study was derived from the first author's doctoral thesis on Experimental Psychology.

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