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The Influence of Emotional and Non-emotional Concepts Activation on Information Processing and Unintentional Memorizing

The aim of the work is to compare mechanisms of semantic and emotional processing and memory. Targets (words and non-words) were primed (100 ms) by category name (semantic in Experiment 1 and emotional in Experiment 2). The congruency of prime and target was manipulated. The reaction time of lexical decisions and the effects of unintentional memorizing of word targets were measured. Activation of semantic (Experiment 1) and emotional (Experiment 2) nodes leads to faster processing of related concepts: congruent targets are processed faster than incongruent. Processing congruent primed emotional concepts depends on their modality: anger and joy words are processed faster than sadness. Thus, congruently primed activating emotional concepts are processed differently from congruently primed deactivating concepts. The effectiveness of unintentional memory of emotional and non-emotional concepts (words) is based on different mechanisms: congruently primed emotional words are better remembered than incongruently primed. The results are discussed in the framework of spreading activation theory and theory of emotional memory.

Keywords: *semantic concepts, cognitive representation of emotion, congruency effect, lexical decision task (LTD), priming effect, priming paradigm, unintentional memorizing.*

The activation model of long-term memory (Collins & Loftus, 1975) assumes that when a semantic memory category is activated, this activation spreads to other related memory units. Representation is activated automatically when a word is presented, and the activation spreads to representations which are semantically related to the exposed word. Word recognition will be facilitated if another semantically related word is presented prior to its exposition, because activation of the appropriate representation increases and less activation is needed to recognize the target word (cf. Ray & Bly, 2007, 2008).

This mechanism of activation has often been tested in a lexical decision paradigm. A classical lexical decision task (LDT) is a procedure in which the decision-maker must decide whether a series of letters constitutes a word in a given language. Participants are randomly presented with words and non-words and reaction time and response correctness are measured. The effect of facilitation on word processing is usually studied using the priming procedure. If the presented word is preceded by another word which is semantically related, a shortening of the lexical decision time is observed. This facilitation is called the semantic congruency effect (Antos, 1979; McNamara & Holbrook, 2003; another meaning of congruency effect, see i.e. Nabeta & Kawahara, 2006).

Processing of emotional information can also be described in the activation model of memory. Bower (1981) assumes that the concepts network consists of emotional nodes whose activation automatically spreads to related nodes and facilitates their retrieval. This model is often used for explanation of empirical results showing that a positive prime facilitates the processing of positive target words and a negative prime facilitates the processing of negative target words. This facilitation is called the emotional congruency effect and denotes the higher accessibility of all representations that are the same valence as the prior exposed stimuli.

The different mechanisms of processing of positive and negative stimuli follow from differences between the positive and the negative activation systems: approach and avoidance (Cacioppo & Gardner, 2001); attention (Derryberry & Tucker, 1994); and memorization (Pratto

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& John, 1991; Robinson-Riegler & Winton, 1996). For a review, see Baumeister, Bratslavsky, Finkenauer & Vohs (2001). Hence, it is improper to infer an emotional congruency effect from aggregated data obtained in conditions of both positive and negative stimuli (e.g., Wentura, 2000).

Narrower understanding of the emotional congruency effect relates to the level of accessibility to the representation due to the modality (specific emotions). Prior exposed stimuli increase the accessibility of those representations which are the same modality (e.g., Carrol and Young, 2005; Rossel and Nobre, 2004). If the prime word is exposed, facilitation is limited to the modality related words and does not apply to all the same valence representations. However, the researchers often use a broad definition of the congruency effect based on valence, not modality coherence.

In many studies of the processing of verbal material differing in emotional valence, lexical decision tasks have been used (Challis & Krane, 1988; Clark, Teasdale, Broadbent & Martin, 1983; Goetz, Goetz & Robinson, 2007; Gross, 2006; Olafson & Ferraro, 2001). The effect of the valence congruency of exposed words on the speed of lexical decision has been empirically demonstrated (Browne, Lawson & Abramson, 2006; Estes & Adelman, 2008; Kuchinke, 2007; Kuchinke, Jacobs, Grubich, Võ, Conrad & Hermann, 2005; Piercey & Rioux, 2008; Stip, Lecours, Chertkow, Elie & O'Connor, 1994; Thomas & LaBar, 2005). Most of the work suggests that positive words are processed more quickly than neutral or negative words. It is less clear how negative words are processed. We think that inconclusive results about negative words processing arise from using the broad meaning of congruency. This implies that the words researchers use can be associated with sadness, anger or fear, although the conclusions are applied to negative words in general. However, different emotions have a differential effect on speed of processing because they involve different levels of activation (cf. Kuchinke, 2007).

The influence of the valence of the word has also been demonstrated in studies conducted in the priming paradigm (Carroll & Young, 2005; Greenwald, Draine, Abrams, 1996; Kemp-Wheeler & Hill, 1992; Rossel & Nobre, 2004; Scott, Mogg & Bradley, 2001). Kemp-Wheeler and Hill (1992) wanted to know whether semantic and emotional relatedness of the prime and the target word would affect lexical decision time. Participants made lexical decisions concerning negative words and non-words. They found that both semantic congruency and emotional congruency shortened reaction times compared with lack of congruency. They concluded that the priming effect of emotional words is a variety of semantic priming (cf. Siegle, 1996). Failure to replicate the results in the next experiment (Kemp-Wheeler & Hill, 1992) weakens this conclusion, however. Moreover, no positive target words were used in this study and therefore the conclusions must be limited to negative words and not extended to emotional words in general. Scott, Mogg & Bradley (2001) developed the affective lexical decision design by introducing additionally two conditions: positive word congruency and incongruency. Using a 28 ms emotional prime, words associated with sadness and joy and neutral words, they found that reaction time was longer for negative congruency than for either positive congruency or neutrality. These results can be explained according to Unkelbach and colleagues' (2009) claim that the mental organization of positive material is more closely governed by the evaluative congruency principle than the mental organization of negative material.

So, in research on cognitive representations of emotions it is necessary to take a modality (i.e., quality differences in emotions) into consideration. Rossel and Nobre (2004) studied speed of lexical decision using the priming procedure and concluded that not only emotional valence but also emotional modality is a significant modifier of reaction time. When they investigated words associated with joy they found a facilitation effect, but when they investigated words associated with sadness they found a reversed effect, i.e., longer reaction times for congruent words. They found no significant effects of priming for fear. This pattern of results emerged for three different prime exposure times: 200 ms, 700 ms and 950 ms. They concluded that affective priming does not generate general, modality-independent facilitation effects. These results arise the next research question, whether words evoking anger cause emotional congruency effect?

The times of prime expositions used in cited research have been rather long. We are interested in investigating whether these results will occur in times of prime exposition that prevent any processes of correction and contrasting but are long enough for preliminary semantic processing, which is subsequent to affective attitude and behavioural tendencies.

Some researchers investigated the effectiveness of unintentional memorization of words which had previously been subject to non-primed lexical decision. However, it is not clear how the emotionally valenced words affected the effectiveness of their memorization following lexical decision. Gross (2006) found that negative words were remembered best, especially if the participant was in a negative mood. Clark and colleagues (1983), meanwhile, found that both positive words and negative words were remembered better than neutral words. Challis and Krane (1988) found no differences in the memorization of words differing in emotional valence. In all these studies, memory effectiveness was measured using free recall. Our aim is to test the unintentional memorization effects of words previously processed in a congruently and incongruently primed lexical decisions. We check these effects in the

context of recognition procedure, which has been less explored.

The following hypotheses about processing and memory effects have been set up on the base of the presented theoretical frame and experimental results.

Hypotheses: Semantical/Emotional Congruency in LDT. Adopting the assumptions of the automatic spread of activation theory, we predict that both emotional and non-emotional concepts are subject to the facilitation in the case of congruent priming. At the operational level, this means that reactions to words primed by the name of the category to which these words belong should be faster than reactions to words primed by the names of other categories.

We assume, however, that the emotional concept network and the non-emotional concept network will work differently. As far as the non-emotional concept network is concerned, we expect, as in many previous studies, that congruency effects will emerge whatever the semantic category (animals, furniture, birds). However, the processing of emotional words should depend not only on their valence congruency with the prime but also on the modality. We hypothesised that the congruency effect was modified by the activating properties of the emotion. Hence processing of words associated with joy and anger should be facilitated (RT shortened), whereas processing of words associated with sadness should not be facilitated, even when primed by a congruent category label. In this case the reaction may even be particularly delayed.

Hypotheses: Semantical/Emotional Congruency Effect in Unintentional Memorization. We hypothesise that congruency with the prime will affect not only speed of LDT but also the unintentional memorization of the primed words (in terms of both memorization effectiveness and speed of access to coded contents). In the case of non-emotional information, congruently primed words should be memorized better and recognized faster than incongruently primed words (i.e., words preceded by a word belonging to a different category). The effectiveness of unintentional memorization and speed of access to emotional words should depend on the valance congruency and on the modality. Positive words, congruently primed in LDT should be better and faster recognised than incogruently primed. The effectiveness and speed of recognition of congruently primed negative words will depend on the words' activating properties. Memory should be better and access faster when congruently primed words are associated with anger, a negative, intensely activating emotion. Deactivating sadness may reduce the effectiveness of memorization. Recognition of words associated with sadness should also be slower, especially when congruently primed.

Hypotheses: Depth of processing of non-emotional and emotional words. The foregoing hypotheses have been inferred from the activation theory of semantic memory and are based on the assumption that the lexical decision process involves not only perceptual processing but also deeper semantic analysis. We assume that, rather than being limited to physical analysis (based on rough estimation of the probability of coexistence of letters), lexical decisions take place at a deeper, semantic level. If activation spreads to semantically related words then it should also spread to words which were not presented during the LDT. These preactivated words presented later for recognition should lead to memory errors (false alarms). If a new word (*misleaders*)presented for recognition is semantically similar to exposed words it should also cause decisional difficulties leading to a longer reaction times.

Many researchers have already dealt with word processing and tried to set up the underlying mechanisms. However, previous research did not compared the outcomes obtained from emotional and non-emotional material. Our study has been design to enable this comparison. Moreover, in previous research the memory effects of lexical decision have been measured very rarely. The aim of our research was to confront the mechanisms of processing and memorizing of emotional and non-emotional words. Two independent studies were conducted: with neutral stimuli (Experiment 1) and with stimuli-evoking emotions (Experiment 2). In Experiment 1, the mechanisms of processing and memorizing of the neutral words, congruently and incongruently primed, were set up. Experiment 1 was partially a replication of previous research dealing with the primed lexical decision paradigm (see: Antos, 1979; McNamara & Holbrook, 2003. However, adopting this procedure let us also answer a less explored question about the relation between processing and memory of non-emotional words.

The aims of Experiment 2 were (1) to determine the mechanisms of processing and memorizing of emotional words under congruent and incongruent priming conditions, (2) to ascertain a relation between these mechanisms, and (3) to reveal how these mechanisms and their relation depend on specific emotions (modalities).

Even though the experiments are independent and despite the replicating character of Experiment 1, using the identical procedure allowed us to make a reference between obtained results.

Experiment 1: Processing and Memory of Non-emotional Words

Two central questions were checked out in Experiment 1. The first question refers to the speed of processing of non-emotional words which were congruently and incongruently primed. The second question refers to the unintentional memorization of words processed under congruent and incongruent conditions.

Participants

There were 68 participants (51 women and 17 men) in Experiment 1. All participants were undergraduate students and they received mandatory credit points for their contribution.

Material

The material for lexical decisions was collected on the basis of a selection study. The purpose of this study was to choose the most typical exemplars of specific semantic categories. The need for a selection study was based on previous research showing that exemplar typicality significantly affects lexical decision time (e.g., Neely, Keefe & Ross, 1989; Wentura & Frings, 2005). In our selection procedure 30 students were asked to write down three associations (nouns) which first came to mind following presentation of the names of particular categories. The students generated associations to four semantic categories (furniture, birds, clothes, tools). The most frequently generated words were used in the main study (cf. Perea & Rosa, 2002). The category "tools" was not used in the main study because of the too broad heterogeneity of associations which prevented identification of typical exemplars.

The following words were used in Experiment 1: *bench*, *table*, *armchair*, *bookcase*, *chair*, *wardrobe*, *commode*, *sofa* in the "*furniture*" category; *sparrow*, *swallow*, *starling*, *pigeon*, *thrush*, *tit*, *raven*, *seagull* in the "*birds*" category; *skirt*, *jacket*, *cap*, *shirt*, *blouse*, *trousers*, *shoes*, *coat* in the "*clothes*" category. The words used in this study were in Polish.

These typical exemplars of semantic concepts (24 words) were used as target words in the main study. Additionally, 24 pronounceable non-words containing similar numbers of syllables to the target words were used (cf. Ratcliff, Gomez & McKoon, 2004; Piercey et al., 2008).

Material for the recognition phase consisted of five lists: the list of 24 words previously processed (targets), and two lists of new words misleading in character. One misleading list consisted of 12 new words semantically similar to the targets. These words referred to half of the previously processed words. For the other half of the target words, a list of 12 physically similar words was created. This procedure resulted in material with deep (semantic) and shallow (physical) similarity to the target words. Additionally, there were two lists of non-words: previously presented and a new one.

Physically similar word-stimuli were either graphically similar or similar in sound. For example, the stimulus *szpik* (*bone marrow*) was physically similar to the stimulus *szpak* (*starling*), presented earlier. Semantic similarity means belonging to the same category of words. For example, the word presented for recognition *divan* was semantically similar to the previously presented word *sofa*.

Procedure

Experiment 1 was designed in E-prime version1.0 software. For each participant, an experimental session was run individually. In step one participants performed the lexical decision task. The following elements were displayed on the computer screen in the experimental group: instruction, visual fixation point (1000 ms), category name as prime (100 ms), mask (50 ms), target stimulus (word or non-word). The names of the three semantic categories served as primes: *furniture*, *birds*, *clothes*. The exemplars of these categories or non-words were the target stimuli. The prime-target pair could be either (1) congruent - if the target was an exemplar of the priming category (e.g. "*furniture*" – "*wardrobe*") or (2) incongruent - if the target word was the name of an exemplar of a different priming category (e.g., "*birds*" – "*coat")* or (3) a pair: category name – non-word (e.g., "*clothes*"- "*doryga*"). Both the primes and the targets were presented in random order. No primes were presented in the control group. The screen remained empty for 100 ms following presentation of the fixation point in this group.

Each participant had to decide whether the presented target (a series of letters) was a word or not a word in the Polish language. The participants made 48 lexical decisions following a four-exposure training phase. Time for lexical decision has been not limited. Reaction time was recorded from the moment the target appeared on the screen until the moment the lexical decision was signalled by pressing the appropriate key ("word" or "non-word") on the computer keyboard.

After the lexical decision task, the effects of unintentional target memorization were measured. Ninety-six (96) stimuli (words and non-words) were presented sequentially. Half of the stimuli had already been presented in the lexical decision task. Participants were requested to decide whether the given stimuli had been previously presented in the lexical decision task by pressing the appropriate key. All new words were similar to the words presented in step one – either physically (shallow similarity) or semantically (deep similarity) (cf. Ratcliff & McKoon, 2001). Reaction time and response correctness were recorded in the recognition phase.

Results

The logarithms of reaction times were computed. The results presented below are for words only.

Semantical Congruency in LDT

Data of accuracy and reaction time in lexical decision have been collected. Due to the high accuracy achieved in the LDT, it has been excluded from the results presentation. Reaction times quicker than 300 ms and slower than 4000 ms (4,1% of all the observations) were excluded from

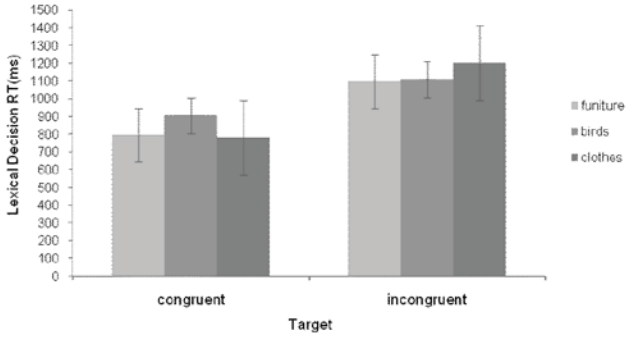

Figure 1. Speed of lexical decisions (Means in ms) for congruently and incongruently primed non-emotional words in the experimental group. Standards errors are represented in the figure by the error bars attached to each column.

further analysis.

In order to test the assumption that facilitation of lexical decision takes place when words, whatever their semantic category, are congruently primed, analysis of variance with repeated measures in a 2 x 3 x 2 (Congruence [congruent, incongruent] x Category of Target Word [furniture, birds, clothes] x Group [experimental,control]) was conducted.

Just as expected, the reaction times to target words belonging to three different categories did not differ significantly ($p > .05$) and no interaction was found between target category and priming congruency ($p > .05$). Also, just as expected, a significant congruency x group interaction was found, $F(1, 62) = 15.26$, $p < .001$, $\eta^2 = 0.197$. In the experimental group the lexical decision reaction time for congruently primed words ($M = 781$) was significantly faster than the lexical decision reaction time for incongruently primed words ($M = 1013$). Decision time for congruent words was faster for all categories (furniture *NIR*: $p = .0002$, birds *NIR*: $p = .0034$, clothes *NIR*: $p = .0001$). In the control group decision times did not differ significantly (congruent: $M = 1063$, incongruent: $M = 1015$).[1]

Semantical Congruency Effect in Unintentional Memorization

Reaction times quicker than 300 ms and slower than 6000 ms (2,8% of all the observations) were excluded from further analysis

In order to check whether the target category and priming congruency had any effect on the unintentional memorization[2], analysis of variance with repeated measures was conducted for the experimental group according to the following design: 2 x 3 (Congruency [congruent, incongruent]) x Category of Target Word [furniture, birds, clothes]). Neither the category of target word nor the priming congruency had any effect on the correctness of recognition ($p > .05$).

Another analysis was conducted to check whether recognition time depended on word category and on prime-target congruency in the lexical decision task. The experimental group data were submitted to analysis of variance with repeated measures according to the following design: (2) congruency *x* (3) target category. A significant main effect was found for congruency, $F(1, 32) = 31.68$, $p < .00001$, $\eta^2 = 0.498$ irrespective of the target category. As expected, congruently primed words recognized faster than incongruently primed.

Depth of Processing of Non-emotional Words: correctness and speed of rejection of physical and semantic "misleaders".

The next step in the analysis was to check whether lexical decision involves activation at a deep semantic level. In order to find out whether type of similarity (shallow or deep) to previously exposed words affected rejection correctness and speed, analysis of variance with repeated measures was conducted according to the following design: 2 x 2 (Type of Similarity [physical, semantic] x Group [experimental, control]).

The analysis revealed a main effect for type of similarity to the exposed word, $F(1, 66) = 43.80$, $p < .00001$, $\eta^2 = 0.399$. In both the experimental group (*NIR*: $p = .0002$) and the control group (*NIR*: $p = .000001$) physically similar words were rejected more correctly ($M_{exp} = 0.850$, $M_{control} = 0.914$) than semantically similar words ($M_{exp} = 0.740$, $M_{control} = 0.765$). Additionally, when speed of rejection was analyzed, a significant effect was found for type of similarity to the exposed word, $F(1, 66) = 8.35$, $p < .01$, $\eta^2 = 0.18$. In the experimental group physically similar words were rejected more quickly ($M = 1061$) than semantically similar words ($M = 1128$, *NIR*: $p = .013$). The same effect was found in the control group ($M = 1175$ *vs*. $M = 1246$, *NIR*: $p = .053$).

To conclude, words which are physically similar to words previously exposed to lexical decision are rejected faster and more correctly than words which are semantically similar.

Experiment 2: Processing and Memory of Emotional Words

Two questions were checked out in Experiment 2. The first question refers to a speed of processing of emotional words presented after congruent and incongruent primes. The second question refers to the memory of emotional words processed under these conditions. The principal aim of Experiment 2 was to reveal whether determined rules of words processing and memorizing vary in emotional modalities.

1 In the control group the target words were not primed and therefore the terms „congruent" and „incongruent" are arbitrary. They are used here to describe the control words, i.e., words which were really congruently or incongruently primed in the experimental group.

2 Correctly recognized words (hits) were scored 1, misses were scored 0, and the mean was computed.

Participants

There were 70 participants (55 women and 15 men) in Experiment 2. All participants were undergraduate students and they received mandatory credit points for their contribution.

Material

The same selection procedure was applied as in Experiment 1. The purpose of the selection study was to choose the most typical exemplars of specific emotional categories. In the selection study 30 students generated associations to four emotional categories: *joy*, *sadness*, *anger*, *disgust*. The most frequently generated words were used in the main study. A category *disgust* was not used in the main study because of a too broad heterogeneity of associations.

The following target words were used in the main study: *play*, *ecstasy*, *comedy*, *smile*, *success*, *laughter*, *delight*, *merriment* in the "*joy*" category; *loss*, *sobbing*, *mourning*, *bitterness*, *weeping*, *depression*, *grave*, *grief* in the "*sadness*" category; *fury*, *revenge*, *violence*, *quarrel*, *attack*, *fight*, *fist*, *blow* in the "*anger*" category. The words used in this study were in Polish. Additionally, 24 pronounceable non-words containing similar numbers of syllables to the target words were used.

In order to measure the effects of unintentional target memorization, as in Experiment 1, three lists of words and two lists of non-words were created . One list consisted of words previously processed in a lexical decision, i.e., target words. Two lists of new words were similar to the targets: one list consisted of shallowly similar words and the second one consisted of deeply (semantically) similar words. One non-words list consisted of material presented in lexical decisions and the second list of non-words was a new one. Physically, i.e., shallowly similar stimuli were either graphically similar or similar in sound. For example, the stimulus "*strawa*" (*fare*) was physically similar to the stimulus "*strata*" (*loss*) presented earlier. Deep similarity means belonging to the same category of words. For example, the target word was "*play*" and the word to be identified was "*game*".

Procedure

The procedure for Experiment 2 was identical to the procedure for Experiment 1. The only difference was the material, whose content was emotional.

The names of the three emotional categories (modalities) used as primes were: *joy*, *sadness*, *anger*. The names of exemplars of these categories or non-words were the target stimuli. The prime-target pair could be either (1) congruent if the target was the exemplar of the priming category (e.g., "*joy*" – "*play*") or (2) incongruent if the target word was the exemplar of a different category (e.g., "*anger*" – *loss*") or (3) a pair: category name – non-word (e.g., "*sadness*"-"*dukro*").

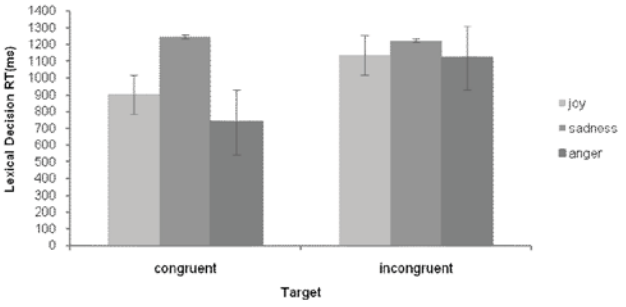

Figure 2. Speed of lexical decision (Means in ms) for congruently and incongruently primed emotional words in the experimental group. Standards errors are represented in the figure by the error bars attached to each column.

Reaction time and response correctness were recorded for both lexical decisions and the recognition phase.

Results

The logarithms of reaction times were computed. The results presented below are for words only.

Emotional Congruency in LDT

As in Experiment 1, data of accuracy and reaction time in lexical decision have been collected and due to the high accuracy achieved in the LDT, it has been excluded from the results presentation. Reaction times quicker than 300 ms and slower than 4000 ms (3% of all the observations) were excluded from further analysis.

In order to check whether there were any differences in the processing of words associated with different modalities and whether the congruency effect was modified by emotional modality, an analysis of variance with repeated measures was conducted using the following design: 2 x 3 x 2 (Congruency [congruent, incongruent] x Target Modality [joy, sadness, anger] x Group [experimental, control]). A significant main effect emerged for target modality, $F(1, 64) = 5.76$, $p < .001$, $\eta^2 = 0.153$. The lexical decision time was longer for words associated with sadness ($M = 1084$; *NIR*: $p = .005$) than for words associated with anger ($M = 842$). A significant main effect was also found for the congruency, $F(1, 64) = 10.38$, $p < .005$, $\eta^2 = 0.138$). Reaction times for words congruently primed were shorter compared to incongruently primed words. A significant interaction was found for group and congruency, $F(1, 64) = 6.91$, $p < .05$, $\eta^2 = 0.1$. Finally, a significant interaction of all three variables (congruency *x* target modality *x* group) was found, $F(2, 64) = 7.38$, $p < .01$, $\eta^2 = 0.188$.

The main congruency effect is due to the difference between reaction times for congruently and incongruently primed words associated with anger and joy only. Hence, facilitation took place after congruent priming only when the words were associated with anger and joy. Facilitation was not observed in the case of congruently primed words associated with sadness (see Fig. 2).

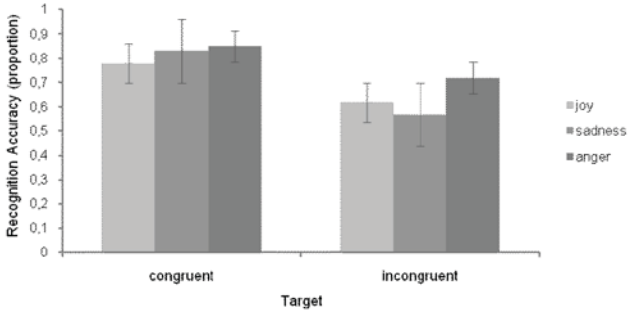

Figure 3. Recognition accuracy for congruently and incongruently primed emotional words in the experimental group. Standards errors are represented in the figure by the error bars attached to each column. Correctly recognized words (hits) were scored 1, misses were scored 0, and the mean was computed.

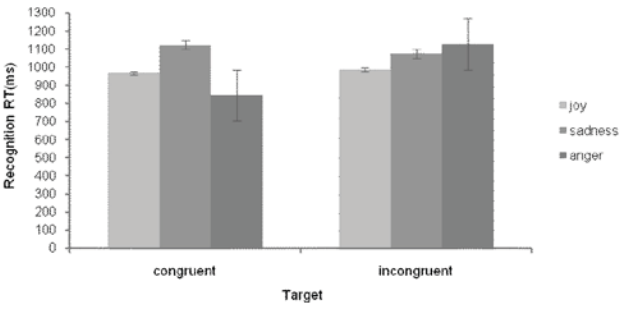

Figure 4. Speed of recognition (Means in ms) for congruently and incongruently primed emotional words in the experimental group. Standards errors are represented in the figure by the error bars attached to each column.

Emotional Congruency Effect in Unintentional Memorization

Reaction times quicker than 300 ms and slower than 6000 ms (2 % of all the observations) were excluded from further analysis.

In order to check whether target modality and congruency influence unintentional memorization, an analysis of variance with repeated measures was conducted according to the following design: 2 x 3 (Congruency [congruent, incongruent] x Target Modality [joy, sadness, anger]) for the experimental group. Separate analyses for correctness and access time were conducted.

Correctness. Significant main effects were found for target modality, $F(2, 33) = 5.00$, $p < .05$, $\eta^2 = 0.230$ and for congruency, $F(1, 34) = 48.682$, $p < .00001$, $\eta^2 = 0.580$. For all emotional modalities, congruently primed words were memorized better ($M_{joy} = 0.78$; $M_{sadness} = 0.83$; $M_{anger} = 0.86$) than incongruently primed words ($M_{joy} = 0.62$; $M_{sadness} = 0.58$; $M_{anger} = 0.72$) (see Fig. 3).

Analysis of speed of recognition during recall of words processed in congruent vs. incongruent condition revealed a significant main effect of the target modality, $F(2, 33) = 8.43$, $p< .01$, $\eta^2 = 0.338$. Irrespective of priming, recall time was significantly longer for words associated with sadness ($M = 1051$) than for words associated with joy ($M = 915$, *NIR*: $p = .006$) or anger ($M = 918$, *NIR*: $p = .0001$). Although no congruency effect was found ($p > 0.05$), there was a significant interaction between congruency and target modality, $F(2, 33) = 6.01$, $p < .01$, $\eta^2 = 0.27$. More specific comparisons revealed that the congruency effect, expressed in shorter recognition times, was only present for anger (*NIR*: $p = .008$). Congruently primed words associated with sadness took longer to recognize than congruently primed words associated with joy (*NIR*: $p = .008$) or anger (*NIR*: $p = .0001$; see Fig. 4).

The results show that while the congruency effect occurs for correctness independently of modality, access time is modified by emotional modality. Congruent priming facilitates access time in the case of anger, but in the case of sadness congruent priming postpones access.

Depth of Processing of Emotional Words: correctness and speed of rejection of physical and semantic "misleaders".

As in Experiment 1, in order to find out whether type of similarity to previously exposed words affected rejection correctness and speed, an analysis of variance with repeated measures was conducted: 2 x 2 (Type of Similarity [physical, semantic] x Group [experimental, control]).

The analysis, as in Experiment 1, revealed a significant main effect of type of similarity, $F(1, 68) = 12.01$, $p < .001$, $\eta^2 = 0.15$) on "misleader" rejection correctness. Irrespective of the group, physically similar words ($M_{exp} = 0.895$, $M_{control} = 0.893$) were rejected more correctly than semantically similar words ($M_{exp} = 0.816$, $M_{control} = 0.822$, *NIR*: $p = .012$). Analysis of speed of rejection also revealed an effect of type of similarity, $F(1, 68) = 14.90$, $p < 0.001$, $\eta^2 = 0.18$. In the experimental group, physically similar words were rejected more quickly ($M = 1117$) than semantically similar words ($M = 1232$, *NIR*: $p = .03$). A similar pattern was found in the control group ($M = 1251$ and $M = 1399$ respectively; *NIR*: $p = 0.0004$).

As in Experiment 1, in the recognition phase, the words which are physically similar to targets in lexical decisions are rejected more correctly and faster than words which are semantically similar.

Summary of findings. The congruency principle applies to both emotional words and non-emotional words. Reactions to words primed by the category to which the words belong are quicker than reactions to words primed by other categories. Just as predicted, as far as memory of emotional representations is concerned, emotional modality modifies the speed of processing of congruently primed words. Words associated with sadness are not governed by the congruency principle. The connection between word congruency and memorization was only found for emotional concepts. Whatever the modality, congruently primed words are memorized better. The emotional congruency effect does not depend on valence or the intensity of activation evoked by the words. However, modality does affect speed of access to emotional memory units. It was also

demonstrated that congruently primed words associated with sadness are slower to be recognized than congruently primed words associated with joy or anger.

General Discussion

This study compared emotional and non-emotional information processing and its effects. It showed the specific ways in which various types of words are processed and the role of congruency in the processing of emotional and non-emotional contents. The purpose of the investigation was to see how neutral and emotional data acquired under congruent as opposed to incongruent conditions are processed and memorized. The study belongs to the wider context of research on the activation of emotional and non-emotional conceptual networks (cf. Bower, 1981). It was assumed that some of the observed effects would be similar for both types of representation and others would be specific to emotional concepts. As far as the emotional conceptual network is concerned, we are dealing not only with the semantic properties of cognitive representations but also with their emotional valence (Winkielman, Knutson, Paulus & Trujillo, 2007). By comparing semantic and emotional memory we were able to identify effects caused by the purely emotional nature of representations.

As in many other studies (Antos, 1979; McNamara & Holbrook, 2003), we demonstrate that semantically congruent priming quickens reaction time. As expected, the replication of previous research has been obtained: whatever the semantic category, congruent priming facilitates processing. More importantly we achieved reliable point of reference for the Experiment 2.

The emotional representational network operates just like the semantic network, i.e., words primed by the name of the emotional category to which they belong are processed more rapidly. However, the congruency effect depends on the modality of the emotion.

When words are associated with sadness, congruent priming with the name of the category does not speed up lexical decision (Rossel et al. (2004) reported a similar effect). This is may due to the deactivating nature of sadness. Sadness is associated with passivity, withdrawal, and demobilization. When sadness-related concepts are activated, the work of the mind (i.e. information processing) is greatly affected by these states. Hence the lack of response acceleration following congruent priming can be explained in terms of the deactivating nature of sadness and the cancelling out of the effects of semantic activation.

Rossel et al. (2004) did not introduced words evoking anger to their experimental procedure. Moreover, in their research, other negative words (evoking fear) did not give any effect of congruency. In our research, as we expected, the congruency effect has been observed on negative words associated with anger. This result confirm that emotional congruency effect should not be interpreted without taking modality into consideration (comp. Carrol, Young, 2005).

Since there is no need to be attentive, processing in conditions of non-emotionally (semantically) congruent priming is rapid but does not lead to better memorization. There is no difference between the level of memorization of congruently and incongruently primed contents. However, activation processes facilitate the work of the memory by accelerating the recall process. Hence we may say that dual activation takes place in congruent conditions. The word representation is activated first by former exposure of the name of the category to which the word belongs (the prime) and second by exposure of the word for lexical decision. This dual activation during coding leads to quicker access to the representations of congruent words in later recall. When priming is incongruent, the word representation is activated only once – only during exposure in lexical decision task – and that is why access to these words at later recall is more difficult (slower).

As far as memory of emotional concepts is concerned, the effects of congruent priming are different from the effects observed for non-emotional (semantic) memory. Unintentional memorization of emotional contents in conditions of congruent priming, whatever the modality, is always better than in conditions of incongruent priming. The processing of words primed by the name of the category would probably be fast and inattentive were it not for its emotional nature. When the content is emotional, attention is involved and cognitive resources are allocated to the source of the emotion (cf. e.g., Eysenck & Keane, 2005; Kolanczyk, 2003; Pawlowska-Fusiara, 2005), leading to better memorization. Therefore, storage of emotional information which has been acknowledged (the prime is congruent with the target word) is presumably adaptive whatever the modality of the emotion.

Modality is important, however, when speed of recall of emotional content from memory storage is the issue. Recognition time of congruent words depends on their modality. Words associated with joy and anger, congruently primed, are faster recognised. Words associated with sadness are not governed by the congruence principle. Access to words associated with sadness is more difficult, even when they have been congruently primed, because activation due to semantic congruency has been inhibited.

The foregoing interpretation of the present findings in terms of activation theories of memory is valid as long as words are submitted to deeper, semantic processing during lexical decision (cf. e.g., Perea & Rosa, 2002). We therefore investigated whether activation at a deeper, semantic level takes place during lexical decision. This was possible by introducing in recognition phase two types of new words: physically or semantically similar to the words which were submitted to lexical decision. The results demonstrated that

deep, semantic processing did indeed take place during lexical decision. As we assumed, it was more difficult to reject semantically similar words because, although they were not used in the study, their representations were activated due to activation spread from the target words. The numerous errors and relatively long rejection times for semantically similar words may be explained in terms of competition and the control process mechanism. Competition takes place between the target and its respective semantic "misleader". Since they are semantically related, when one is exposed the other is activated. Therefore, when a word is exposed for lexical decision this automatically activates the representation of the word used later as the semantic "misleader" at the recognition stage. Exposure of the misleading word for recognition re-activates the previous target word. Hence both words become accessible and compete with each other. This is why the cognitive decision as to which one was presented in the study is often wrong and, even if it is correct, the decision takes a long time. Rejection of a strongly activated word takes a lot of time because effective control processes, i.e., inhibition of competing tendencies, are involved.

In presented research, activation model of memory has been applied. Of course the priming effect can be interpreted in the alternative theoretical frameworks, (i.e. response competition model; Klinger, Burton, Pitts , 2000; parallel distributed processing model; Plaut, Booth, 2000). Although, most of the hypotheses which we set up basing on spreading activation theory were confirmed. So, it seems activation model provides an adequate theoretical background for obtained results.

The particular strength of our research is that the experimental design allows a comparison of semantic and emotional processing across a number of word categories. Based on applied methodology we could draw inferences about emotional processing over and above basic semantic processing. However, to improve the knowledge of the issue, future research could explore the precise nature of the activation in emotional memory, i.e. the influence of awareness on processing the emotional charged events. It would be possible if different prime duration were introduced in experimental design. It also seems necessary, to introduce three type of negativity in one experimental design: fear, anger, sadness. It would enable more reliable explanation of the emotional congruency effect. Additionally, it would be worth to introduce to experimental design the between subject priming procedure; to enlarge the number of expositions for each category; to add the further specific emotional categories.

Finally, we would like to point out that this study could be an important contribution in an investigation about processing the emotional and non-emotional events and may initiate a series of studies in this field.

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