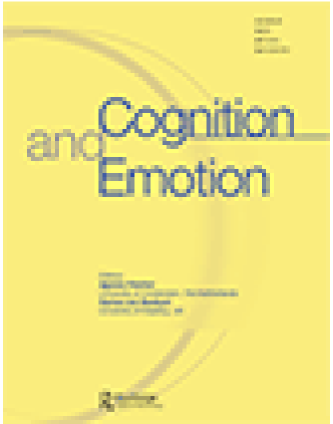

Cognition and Emotion
Publication details, including instructions for authors and subscription information:
http://www.tandfonline.com/loi/pcem20

Processing negative valence of word pairs that include a positive word

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Published online: 26 May 2015.

To cite this article: Oksana Itkes & Nira Mashal (2015): Processing negative valence of word pairs that include a positive word, Cognition and Emotion, DOI: 10.1080/02699931.2015.1039934

To link to this article: http://dx.doi.org/10.1080/02699931.2015.1039934

COGNITION AND EMOTION, 2015
http://dx.doi.org/10.1080/02699931.2015.1039934

BRIEF REPORT

Processing negative valence of word pairs that include a positive word

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(*Received 31 January 2015; accepted 7 April 2015*)

Previous research has suggested that cognitive performance is interrupted by negative relative to neutral or positive stimuli. We examined whether negative valence affects performance at the word or phrase level. Participants performed a semantic decision task on word pairs that included either a negative or a positive target word. In Experiment 1, the valence of the target word was congruent with the overall valence conveyed by the word pair (e.g., fat kid). As expected, response times were slower in the negative condition relative to the positive condition. Experiment 2 included target words that were incongruent with the overall valence of the word pair (e.g., fat salary). Response times were longer for word pairs whose overall valence was negative relative to positive, even though these word pairs included a positive word. Our findings support the Cognitive Primacy Hypothesis, according to which emotional valence is extracted after conceptual processing is complete.

Keywords: Valence; Automatic vigilance; Affective primacy; Cognitive primacy; Word pair processing.

Stimuli with negative valence are thought to capture attention automatically, ensuring fast detection and processing of potentially dangerous information (e.g., Hansen & Hansen, 1988; LeDoux, 1996; Mogg & Bradley, 1999). The effects of negative valence on behaviour have been studied extensively (Wentura, Rothermund, & Bak, 2000), and one of the most documented phenomena is the disruption of performance on tasks that include negative words (Williams, Mathews, & MacLeod, 1996). However, little is known about the exact stage of semantic processing in which negative valence exerts its impact on performance. In the current study, we examine the temporal order of affective and semantic processing within word pairs.

The emotional Stroop task has been used to examine the impact of negative valence on

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performance (Williams et al., 1996). On this task participants are required to name the colour in which words are printed while ignoring their semantic content. Words usually convey negative (e.g., *death*) or neutral (e.g., *table*) valence, and findings suggest that responses to negative words are slower than are responses to neutral words. According to Algom, Chajut, and Lev (2004), performance on this task reflects a generic and automatic slowdown caused by threatening information. Algom et al. (2004) reported that participants were slower to name the colours in which emotionally negative words were printed, slower to name negative words regardless of their colour, and slower to perform a lexical decision task that included words with negative valence relative to neutral words. The slowdown in response to stimuli with negative valence has been observed relative to positive stimuli as well. For instance, using the divided visual field technique, Mashal and Itkes (2014) found slower and less accurate responses to word pairs with negative valence (e.g., *dangerous building*) than to word pairs with positive valence (e.g., *fun day*). In this study each word pair included either a negative or a positive word that was presented to either the left or the right visual field. Slower response times to negative versus positive stimuli were obtained regardless of visual field presentation.

According to the Automatic Vigilance Hypothesis, environmental stimuli are automatically evaluated as either negative or positive (Klauer & Musch, 2003). Emotional evaluation occurs in a fast and automatic fashion (Lazarus, 1982; Zajonc, 1980) in order to enable either avoidance or approach behaviour (Lavender & Hommel, 2007). Studies that focused on both behaviour and brain activity demonstrated that negative information is given priority over neutral and even positive information (e.g., Mogg & Bradley, 1999; Phan, Fitzgerald, Nathan, & Tancer, 2006). This prioritisation prepares the cognitive system for a potential threat, often at the expense of current information processing (Öhman, 2007).

Thus, researchers agree that valence is processed early. Yet, there has been much discussion of the order of processing of affective versus semantic information (see Storbeck & Clore, 2007, for a review). The question is whether a person who faces the word *snake* processes its affective content (threatening) prior to its non-affective content (a reptile, something that crawls on the ground). The Affective Primacy Hypothesis argues that affective content is activated first (LeDoux, 1996; Zajonc, 1980), whereas the Cognitive Primacy Hypothesis argues that retrieval of semantic content precedes affective activation (Lazarus, 1984). Nummenmaa, Hyönä, and Calvo (2010) compared the speed of affective and semantic judgements in response to complex scenes. Participants were briefly flashed with two pictures, simultaneously, and asked to make either an affective (negative vs. positive) or a semantic judgement (animal vs. human, snake vs. tiger). The pictures displayed animals and humans with positive, negative or neutral valence. The results showed that semantic processing was faster than was affective categorisation, suggesting that semantic categorisation can occur prior to emotional evaluation. We note, though, that most studies examined the effects of negative valence on performance using picture stimuli or single words.

Word pair stimuli can provide a way to compare the predictions of the Affective and the Cognitive Primacy Hypotheses because they allow direct manipulation of the valence of the context in which an emotional word appears. According to most theories of language comprehension, understanding sentences is hierarchical, proceeding from individual words to phrase and sentence meaning (e.g., Vosse & Kempen, 2000). Thus, when readers are presented with a word pair (e.g., *love triangle*), they first process the semantic meaning of each individual word and only then compute the meaning of the phrase by combining the meaning of its components. However, the emotional valence of individual words can be incongruent with the emotional valence of the phrase. Thus, while the word *blood* conveys negative valence, the phrase *blood relation* conveys positive valence. A large body of evidence suggests that semantic incongruence slows performance relative to congruent contexts (e.g., Kutas & Federmeier, 2000), but not much is known about the effects of emotionally incongruent words on phrase processing. In the current study, we use word pairs that are either congruent or incongruent with the emotional valence of their constituents in an attempt to identify the stage at which valence is processed.

Two experiments were conducted. First we wanted to document slowdown following the detection of negative valence in emotionally congruent word pairs, and then we looked for patterns of response to incongruent pairs. Experiment 1 included word pairs whose emotional valence was congruent with the valence of their constituents, which could be either negative or positive. For example, the negative word pair *blood stain* included the negative word *blood.* Participants were asked to decide as fast as possible whether the two words formed a meaningful expression. We expected that decision times would be longer for negative than for positive word pairs.

In Experiment 2, the overall meaning of the word pair was incongruent in valence with the valence of the individual words. For instance, the negative word pair *love triangle* included the positive word *love.* We hypothesised that if word level processing affected response times, responses should be slower when the word was negative, regardless of the overall meaning of the expression. Alternatively, if message level processing affected response times, then responses should be slower when the pair conveyed a negative meaning, regardless of the meaning of its constituents. Slow responses to stimuli that include a negative word but convey an overall positive meaning will fit the Affective Primacy Hypothesis, suggesting that processing of emotional valence precedes semantic processing. Slow responses to negative word pairs that include a positive word will support the Cognitive Primacy Hypothesis, suggesting that emotional valence is extracted after conceptual processing.

EXPERIMENT 1

Participants

For the two studies reported in this manuscript, we determined our sample size by aiming for 35–40 participants for each study. Forty participants between age 18 and age 35 (M = 25.74, SD = 3.92), 23 of them women, took part in this study. Participants were undergraduate students at Bar Ilan University who received credit for their participation. They were native Hebrew speakers, right-handed according to self-report, and had normal or corrected to normal vision.

Stimuli

Thirty-two word pairs were selected in two experimental conditions, such that the first word (the head noun) was not negative and the second word (the modifier) was either negative or positive. The valence of the second word was congruent with the overall meaning of the pair. Note that in Hebrew the head noun appears before the modifier so that the target word that conveyed emotional valence always appeared second. For example, the negative word *shamen* (e.g., fat) appeared in the negative pair *yeled shamen* (e.g., fat kid), and the positive word *emet* (e.g., truth) appeared in the positive pair *dover emet* (e.g., truth speaker). Fillers were unrelated word pairs that included either a negative or a positive second word.

Three pre-tests were performed in order to assess the valence of the words, the valence of the pairs and the familiarity of the pairs.

Thirty volunteers (age range 18–35, M = 27.62, SD = 4.28) were asked to judge the valence of all words on a 7-point scale ranging from 1 (highly negative) to 7 (highly positive). A score of 4 served as the cut-off point, and words with an average score below 4 were considered to convey negative valence while words with an average score above 4 were considered to convey positive valence.

The mean score of negative target words was 2.42 (SD = .44), the mean score of positive target words was 5.62 (SD = .51), and the difference between these stimuli was statistically significant, $t(30) = -19.03$, $p < .001$. In addition, the mean rating of negative words that appeared within the filler word pairs (M = 1.68, SD = .71) was significantly different from the mean rating of positive words that appeared within filler word pairs (M = 6.00, SD = .61), $t(30) = 18.43$, $p <$ .001. Only words that received a mean rating score above 4 were selected as the first word of a pair (e.g., the head noun), with a mean rating of 4.49 across conditions (SD = .37).

In the second pre-test, 18 additional volunteers (age range 20–35, M = 25.31, SD = 5.09) were asked to rate the valence of the 32 experimental word pairs on a 7-point scale ranging from 1 (highly negative) to 7 (highly positive). Word pairs that included a negative word received a mean rating of 3.10 (SD = .33), word pairs that included a positive word received a mean rating of 5.83 (SD = .46) and ratings of word pairs in the two conditions were significantly different, $t(30)$ = 19.45, $p <$ .001.

The same 18 participants who participated in the second pre-test were also asked to judge their familiarity with each word pair on a 7-point scale ranging from 1 (completely unfamiliar) to 7 (highly familiar). The mean familiarity rating of the negative word pairs (M = 6.03, SD = .94) did not differ significantly from the mean familiarity rating of the positive word pairs (M = 5.75, SD = .88), $t(30)$ = .88, ns.

Length of target words varied between 2 and 6 letters (negative: M = 3.81, SD = 1.28, positive: M = 4.06, SD = 1.29) as well as word frequency based on Linzen (2009; negative: M = 42.69, SD = 91.26, positive: M = 73.13, SD = 146.81) were matched across the two experimental conditions.

Procedure

Each participant was tested alone in a quiet room. Every trial began with a fixation cross that appeared for 2500 ms at the centre of the screen. The first word of each pair (e.g., the head noun) appeared next and remained on the screen for 250 ms, then another fixation cross appeared on the screen and remained for 200 ms. Finally, the target word appeared for 300 ms. The next trial began after 2000 ms. The session included six practice trials. The instructions were:

> Following the fixation cross, a word will appear at the center of the screen for a short period of time. After this word disappears, another word will appear at the same location. Your task is to decide as quickly and as accurately as possible, without moving your eyes, whether the two words together form a meaningful word pair or have no meaning. If the words form a meaningful phrase, press the green key (N) and if they do not form a meaningful phrase press the red key (B). The task will start with a few practice trials after which the experiment will begin.

Half of the participants pressed the N key to indicate that the word pair was meaningful and half of the participants pressed the B key to indicate that the word pair was meaningful.

RESULTS

Prior to the analysis, we excluded reaction times that exceeded 2.5 standard deviations of the participant's mean in each condition. Overall, 2.5% of trials were excluded. Only correct trials were analysed. Table 1 presents reaction time and accuracy data in each condition.

Response times to related word pairs (M = 866.46, SD = 121.41) were significantly faster than were responses to unrelated word pairs (M = 955.72, SD = 148.67), $t(39)$ = 4.36, $p <$ .0001, Cohen's d = .72. Accuracy was significantly higher for unrelated (M = .95, SD = .10) compared to related word pairs (M = .85, SD = .10), $t(39)$ = 7.35, $p <$ .0001, Cohen's d = 1.71. Further analyses of valence were conducted for meaningful word pairs alone as we had no specific hypotheses regarding the valence of unrelated word pairs.

A paired sample t-test that compared response times to negative and positive word pairs was significant, $t(39)$ = 2.15, $p <$ .05; Cohen's d = .26.

Table 1. *Mean RT and per cent of correct responses in Experiment 1*

Condition	*Mean RT*	SD	*Accuracy*	SD
Negative word pairs	882.25	125.34	86	.11
Positive word pairs	850.67	116.78	83	.08
Unrelated-negative	955.54	153.10	94	.09
Unrelated-positive	955.90	105.80	93	.11

As expected, response times to word pairs that included a negative word were significantly slower than were responses to word pairs that included a positive word.

An additional paired-samples *t*-test that compared the per cent of correct responses in each condition was also significant, $t(39) = 2.58$, $p < .05$, Cohen's $d = .19$, with more accurate responses to negative than to positive word pairs.

The correlations between reaction times and accuracy were all negative (*r*s ranging from −.001 to −.48, ns, $p < .05$, respectively), indicating no speed–accuracy trade-off.

EXPERIMENT 2

The results of Experiment 1 replicate the well-documented effect of slowdown in the presence of negative valence, showing that performance slows down when word pairs have a negative meaning. It is unclear, however, whether negative valence interrupts performance following the identification of an individual word or following the semantic computation of phrase meaning. Experiment 2 was designed to test this question, using stimuli in which the valence of the phrase is incongruent with the valence of one of its constituents.

Participants

Thirty-eight participants between age 20 and age 35 ($M = 26.5$, $SD = 3.42$), 20 of them women, took part in this study. One participant failed to complete the task and was therefore excluded from the analysis. Participants were undergraduate students at Bar Ilan University who received credit for their participation or volunteered to the study. They were native Hebrew speakers, right-handed according to self-report, and had normal or corrected to normal vision.

Stimuli

The same 32 target words that were used in Experiment 1 served as target words in the current experiment as well. As in Experiment 1, the first word (e.g., the head noun) was not negative and the second word (e.g., the target) was either negative or positive. However, unlike the stimuli in Experiment 1, the valence of the second word was incongruent with the overall valence of the pair. For example, the negative word *dam* (e.g., blood) appeared in a positive pair *kesher dam* (e.g., blood relation), and the positive word *ahava* (e.g., love) appeared in the negative pair *meshulash ahava* (e.g., love triangle). Due to the word order of Hebrew the target word that conveyed emotional valence always appeared second. We used the same fillers that were used in Experiment 1.

The same 30 volunteers who rated the valence of single words in the pre-test of Experiment 1 also rated the valence of the words that appeared first in each word pair in Experiment 2. Rating was done on a 7-point emotionality scale ranging from 1 (highly negative) to 7 (highly positive). We selected only words that received a rating above 4 ($M = 4.35$, $SD = .39$).

In another pre-test, 20 additional volunteers (age range 20–35, $M = 28.641$, $SD = 3.22$) were asked to rate the valence of the experimental word pairs on a 7-point scale ranging from 1 (highly negative) to 7 (highly positive). Word pairs that included a positive word but were supposed to be negative overall received a mean rating of 2.75 ($SD = .53$), word pairs that included a negative word but were supposed to be positive overall received a mean rating of 4.69 ($SD = .54$), and ratings in these two conditions were significantly different, $t(30) = 10.25$, $p < .001$.

The same 20 participants were also asked to judge their familiarity with each word pair on a 7-point scale ranging from 1 (completely unfamiliar) to 7 (highly familiar). The mean familiarity rating of the word pairs that included a negative word but were rated as positive overall ($M = 5.72$, $SD = 1.15$) did not differ significantly from the mean familiarity rating of the word pairs that included a positive word but were rated as negative overall ($M = 5.92$, $SD = .54$), $t(30) = -.62$, ns.

Procedure

The procedure was identical to the procedure in Experiment 1.

RESULTS

Table 2 presents reaction time and accuracy data in each condition. Reaction times that exceeded 2.5 standard deviations of the participant's mean in each condition were excluded. Overall, 2% of trials were excluded. Only correct trials were analysed.

Reaction times to related word pairs (*M* = 886.72, *SD* = 144.40) were significantly faster than reaction times to unrelated word pairs (*M* = 1011.34, *SD* = 174.17), $t(39) = 4.60$, $p < .0001$, Cohen's $d = .35$. Accuracy was significantly higher for unrelated (*M* = .94, *SD* = .07) than for related word pairs (*M* = .90, *SD* = .09), $t(39) = 3.43$, $p < .01$, Cohen's $d = .78$.

A paired sample *t*-test that compared response times to negative and positive word pairs was significant. Responses to negative word pairs that included a positive word were significantly slower than were responses to positive word pairs that included a negative word, $t(36) = 2.79$, $p < .01$; Cohen's $d = .28$. A paired-samples *t*-test was performed on the per cent of correct responses, with no significant difference between negative and positive word pairs $t(36) = .61$, ns.

The correlations between reaction times and accuracy were all non-significant (*r*s ranging from .09 to −.17, ns), indicating no speed–accuracy trade-off.

DISCUSSION

In the present work, we found that responses to word pairs that conveyed overall negative valence were slower than responses to word pairs that conveyed overall positive valence. Experiment 1 replicated findings reported before for non-linguistic stimuli as well as for single words (Algom et al., 2004). Word pairs with negative valence slowed down performance relative to word pairs with positive valence. The results of Experiment 1 also revealed a higher accuracy rate for negative as compared with positive word pairs. The effect of negative valence on accuracy performance is less clear since in most previous studies, negative valence was manipulated using relatively easy tasks that resulted in a ceiling performance (Algom et al., 2004). The accuracy results of Experiment 1 show that the semantic judgement task performed in the current study was relatively difficult. It is possible that because more cognitive resources were allocated towards the negative stimuli (Öhman, 2007), participants were more accurate in deciding that a word pair with negative as compared to positive valence are meaningful. It is yet unknown to what extent negative valence, once detected, can increase the accuracy of semantic analysis and this point needs to be further clarified in future studies.

One important question remains as to whether the system first runs an affective analysis or a semantic analysis. The aim of Experiment 2 was to investigate whether processing of the semantic meaning of a word pair takes precedence over processing of the valence of its constituents. The results of this experiment show that the overall valence of the word pair affects performance, regardless of the valence of individual words. Responses to word pairs with overall negative valence that included a positive word were slower than responses to positive word pairs that included a negative word. We note that words were presented one after the other, and each word remained on the screen long enough for participants to extract its full meaning prior to processing the meaning of

Table 2. *Mean RT and per cent of correct responses in Experiment 2*

Condition	*Mean RT*	SD	*Accuracy*	SD
Negative word pairs with a positive second word	907.05	149.96	90	.11
Positive word pairs with a negative second word	866.40	137.64	91	.07
Unrelated-negative	1007.91	176.74	96	.06
Unrelated-positive	1014.97	128.87	94	.08

the expression as a whole (as in Hauk, Pulvermüller, Ford, Marslen-Wilson, & Davis, 2009). We believe that similar effects will be found for simultaneous presentation; however, future research should examine whether the results remain the same when the phrase is presented in full rather than each word separately.

Our findings suggest that negative valence is activated after the meaning of the entire word pair is computed, as predicted by the Cognitive Primacy Hypothesis (Lazarus, 1984). This conclusion is compatible with recent work that compared the predictions of Affective and Cognitive Primacy Hypotheses in the context of natural scene recognition. Nummenmaa et al. (2010) have shown that semantic recognition of scenes and objects precedes their affective analysis. Schacht and Sommer (2009) pointed out that unlike pictorial stimuli, linguistic stimuli represent valence at a more abstract and symbolic level and therefore might be processed differently. Yet, the results of the current study imply that the order of processing of pictorial and verbal stimuli is rather similar.

Several limitations of the current study should be acknowledged. Our findings are confined to implicit processing of affective linguistic stimuli. Participants performed a semantic decision and did not explicitly attend to the emotional valence of the stimuli. According to Algom et al. (2004), slowing occurs both in experiments in which words are task-irrelevant (emotional Stroop) and in tasks that require explicit attention to words (word naming). While we show that semantic analysis precedes affective activation when the meaning of the words is task-relevant, it is unclear whether the same is true for tasks in which the meaning is irrelevant.

Another limitation of the present study is that we did not provide a neutral condition in Experiment 2 to account for possible hierarchy in the way negative valence affects performance. That is, while it is evident that word pairs that convey an overall negative meaning but include a positive word disrupt performance more than word pairs that convey positive meaning but include a negative word, it is unknown whether the latter still disrupt performance to some degree relative to completely neutral word pairs. Ideally, we would find that negative word pairs that consist of a positive word would slow performance not only relative to positive word pairs but also relative to neutral word pairs. Finally, although the current findings suggest that semantic analysis is performed prior to affective analysis, additional research is required in order to examine whether this conclusion applies for other linguistic structures (e.g., more complex sentences).

In sum, consistent with the Cognitive Primacy Hypothesis (Lazarus, 1984), the present study demonstrates that the effect of negative valence occurs after the meaning of both constituents of a word pair is computed. When the valence of the phrase in incongruent with the valence of the constituent single words, the valence of the constituents does not affect performance.

Disclosure statement

No potential conflict of interest was reported by the authors.

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