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Processing of Words Related to the Demands of a Previously Solved Problem

Abstract: *Earlier research by the author brought about findings suggesting that people in a special way process words related to demands of a problem they previously solved, even when they do not consciously notice this relationship. The findings concerned interference in the task in which the words appeared, a shift in affective responses to them that depended on sex of the participants, and impaired memory of the words. The aim of this study was to replicate these effects and to find out whether they are related to working memory (WM) span of the participants, taken as a measure of the individual's ability to control attention. Participants in the experimental group solved a divergent problem, then performed an ostensibly unrelated speeded affective classification task concerning each of a series of nouns, and then performed an unexpected cued recall task for the nouns. Afterwards, a task measuring WM span was administered. In the control group there was no problem-solving phase. Response latencies for words immediately following problem-related words in the classification task were longer in the experimental than in the control group, but there was no relationship between this effect and WM span. Solving the problem, in interaction with sex of the participants and, independently, with their WM span, influenced affective responses to problem-related words. Recall of these words, however, was not impaired in the experimental group.*

Key words: *task-irrelevant processing, interference, inhibition, working memory span*

Information that we process while performing a task can be related to a goal that we were striving for earlier, either already accomplished or still unattained. Coming across an external object associated with such a goal or retrieving goal-related item from memory can instigate specific mental activity – a response of the cognitive system indicating that it somehow detects the relationship or is sensitive to it. One obvious manifestation of this sensitivity are conscious thoughts unrelated to the current task and referring to this earlier striving of the subject (e.g., Klinger, 1978, 1996; Martin & Tesser, 1996; McVay & Kane, 2010). However, there are also other indices of this sensitivity, for example, interference effects caused by goal-related stimuli (Riemann & McNally, 1995; Young, 1987, after Klinger, 1996), subtle affective responses to them (Ferguson & Bargh, 2004), or memory consequences of their association with a goal (Bock & Klinger, 1986), which are not necessarily accompanied by conscious detection of the critical relationship or by conscious thoughts related to the goal.

Klinger (1975, 1996) introduced a concept of „current concern", which relates to a latent motivational state of an organism that persists between the commitment of an individual to striving for a particular goal and either the accomplishment of this goal or disengagement from it. According to Klinger, a current concern makes the person more sensitive to cues associated with the respective goal or the means for attaining it. Part and parcel of this sensitivity is in Klinger's theory an emotional response to concern-related stimuli, which facilitates their further processing.

Research indicates that stimuli related to current concerns of an individual attract his or her attention and cause interference when they are irrelevant to the task at hand. For example, concern-related words have been shown to cause interference in the emotional Stroop task (Riemann & McNally, 1995) and in a lexical decision task in which they appeared as peripheral distractors (Young, 1987, after Klinger, 1996).

Concern-relatedness of stimuli or thoughts seems to have affective consequences. In a study by Bock and

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Klinger (1986), ratings of concern-relatedness of words were positively correlated with ratings of their arousal potential. Nikula, Klinger, and Larson-Gutman (1993) found that words related to current concerns of the subjects evoked larger skin conductance responses than words related to current concerns of others and that self-generated thoughts associated with nonspecific skin conductance responses were rated by the subjects as more concern-related than were thoughts that occurred in periods of electrodermal inactivity.

Ferguson and Bargh (2004), using the affective priming technique, have found more positive automatic evaluations of objects related to a goal that had not been accomplished (the continuation of goal-related task was announced) than in the conditions in which it had been fulfilled (the task was terminated). Goal-relatedness did not affect explicit evaluative judgments from the participants. In contrast, Szymańska and Kolańczyk (2002) and Kolańczyk (2008) observed a shift toward more positive explicit evaluations of objects related to the demands of the task the participants were told they would be performing later, and toward more negative evaluations of task-unrelated objects. These effects were apparently moderated by some motivational variables.

In a line of research initiated by Raymond, Fenske, and Tavassoli (2003), it has been shown, using explicit evaluative judgments, that stimuli that appear as distractors in selective attention tasks tend to be devaluated (Fenske, Raymond, & Kunar, 2004; Frischen, Ferrey, Burt, Pistchik, & Fenske, 2012; Raymond, Fenske, & Westoby, 2005; Veling, Holland, & van Knippenberg, 2007).

The relationship between goal-relatedness of a material and remembering it is not clear. In the Bock and Klinger's (1986) study mentioned above, recall of words was positively correlated with ratings of their concern-relatedness. However, when controlling for arousal potential of these words, the partial correlation between recall and concern-relatedness was reduced virtually to zero. An analysis of variance in which proportions of words judged by subjects as related to their current concerns were compared in recalled and not-recalled words and arousal potential of words was included as a covariate suggested a negative relation between concern-relatedness and recall. The authors hypothesized that inhibitory mechanisms might be responsible for this effect.

An influence of goal-striving on the processing of stimuli that appear in the context of a later task is not restricted to the circumstances when these previous goals have not been accomplished. For example, participants in experiments on visual search who in numerous trials looked for letters from a memory set that was consistent across trials (i.e., the searched-for letters never became distractors to be ignored and vice versa) found it difficult to read for an hour or more after the experimental session, because the letters they had been searching for in the experiment "jumped out" from the page (Shiffrin & Schneider, 1977). Pashler and Shiu (1999) have shown that merely imagining an object can lead to "attentional blink" in a subsequent task, in which a drawing of this object appears in a rapid serial visual presentation of line drawings. The target stimulus (a digit) was less likely to be detected when it followed the display of this critical object. The decreased ability to detect the target was observed in these conditions even when the participants were told to get rid of the image before the search of the digit.

In research by the author (Kowalczyk, 1999, 2006), indices of special sensitivity to verbal material related to the demands of a recently solved problem were found, though the subjects did not consciously detect the critical relationship. The participants in these studies solved a simple divergent problem under the instruction of thinking aloud, then performed an ostensibly unrelated speeded affective classification task concerning each of a series of nouns, and then were given a surprise free recall test for these words. Some of the nouns in the classification task corresponded to certain demands of the problem. There were several indices of special processing of these words. In some temporal conditions of the classification task an interference effect was observed in reaction times for words immediately following problem-related words. Analyses concerning the decisions made in the classification task indicated that problem-relatedness affects differently evaluative responses from men and women. After solving the problem men tended to react positively to problem-related words more often than in the control condition, whereas women showed the opposite tendency. Finally, problem-related words were often recalled worse by the participants who solved the problem before the classification task than by the participants in the control condition, who either did not solve any problem or solved some other problem. I refer to this phenomenon as "the effect of impaired recall" (Kowalczyk, 2006).

In one experiment (Kowalczyk, 2006), response-to-stimulus interval (RSI) in the classification task was manipulated between groups. RSI was 350, 750, 1150 and 1550 ms in the experimental groups, solving the problem, and 1150 ms in the control group, in which the problem was not solved. Response latencies for words that immediately followed problem-related words were significantly longer in the 1550-ms RSI experimental condition than in either the 1150-ms RSI experimental condition or in the control condition. Other experimental conditions, with RSIs shorter than 1550 ms, did not differ from the control condition. The effect of manipulation of RSI on response latencies for words immediately following problem-related words in the classification task remained significant even after a nonspecific effect of RSI on latencies was statistically removed.

In each of the experimental groups, men signaled positive affective response to problem-related words significantly more often than women did. The difference did not depend on RSI in the classification task. In the control condition, the difference between men and women was negligible, and in fact, the order of the means was reversed. It should be added, however, that, although the interaction of sex and condition was significant, in analyses performed separately on the results of men and of women, the differences between the experimental conditions and the control condition were not.

In the experimental groups, recall of problem-related words, but not of control words, unrelated to the problem, depended on RSI in the classification task, with best recall at the 1150-ms RSI and significantly worse recall at the shorter RSIs (350, 750 ms) and the longer RSI (1550 ms). Recall of problem-related words was significantly worse in the 350-ms and 750-ms RSI conditions than in the (1150-ms) control condition; however, the difference between the 1550-ms RSI condition and the control condition was not significant.

It should be underlined that most probably these effects were not a consequence of conscious detection of the relationship between words in the classification task and the divergent problem. There were only very few participants who in an extensive post-experimental interview admitted noticing this relationship, and their results were not included into the analyses.

In an explanation of these effects that I have advanced (Kowalczyk, 2006, 2007), they are attributed to mental activity that is triggered when stimuli related to an earlier goal of the subject appear in the classification task. Impaired recall of problem-related words is assumed to be a consequence of inhibitory defense against interference such activity can cause. The representations of these words are suppressed as sources of potential or actual distraction, and as a result of this suppression they are less accessible at recall. The dependence of this effect and of the interference itself on the temporal conditions in the classification task is explained by the assumption of two qualitatively different phases of task-unrelated activity triggered by the problem-related word and the assumption that strategically controlled inhibition may block task-irrelevant processing at the earlier or at the later phase. It depends on the sufficiently long RSI whether the second phase, apparently making greater demands on central processing resources and thus involving interference, can be reached. It is assumed in this explanation that the extent of task-unrelated processing stimulated by the appearance of the critical words can be regulated by manipulating RSI. On the other hand, the subtle influence of problem-relatedness on evaluative decisions, in opposite directions in men and in women, is taken as evidence that problem-related words might be processed in a special way as early as when the classificatory decision is being made, and not just in the "spare" time between a reaction to the word and the appearance of the next one.

The effect of impaired recall of problem-related words and its relationship with RSI in the classification task can also be interpreted in a non-inhibitory way. The main competitor to the inhibitory account is proactive interference due to similarity between the critical material in the classification task and the contents generated during solving the problem. The difference between number of problem-related words recalled in the 1150-ms and 1550-ms RSI experimental conditions may be explained by the difference in the delay to the recall task. Because RSI was manipulated between subjects, RSI was confounded with this delay, and longer delay might strengthen either proactive interference or interference due to interitem similarity of problem-related words[1] (see Kowalczyk, 2006, 2007 for a detailed presentation of the two-phase inhibitory account and the discussion of the alternative explanations). Obviously, a confirmation of the effect in the 1550-ms RSI condition is needed, with the RSI equal in the experimental and in the control group.

It seems that the controversy concerning the nature of the effect of impaired recall can be resolved by finding out how the effect relates to the participants' working memory capacity (WMC). WMC is measured by means of complex span tasks, which require subjects to remember sequences of incoming stimuli while simultaneously processing additional new information. According to Kane and Engle (2003; Engle & Kane, 2004; Kane, Conway, Hambrick, & Engle, 2007), individual differences which underlie performance on complex span tasks are related to differences in the ability to control of attention. Considerable empirical evidence supports the claim that people with high WMC are better able than people with low WMC to sustain access to goal-relevant information despite the presence of external or internal distractors, to overcome conflicts in processing or resist interference due to distracting stimuli or thoughts, and to suppress prepotent responses when they are contextually inappropriate (for reviews see Kane, Conway, et al., 2007; Redick, Heitz, & Engle, 2007; Unsworth, Heitz, & Engle, 2005). Recent work indicates that people with high WMC have less off-task thoughts while performing demanding tasks than people with low WMC (Kane, Brown, et al., 2007; McVay & Kane, 2009, 2012; Unsworth & McMillan, 2012). WMC seems to be positively related to the efficiency of inhibitory mechanisms (for a review and discussion see Redick et al., 2007) and is negatively related to the susceptibility to proactive interference (Friedman & Miyake, 2004; Kane & Engle, 2000; Rosen & Engle, 1998; see also Lustig, May, & Hasher, 2001; Unsworth, 2007; Unsworth & Brewer, 2010; Unsworth, Brewer, & Spillers, 2011; Unsworth & Engle, 2007). Thus, the relationship between WMC and the recall of previous-problem-related words might help to resolve the issue whether their impaired memory results from inhibition or from proactive interference. A positive relationship between WMC and the magnitude of the effect of impaired recall would support an inhibitory account of this effect, whereas a negative relationship would favor the memory interference account.

In light of the findings that concern the functioning of attention in high and low WMC subjects, a conflict between current-goal-related processing and previous-goal-related processing should be more efficiently resolved in favor of the current task in subjects with greater WMC. In our paradigm, this would imply attenuated interference effect in the classification task and inflated impaired recall effect in high WMC participants, if the latter is due to inhibitory defense against distraction.

More generally, assuming that working memory span represents an individual's ability to prevent distraction

[1] These concerns have been raised by W. Trammel Neill in a review of that study.

caused by current-goal-unrelated mental activity, the analysis of the relation between each of the indices of special processing of previous-problem-related words and WM span might shed some light on the mechanisms by which this resistance against distraction is realized.

The Present Study

The present study had two major goals. First, it was an attempt at confirming the phenomena that presumably accompany processing of previous-problem related words at relatively long RSI of 1550-ms in the classification task, with the experimental and the control conditions equaled in terms of RSI. Based on earlier results (Kowalczyk, 2006), all three effects of special processing of problem-related words could be expected in these temporal conditions of the classification task, i.e., interference caused by these words, opposite shifts in frequencies of their positive evaluations in men than in women, and finally, their impaired recall. A second aim of this study was to find out how these effects relate to working memory capacity of the participants.

Participants in the experimental group solved a divergent problem, then performed a speeded affective classification task concerning each of a list of words, and then performed a surprise cued recall test for the words from the classification task. In the control group, there was no problem-solving phase. After the experiment, participants from both groups performed an automated operation span task (Aospan; Unsworth, Heitz, Schrock, and Engle, 2005). The main analyses concerned between-group comparisons of a) response latencies for words immediately following problem-related words in the classification task, b) classificatory decisions for problem-related words in this task (in interaction with sex of the participants), c) recall scores for problem-related words, and d) relationships between each of these variables and WM span of the participants in the experimental and in the control condition. Based on the earlier results and on the inhibitory account of the effect of impaired recall of problem-related words (Kowalczyk, 2006, 2007), the following results were expected: a) longer reaction times for words that immediately followed problem-related words in the classification task in the experimental (problem) than in the control (no-problem) group; b) more frequent positive classificatory decisions for problem-related words in men than in women in the experimental group and no difference related to sex of the participants in the control group; c) worse recall of problem-related words in the experimental than in the control group; d) a negative relationship between WM span of the participants and the magnitude of the interference effect and a positive relationship between their WM span and the magnitude of the effect of impaired recall.

A potentially significant change that concerned memory task had been made in this study relative to all previous experiments in this paradigm: cued recall instead of free recall was used as a memory test. The main rationale behind this step was to increase the base level of recall of problem-related words in the control condition. It had been quite low in studies in which free recall task was used, and this was unfortunate, because the main point of interest in these experiments was the worsening of recall of the critical words in the experimental condition. Low performance on a memory task in the control condition reduces the chances of obtaining a strong and replicable effect of this kind. Moreover, it was expected that a cued recall task would reduce uncontrollable variability due to different strategies that can be used by participants when they perform the free recall task and that a cued recall task would help to control for output interference.

Method

Participants

Eighty one adults (51 women) from 19 to 29 years old ($M = 21.52$, $SD = 2.12$) took part in the study. The majority of them were students of Poznań universities – mostly from various faculties of Adam Mickiewicz University, but also from Medical University, Economic University, Technical University, University of Life Sciences and other colleges. Some participants had already graduated from a college, all had completed high school. The participants received a gift (a USB flash drive or a pen) worth around 6 Euros for taking part in the study. The participants were randomly assigned to the experimental group and to the control group. One participant was excluded from the experimental group, because she discovered (apparently while performing the classification task) the relationship between the critical words and the demands of the divergent problem. After the exclusion there were 40 participants in the experimental group (25 women, $M = 21.6$, $SD = 2.48$, range 19-29) and 40 participants in the control group (25 women, $M = 21.4$, $SD = 1.66$, range 19-25).

Materials

The divergent problem and stimulus words used in the classification and cued recall tasks.

The divergent problem read: "What things from an average flat could be used to sweep out an object that is deep under a cupboard?" There were 33 concrete nouns in the classification task, which belonged to various semantic categories and were rather neutral in their basic affective meaning (see Appendix). Five of them were related to the demands of the problem: *szabla* (sabre), *narta* (ski), *wiosło* (oar), *smyczek* (bow), and *tyczka* (pole)[2]. They denote things of a long shape that usually do not occur in flats. The remaining words in the task did not denote objects of a long shape. Most of them were names of quite simple things that do not occur in flats.

The first four words and the last four words that appeared in the classification task (forming the beginning and the ending block) were presented in the same order for

[2] Smyczek is unambiguously a long rod with a string used for playing musical instruments; tyczka is a long straight stick. These Polish words are not as polisemous as their English translations.

each participant. The remaining 25 words were divided into five blocks of five words each: problem-related words (block 3), words immediately preceding problem-related words in the classification task (block 2), words immediately following problem-related words in this task (block 4), and two blocks of words that neither immediately preceded nor followed problem-related words (blocks 1 and 5). Apart from problem-related words, assignment of words to blocks was made on random bases and was the same for all participants. After the beginning block, words from blocks 1, 2, 3, 4, 5 or 5, 2, 3, 4, 1 (the two orders were counterbalanced across conditions) appeared in turn in the classification task, one word from each block at a time. The cycle repeated five times, each time with different words. Thus, the first noun related to the problem was the seventh word in the series, the last problem-related word was followed by six words not related to the problem, and there were four problem-unrelated words between each two consecutive problem-related words. The positions in the sequence for words from a particular block were fixed, but the order of presentation of the words from a block in these positions was randomized independently for each participant.

Words used as retrieval cues in the recall task were also concrete nouns, related associatively or semantically to the words in the classification task (see Appendix)[3]. There were 33 such cues, each corresponding to one word from the classification task. The first four and the last four word cues in the recall task were presented in the same order for each participant. They were related to words from the beginning and the ending blocks in the classification task, but both in the beginning and in the ending block in the recall task two cues were related to words from the beginning block in the classification task and two cues were related to words from the ending block in the classification task. This arrangement was made to discourage the participants from attempts at using sequential information at recall. The remaining 25 cues were divided into five blocks of five words each, with each block corresponding to a block of words in the classification task. As in the classification task, there were fixed positions in the sequence for cues from different blocks, and words from the particular block were assigned to these positions randomly and independently for each participant. However, the order of blocks in the sequence was different than the order of the corresponding blocks in the classification task. The rearrangement was made so that no two adjacent cues could relate to words that were in the adjacent positions in the classification task. For each sequence of blocks of words in the classification task, two sequences of blocks of cue words that met this requirement were created. The four sequences of blocks of cues in the recall task were counterbalanced across conditions.

Working memory span task

An automated operation span task (Unsworth et al., 2005), obtained from Randall Engle's Attention and Working Memory Lab, with instructions translated into Polish, was used to assess working memory span of the participants. Short lists of to-be-remembered letters were presented, with each letter preceded by a simple equation involving a multiplication or division and then an addition or subtraction. The participant verified the equations and tried to memorize the letters. After each list was presented, the participants were required to recall the letters in the correct order. Lists of three to seven letters were used. There were three sets of each set size, which makes for a total of 75 letters and 75 equations. The order of set sizes was randomized for each participant.

This automated version of the Turner and Engle's (1989) Ospan task requires the participant to only click the mouse button and does not need an assistance of the experimenter. To prevent participants from rehearsing the letters while the equations are being processed, a response deadline is set, based on the participants' individual mean latencies for 15 practice trials in which the equations are verified and the letters are not presented. The limit is set at *M* + 2.5 *SD*s.

The main scores computed by the program are Ospan absolute score and Ospan total correct. Ospan absolute score is the sum of letters in perfectly recalled sets. Ospan total correct is the total number of letters recalled in the correct positions.

Procedure

Participants were tested individually in an office room with the experimenter present. A laptop computer with 15.6 inch anti-glare screen was used for the presentation of instructions and stimuli, and a mouse and a PST Serial Response Box (SR box) were used for manual response data collection. Two buttons of the SR box were labeled "T" (the first letter of "tak", meaning "yes" in Polish) and "N" (the first letter of "nie", meaning "no" in Polish). (Further I will refer to them as the *Yes* and the *No* button, respectively). Participants were instructed to use the index and middle fingers of their dominant hand in their manual responses. SR box was placed to the right or to the left of the computer for the right-handed and the left-handed participants, respectively. Verbal responses of the participants were recorded by means of a digital device. The software used for creating and running the experiment was E-prime Professional 2.0.

At the beginning of the session the participants were encouraged to arrange the position of the laptop, the mouse and the SR Box in the most preferable way.

The initial instructions announced that the study concerned "a variety of mental processes, like memory, thinking, judging, classifying, etc." and that the participant

[3] Candidate nouns had been tested in small groups of students and also in a pilot study in which there were 42 participants. The following criteria of acceptance of a word as a retrieval cue were adopted: 1) a cue had to be related to only one word from the classification task; 2) cues had to be effective, facilitating recall, yet 3) they must not be too strong, to avoid a ceiling effect.

would be asked to do "a few different tasks" and also to answer questions concerning his or her feelings and thoughts. To keep up the impression that the tasks concerned a set of separate mental abilities or skills, each task was preceded by a "title", e.g., "Generating of solution ideas", "Classification of numbers", "Memory", which was displayed for 5000 ms. After each task "Thank you" was displayed for 2000 ms. Reading the introductory instructions to all tasks was subject-paced.

The events in the experiment were as follows:

Exercise task: speeded classification of towns. Each of a list of towns appeared in the centre of the screen and participants were instructed to respond as quickly as they could by pressing the *Yes* button when the town was in Poland and the *No* button when the town was abroad. There were 11 names of Polish and 11 names of foreign towns, presented in random order. The names were displayed until the participant responded or 1500 ms elapsed. If the response was correct, the message "Right!" and the participant's reaction time in seconds were displayed in blue font for 1500 ms. If the answer was wrong, there was a tone, and the message "Error!" was displayed in red for 1500 ms. If the participant did not respond within 1500 ms after the stimulus onset, there was a tone and the message "There hasn't been a response for too long" in red font appeared on the screen for 1500 ms. After a feedback message the presentation of the next stimulus began.

Problem solving. (Only in the experimental group). Introductory instructions to the task told participants that they would be asked to find as many things from an average flat as possible with which one could achieve a practical goal. Participants were instructed that they would be required to "think aloud" while doing this task, that is, to say out loud all ideas that would come to their mind, both the good ones and the bad ones. They were also encouraged to make use of all the time that was given for the task and not to give up before being signalled that it was over. Participants were not told about the amount of time they would have to do the task. Having read the instructions, the participant clicked the mouse, and the problem appeared on the screen along with the reminder to verbalize aloud all solution ideas. The text remained on the screen till the end of the task.

If when solving the problem the participant lapsed into a prolonged silence, the experimenter prompted him or her to keep verbalizing ideas coming to mind. If participants announced that they would not find any new solutions, the experimenter encouraged them not to give up as long as there was time to do the task.

After three and a half minutes, the task was discontinued by a tone, the problem disappeared from the screen, and "Thank you" was displayed. Immediately afterwards, the participant was inquired about any solution ideas he or she had had and yet had not reported, in particular, about ideas that did not meet the demands of the problem.

Filler task: speeded classification of numbers. Numbers were displayed in the centre of the screen, one at a time. Participants responded by pressing the *Yes* button when the number was even and the *No* button when it was odd. The instructions stressed speed and accuracy. There were 28 one- and two-digit numbers, half of them even and half odd, presented in random order. Immediately after a response from the participant or when 1500 ms since the stimulus onset had passed, the screen went blank for 1000 ms and the next number was displayed. There was no feedback message. The task along with reading the instruction to it lasted approximately 1 min.

Word classification task. The task was announced to participants as "The emotional classification of words". Participants were requested to decide quickly whether the word appearing on the screen evokes rather positive or rather negative feelings in them and to press the button *Yes* or *No*, respectively. Participants were asked to respond "spontaneously and quickly" and to follow their "first impression rather than a long deliberation".

Words were presented in the center of the screen, one at a time, in one series. The word was displayed until the participant responded or until 5000 ms elapsed. Then the screen went blank for 1550 ms and the presentation of the next word began.

Filler task: serial recall of digits. Letters and sporadically digits were briefly presented in the center of the computer screen in sequences of 30 stimuli each. Participants were to remember and recall digits. There were 3 digits in the first series of stimuli, 4 – in the second series, and 5 in the last one. The trial began with the word "Attention!" that appeared in the centre of the screen for 500 ms. It was followed by a "+" fixation sign, displayed for 500 ms, after which the screen went blank for another 500 ms and the presentation of stimuli began. Each stimulus was presented for 250 ms. There was no blank interval between the stimuli. After each of the three series the participant had 5 seconds to say out loud the digits in order. The whole task lasted 27 seconds plus the time needed to read the instruction that counted 61 words.

Cued recall task. A word cue that was semantically or associatively related to a noun from the affective classification task appeared on the screen for 5000 ms, e.g., meadow________? for the word *butterfly*. Using the cue the participant was to recall the proper word from the classification task and to say it out loud. After 5 seconds elapsed, the cue was replaced by a cue for another word. Participants were told in the instruction that when the new cue appeared they should try to recall this new word even if they had not succeeded with the previous one. After all cues were presented, the participant was asked if there had been any words from the classification task that he or she recalled but did not say out loud, because the words did not match the cues. If there had been such words, the participant was to say them.

Questions after the experiment. Participants were inquired if they had expected that they would be asked to recall the words from the classification task and if they were trying to remember them while performing the task.

This was meant as a check of what the participant had known about the experiment on arrival. More importantly, participants in the experimental group answered a question that was meant to reveal whether they had noticed the critical relationship between words in the classification task and the divergent problem. „In one of the tasks you were looking for things with which one could sweep a thing from under the cupboard. Did you still think about this problem when you were performing tasks that came later? Did you think of any new solutions?" If the answer was something else than definite „no", the experimenter further inquired about this issue.

After answering these questions, the participants filled in a computerized state questionnaire (a 46-item adjective checklist) concerning their mood, motivation and concentration while they had been performing the experimental tasks. An opportunity of a short break was offered at the end of this part of the session, before beginning the Aospan procedure, but virtually all participants wanted to continue without a break. After the participants completed the Aospan task, two computerized questionnaires were administered. One was a self-report measure of the respondent's proclivity for mind-wandering, and the other referred to the frequency of various "cognitive failures" due to attention lapses[4].

In the control group, the procedure was the same as that in the experimental group, with the exception that participants did not solve the problem and were not asked the question concerning it. Immediately after the exercise task, the number classification task followed.

At the end of the session the participants were encouraged to ask questions about anything concerning the experiment they wished to know. They were asked not to talk about the events in the experiment to people who might serve as participants in the study in the future. The entire session with an individual participant lasted approximately 1 hour.

Results

Working memory span task

Mean Ospan absolute score for all participants was 34.39, *SD* = 16.41, range 3-70. The means in the experimental group (*M* = 35.85, *SD* = 18.73, range 3-69) and in the control group (*M* = 32.93, *SD* = 13.78, range 6-70) did not differ significantly from each other ($F < 1$). Mean Ospan total correct for the participants from both groups was 54.73, *SD* = 12.32, range 20-72. It was the same in the experimental group (*M* = 54.73, *SD* = 14.83, range 20-72) and in the control group (*M* = 54.73, *SD* = 9.36, range 28-71). Analyses concerning Ospan absolute scores will be reported in this paper[5].

Problem solving performance

On average, participants verbalized 11.68 (*SD* = 4.9, range 3-21) "strict" solutions to the divergent problem, i.e. names of things one could use to sweep out something that is under a cupboard (e.g., "broomstick", "ladle", "laptop"). Participants also delivered solutions that, though related to the goal set in the problem, transgressed the literal requirements of the task (e.g., "to move the cupboard", "to use the vacuum-cleaner", "to use a small ball")[6]. On average, there were .53 (*SD* = 0.68, range 0-2) such "loose" solution ideas per participant. Both counts included solutions verbalized during solving the problem and solutions the participants expressed when inquired immediately after solving the problem about ideas they had had and yet had not voiced.

Response latencies

Three categories of words were taken into account in the analyses of mean response latencies: problem-related words, words that in the classification task immediately followed problem-related words, and the control words, i.e., words from blocks 1, 2 and 5. Table 2 presents untransformed mean response latencies for these three categories of words in the experimental and in the control group.

Table 1. Mean Response Latency in the Affective Classification Task (in ms) by Category of Words and Group

GROUP	CATEGORY OF WORDS		
	Problem-related	Following problem-related	Control
Experimental	1037 (239)	896 (144)	972 (174)
Control	955 (265)	833 (205)	956 (215)

Note. [a]Participants in the experimental group solved the problem before the classification task and participants in the control group did not. [b]Numbers in parentheses are standard deviations.

To reduce the skewness in the distribution of the data and the influence of outliers, individual mean response latencies were submitted to the inverse transformation[7]. All analyses to be reported that concern RTs were performed on transformed means.

[4] Analyses concerning data collected with the state and trait questionnaires used in the study will not be reported in this paper. The results did not qualify the relationships found in the analyses which are reported.

[5] In their methodological review, Conway et al. (2005), on the basis of empirical analyses, express preference for partial-credit scoring over all-or-nothing scoring. However, in the present study Ospan absolute scores were normally distributed in both groups, whereas Ospan total scores deviated from normality in the experimental group. The two measures highly correlated with each other (Spearman's *rho* = .92, $p < .001$) and all significant results that are reported were also significant when Ospan total score instead of Ospan absolute score was used as a measure of WM span.

[6] The classification of recorded solutions into "strict" and "loose" categories was made by the author according to the rules developed earlier in this line of research (e.g., Kowalczyk, 2007).

[7] Transforming RTs to the reciprocal of latency normalizes the distribution to some extent, effectively reduces the effects of exceptionally long latencies, and maintains good power (Ratcliff, 1993; Whelan, 2008).

A 2 (Group) x 3 (Category of words) mixed-factorial analysis of variance was performed on response latencies with Category of words as the within-subject factor. There was a significant main effect of Category of words, $F(2, 156) = 40.96$, $p < .001$, partial $\eta^2 = .344$. Paired comparisons with Bonferroni correction indicated that response latencies for words following problem-related words were significantly shorter than response latencies for problem-related words and for control words (in both cases $p < .001$). The main effect of Group was not significant, $F(1, 78) = 2.65$, $p = .108$, partial $\eta^2 = .033$, but there was a significant interaction between Group and Category of words, $F(2, 156) = 3.82$, $p = .024$, partial $\eta^2 = .047$.

Planned between-group comparisons for each of the three categories of words confirmed significant effect of Group for words following problem-related words, $F(1, 78) = 4.64$, $p = .034$, partial $\eta^2 = .056$. For problem-related words, the between-group difference did not reach significance, $F(1, 78) = 2.91$, $p = .092$, partial $\eta^2 = .036$, and for control words, $F < 1$.

The results confirmed the expectation that solving the problem would cause longer response latencies for words immediately following problem-related words in the classification task. However, this effect did not relate to WM span of the participants. Correlations between Ospan score and response latencies for words following problem-related words were -.222 ($p = .168$) in the experimental group and .145 ($p = .373$) in the control group. The difference between the two coefficients is not significant ($z = -1.6$, $p = .11$). Note that since the analyses were performed on inverse-transformed RTs, a negative coefficient indicates a positive relationship between RTs and Ospan score. Thus, the direction of the difference between the two coefficients was opposite to what was expected. An analysis of regression performed on response latencies for words immediately following problem-related words as the dependent variable, and Group, Ospan score (centered), and interaction between the two as predictors indicated that Group did not significantly moderate the relationship between Ospan score and the dependent variable (for the interaction term, $t = -1.51$, $p = .135$). The hypothesis that there would be a negative relationship between WMC and the interference effect in the classification task was not supported.

No significant relationships were found between the number of solutions verbalized by the participants in the experimental group and response latencies to problem-related words and words immediately following problem-related words in the classification task.

Responses in the affective classification task

Mean percent of the positive affective responses to problem-related words and to control words in men and in women in the experimental and the control group is presented in Table 2. The pattern of means was as expected on the basis of previous results: women tended to respond less often positively to problem-related words in the experimental than in the control condition, and the reverse was true for men. However, a 2 (Group) x 2 (Sex of participants) x 2 (Category of words) mixed-factorial analysis of variance performed on mean percent of *Yes* responses, with Category of words as the within-subject factor, did not yield a significant three-way interaction, $F(1, 76) = 1.62$, $p = .206$, partial $\eta^2 = .021$. The main effects of Category of words, Group, Sex, and the two-way interaction of Group and Sex were not significant, either; for Group, $F(1, 76) = 1.3$, $p = .259$, partial $\eta^2 = .017$; for all the remaining effects, $F < 1$. There was a significant two-way interaction between Category of words and Sex, $F(1, 76) = 5.41$, $p = .023$, partial $\eta^2 = .066$, but none of the simple effects in the analysis ignoring groups was significant after the Bonferroni correction.

Table 2. Mean Percent of Positive Affective Classifications of Words by Category of Words, Sex of the Participants, and Group

GROUP	CATEGORY OF WORDS			
	Problem-related		Control	
	Men	Women	Men	Women
Experimental	76.0 (18.8)	60.8 (21.2)	68.4 (13.0)	71.2 (16.1)
Control	64.0 (25.3)	62.4 (21.1)	64.9 (18.6)	68.5 (17.1)

Note. [a]Participants in the experimental group solved the problem before the classification task and participants in the control group did not. [b]Numbers in parentheses are standard deviations.

Although the three-way interaction of Group, Sex, and Category of Words was not significant, planned comparisons of mean percent of *Yes* responses for problem-related words between men and women were performed separately in the experimental and in the control group. In the experimental group, the difference between men and women was significant, $F(1, 38) = 5.23$, $p = .028$, partial $\eta^2 = .121$, while in the control group the effect of Sex was miniscule, $F(1, 38) = 0.05$, $p = .830$, partial $\eta^2 = .001$. This conforms to the expectations based on previous results (Kowalczyk, 1999, 2006).

The same analyses were performed on mean percent of *Yes* responses for the control words, i.e., words from blocks 1, 2 and 5, and they did not reveal any significant effect (all *Fs* < 1).

By means of correlational analyses it was checked whether the number of *Yes* decisions for problem-related words in the experimental and in the control group was related to Ospan score. There was a significant negative correlation between Ospan score and the number of *Yes* responses to problem-related words in the experimental group ($r = -.394$, $p = .012$), and a positive significant correlation between these variables in the control condition ($r = .429$, $p = .006$). The difference between these coefficients was significant, $z = -3.76$, $p < .001$. An analysis of regression performed on numbers of *Yes* responses for problem-related words, with Group, Ospan score (centered), and interaction between Group and Ospan score as predictors, indicated that Group significantly moderated the relationship between Ospan score and the number of *Yes* responses for problem-related words (see part A of Table 3 - see page 187).

Table 3. Regression Analyses for the Frequency of Positive Affective Classifications of Problem-Related Words

Predictor	β	t	p
A. Experimental group and control group			
Ospan	.524	2.97	.004
Group	.072	.690	.492
Ospan x Group	-.692	-3.93	.000
R^2 = .175, F(3, 76) = 5.39, p = .002.			
B. Experimental group			
Ospan	-.412	-2.89	.006
Sex	-.401	-2.89	.007
Percent *Yes* to control words	.099	0.70	.489
R^2 = .318, F(3, 36) = 5.59, p = .003.			
C. Control group			
Ospan	.242	1.53	.135
Sex	-.053	-0.38	.710
Percent *Yes* to control words	.395	2.49	.018
R^2 = .304, F(3, 36) = 5.23, p = .004.			

Note. [a]Sex: 1 = woman, 0 = man. [b]Group: 1 = experimental (problem solved before the classification task), 0 = control (no-problem). [c]Ospan – Ospan score (centered).

To find out whether sex of participants and their Ospan score are independent and selective predictors of the number of *Yes* responses to problem-related words, multiple regression analyses were performed separately for the data from the experimental and from the control group, with Sex, Ospan score and the number of *Yes* responses for the control words as predictors. The results are presented in parts B and C of Table 3. In the experimental group, Sex and Ospan score were significant predictors of the dependent variable, while the number of *Yes* responses to the control words was not. In contrast, neither Sex, nor Ospan score were significant predictors of *Yes* responses to problem-related words in the control group, but the number of *Yes* responses to control words was.

The number of *Yes* responses to problem-related words in the experimental group was also related to the number of strict solutions to the problem that were verbalized by the participants (r = .314, p = .049). When the number of problem solutions was added as a predictor to sex of the participants and their Ospan score (centered) in the regression model for *Yes* responses to problem-related words, all three predictors turned out significant (for Ospan score, β = -.459, t = - 3.60, p = .001; for sex, β = - .390, t = - 3.06, p = .004; for number of problem solutions, β = .339, t = 2.67, p = .011) and the model significantly improved (R^2 = .423, F(3, 36) = 8.78, p < .001; ΔR^2 = .114, F(1, 36) = 7.11, p = .011). None of these predictors was significant in the analysis for number of *Yes* responses to control words, and the whole three-predictor model for this dependent variable was not significant, either (F < 1).

Recall scores

Table 4 presents mean percent of problem-related words, words immediately following problem-related words, and control words recalled in the experimental and in the control group. A mixed-factorial analysis of variance performed on these means yielded a significant effect of Group, F(1, 78) = 4.09, p = .046, partial η^2 = .050, indicating that participants in the experimental group recalled generally more words than participants in the control group, and a significant effect of Category of words, F(2, 156) = 72.80, p < .001, partial η^2 = .483. Post hoc comparisons with Bonferroni correction revealed that all three within-subject differences were statistically significant (all corrected ps < .001). The interaction between Group and Category of words was not significant, F(2, 156) = 1.45, p = 0.237, partial η^2 = .018. Separate between-group comparisons for each of the categories of words revealed that the difference was not significant for problem-related words (p = .317) and for control words (p = .265), and it was significant for words following problem-related words, F(1, 78) = 6.80, uncorrected p = .011, partial η^2 = .080. The difference for words following problem-related words remained significant even when recall score for the control words was used as a covariate in the analysis, to control for a possible nonspecific influence of solving the problem on recall, F(1, 77) = 5.39, p = .023, partial η^2 = .065.

Table 4. Mean Percent of Words Recalled by Category of Words and Group

GROUP	CATEGORY OF WORDS		
	Problem-related	Following problem-related	Control
Experimental	44.5 (22.4)	77.0 (17.9)	53.3 (17.7)
Control	39.5 (21.9)	65.0 (23.0)	48.8 (18.1)

Note. [a]Participants in the experimental group solved the problem before the encoding and participants in the control group did not. [b]Numbers in parentheses are standard deviations.

Neither in the experimental group, nor in the control group, recall of problem-related words and of words following problem-related words was reliably related to Ospan score. For problem-related words, correlations between recall scores and Ospan score were .087 (p = .593) in the experimental group, and .302 (p = .059) in the control group. The difference between them is in the expected direction, but not significant, z = - 0.97, p = .332. As indicated by regression analysis, with Group, Ospan score (centered), and interaction between them as predictors, Group did not moderate significantly the relationship between recall scores and Ospan score (for interaction term, t = - 1.19, p = .238). For words following problem-related words, correlations between recall scores and Ospan score were -.121 (p = .457) in the experimental group, and .149 (p = .360) in the control group. The difference between them is not significant, either, z = -1.17, p = .242. Again, as indicated by regression analysis, Group did not moderate significantly the relationship between recall scores and Ospan score (for interaction term, t = -1.22, p = .227).

To sum up, problem-relatedness of words did not influence their recall. The expected effect of impaired recall of words related to the demands of a previously solved problem was not confirmed and recall of such words was not related to Ospan score. The results suggest that solving the problem before the orienting task generally facilitated recall. This was most pronounced for words immediately following problem-related words in the classification task. Analyses of response latencies have shown that solving the problem can affect processing of words that in the classification task immediately follow problem-related words. Improved recall of words following problem-related words in the experimental group can be another index of this influence. However, taking into account that interaction between Group and Category of words was not significant and that the effect had not been predicted, a final conclusion should be suspended.

Discussion

The aim of this experiment was to replicate and clarify previous findings concerning special processing of words related to the demands of a problem that has been recently solved and to learn whether various indices of this processing are related to working memory capacity of the participants. Two of the three expected basic effects were confirmed.

Response latencies for words immediately following problem-related words in the classification task were longer in participants who had been solving the problem than in participants in the no-problem control condition, though the former apparently did not consciously notice the relationship between the critical words and the problem. This interference effect can be taken as evidence that people are sensitive to the relationship between material processed in the current task and the demands of a problem they have been solving. Previous-problem-related material causes additional mental activity, which can interfere with the current task. However, the magnitude of this interference in the present study was not related to WM span of the participants.

That participants processed previous-problem-related words in a special way is also evidenced by analyses concerning *Yes* and *No* responses in the affective classification task in men and in women, where *Yes* meant that the word evoked a positive feeling in the participant and *No* indicated the opposite. In the experimental group, *Yes* responses for problem-related words were significantly more frequent in men than in women, whereas in the control (no-problem) group, the difference related to sex of the participants was very small and not significant. There were no significant effects related to sex of the participants in the analyses concerning responses to control words. This pattern of results replicates the findings from two earlier studies (Kowalczyk, 1999, 2006). Problem-relatedness of the words in interaction with sex of the participants influenced responses to these words in the affective classification task. This implies that special processing of the stimuli related to a previously solved problem may begin as early as when they are being analyzed with respect to the demands of the current task, before the decision required by the task is made.

The present study brought about new evidence supporting this last conclusion. There was a negative relationship between WM span of the participants in the experimental group and the frequency of their positive evaluative responses for problem-related words. WM span and sex of the participants proved to be independent significant predictors of this frequency, even when the number of *Yes* responses for the control words, unrelated to the problem, was included as a predictor in the regression analysis. In the control group, neither WM span, nor sex of the participants were significant predictors of the frequency of *Yes* responses for problem-related words when the frequency of positive affective responses to control words was included as a predictor in the analysis. First-order correlations between WM span and the frequency of *Yes* responses in the no-problem group were *positive* (and significant) for both problem-related words and control words.

The finding of the negative relationship between working memory capacity and the positive affective classifications of previous-problem-related words, which obviously needs a replication, seems to be extremely interesting in light of the assumption that an evaluative response to an object may facilitate or hamper its further processing. Klinger (1996) suggested that an affective ("protoemotional") response to a concern-related object fosters its further processing, which concerns the relevance of the object to the goal of the individual. Fergusson and Bargh (2004) claim that stimuli related to unfulfilled goals of the person are more positively evaluated and therefore become more "approach friendly". It can be hypothesized that a negative shift in evaluation of objects that are related to *previous* goals of the individual, making the objects less "approach friendly", is a part of the mechanisms by which high WMC individuals are able to concentrate on the current task despite the presence of potentially distracting stimuli that are somehow related to the individuals' earlier tasks or strivings.

Exploratory analyses of the data obtained in the study also suggest a positive relationship between the number of *Yes* responses to problem-related words in the experimental group and the number of the problem solutions verbalized by the participants. Because of the lack of proper control conditions, we cannot be certain whether this relationship is another manifestation of the influence of problem solving activity on affective responses to relevant material that appears in a later task. However, this interpretation is plausible, given that no such relationship was found for the control words.

The results of the experiment did not confirm the expectation that recall of problem-related words would be impaired in participants who solved the problem before encoding. The predicted interaction between problem vs. no-problem condition and WM span of the participants in the analysis of recall scores for problem-related words was not confirmed, either. The failure to find the effect of impaired recall in the conditions of the present experiment is open to different interpretations, both in the general frame of inhibitory account of the effect and in light of its non-inhibitory accounts. This null result can simply mean that solving the problem does not affect memory accessibility of problem-related words when they are encoded in such temporal conditions in the classification task. Alternatively, the memory task used in the present experiment might be not appropriate to reveal such an influence. Unlike all previous experiments in this paradigm, a cued recall task instead of the free recall task was used in the present study. This change in various ways could have offset the effect of impaired memory for problem-related words.

In the first place, it is possible that subtle differences in memory accessibility of problem-related words between the experimental and the control condition can be detected when retrieval cues at test are relatively weak (it is just the information about the context of encoding and about already retrieved items which is at the disposal of the participant), but not when stronger retrieval cues are available (the information about the context of encoding and about previously retrieved items plus a semantic cue). Also, retrieval that is conditioned on the presence of strong cues can to a large extent depend on processes that are different than the processes responsible for retrieval of most items in free recall.

Tulving (1985) using "remember-know" procedure found that proportion of "remember" judgments was highest for items that were recalled in a free recall test, which was performed first, lower for items given in a subsequent category cued recall test but not in free recall, and lowest for items given for the first time in the third, category plus the first letter cued recall test. Under the (simplifying) assumption that "remember" and "know" responses correspond, respectively, to conscious and automatic memory processes (Jacoby, 1991; Jacoby, Yonelinas, & Jennings, 1997; Yonelinas, 2002), these results support the claim that performance in free recall task and in cued recall task can represent different share of these processes.

Graf, Squire, and Mandler (1994) found that amnesic participants' performance was 14% on free recall tests, 58% on a word-stem cued recall test, and 57% on an indirect word-stem completion test. One way of interpreting these participants' achievements in free recall and cued recall tests is in terms of unconscious (automatic) influences of prior experience (see McCabe, Roediger, & Karpicke, 2011). Under this interpretation, these results indicate that automatic influences can quite strongly affect performance in cued recall and to a much lesser extent in free recall. If inhibition (or whatever is the source of lessened accessibility of problem-related material in our paradigm) affects conscious episodic memory and not automatic influences of past experiences, its consequences can be harder to detect when a cued recall test is used. Guided by the cue, the participant can produce the critical item without really recalling its occurrence in the classification task. Automatic influences can compensate for the lack of true episodic retrieval.

Another difference between free recall and cued recall that might be of consequence in our paradigm concerns similarity between the problem solving phase of the experiment and the memory test phase. Replacing free recall with cued recall decreases similarity between the problem solving task and the memory test and perhaps increases the similarity between the classification task and the memory test. When solving the problem and when free-recalling items from memory the participant has to think of the responses and speak them out without external prompts, whereas cued recall involves generating, within given time constraints, responses to stimuli appearing on the screen. Decreased similarity between the problem solving task and the memory test might help participants to resist interference due to similarity between the material generated during solving the problem and the critical stimuli in the classification task.

Finally, one possible explanation of the effect of impaired recall is that task-unrelated processing caused by the critical words in the classification task hampers the encoding of contextual information (see Kowalczyk, 2007). This hampering would substantially impair retrieval when information about context is the only retrieval cue, but it might be of less importance when also a semantic cue is available at the test.

To sum up, the failure to obtain the effect of impaired recall in the present study, with a new memory task in this paradigm, does not allow definite conclusions. It can be reconciled with inhibitory and non-inhibitory accounts of the phenomenon. Information about working memory capacity of the participants is of no help in resolving the controversy concerning the nature of the effect of impaired recall when the conditions created in the experiment disabled whatever mechanism is responsible for the impairment. In the first place, we should find out whether the effect is confirmed with identical temporal conditions in the classification task and free recall as the memory test.

Conclusion

The results of this study indicate that people show special sensitivity to material related to a problem they previously solved, even when they do not consciously notice the critical relationship. This sensitivity was manifested in longer reaction times for words immediately following problem-related words in the classification task and in a shift, moderated by sex of the participants and by their working memory span, in evaluative responses to problem-related words themselves. With this respect the study confirms and extends earlier findings by the author. The effect of impaired recall of problem-related words was not confirmed, and this may be a consequence of using in this study, unlike all previous experiments in this paradigm, cued recall and not free recall as a memory task. Although today this null result is open to various interpretations, it may prove to be of theoretical importance in the future, helping to delineate the boundary conditions of the effect and to shape its explanation.

References

Bock, M., & Klinger, E. (1986). Interaction of emotion and cognition in word recall. *Psychological Research, 48*, 99-106.

Conway, R.A., Kane, M.J., Bunting, M.F., Hambrick, D.Z., Wilhelm, O., Engle, R.W. (2005). Working memory span tasks: A methodological review and user's guide. *Psychonomic Bulletin & Review, 12*, 769-786.

Engle, R.W., & Kane, M.J. (2004). Executive attention, working memory capacity, and a two-factor theory of cognitive control. In B. Ross (Ed.), *The Psychology of Learning and Motivation* (Vol. 44, pp. 145-199). NY: Elsevier.

Fenske, M.J., Raymond, J.E., & Kunar, M.A. (2004). The affective consequences of visual attention in preview search. *Psychonomic Bulletin & Review, 11*, 1055-1061.

Ferguson, M.J., & Bargh, J.A. (2004). Liking is for doing: The effects of goal pursuit on automatic evaluation. *Journal of Personality and Social Psychology, 87,* 557-572.

Friedman, N.P., & Miyake, A. (2004). The relations among inhibition and interference control functions: A latent-variable analysis. *Journal of Experimental Psychology: General, 133*, 101-135.

Frischen, A., Ferrey, A.E., Burt, D.H.R., Pistchik, M., & Fenske, M.J. (2012). The affective consequences of cognitive inhibition: devaluation or neutralization? *Journal of Experimental Psychology: Human Perception and Performance, 38*, 169-179.

Graf, P., Squire, L.R., & Mandler, G. (1984). The information that amnesic patients do not forget. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 10,* 164-178.

Jacoby, L.L. (1991). A process-dissociation framework: Separating automatic from intentional uses of memory. *Journal of Memory and Language, 30,* 513-541.

Jacoby, L.L., Yonelinas, A.P., & Jennings, J. (1997). The relation between conscious and unconscious (automatic) influences: A declaration of independence. In J. Cohen & J.W. Schooler (Eds.), *Scientific approaches to consciousness* (s. 13-47). Mahwah: Erlbaum.

Kane, M.J., & Engle, R.W. (2000). Working-memory capacity, proactive interference, and divided attention: Limits on long-term memory retrieval. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 26*, 336-358.

Kane, M.J., & Engle, R.W. (2003). Working-memory capacity and the control of attention: The contributions of goal neglect, response competition, and task set to Stroop interference. *Journal of Experimental Psychology: General, 132*, 47-70.

Kane, M.J., Brown, L.H., McVay, J.C., Silvia, P.J., Myin-Germeys, I., & Kwapil, T.R. (2007). For whom the mind wanders, and when. An experience-sampling study of working memory and executive control in daily life. *Psychological Science, 18*, 614-621.

Kane, M.J., Conway, A.R.A., Hambrick, D.Z., & Engle, R.W. (2007). Variation in working memory capacity as variation in executive attention and control. In A.R.A. Conway, C. Jarrold, M.J. Kane, A. Miyake, & J.N. Towse (Eds.), *Variation in working memory* (pp. 21-48). New York: Oxford University Press.

Klinger, E. (1975). Consequences of commitment to and disengagement from incentives. *Psychological Review, 82*, 1-25.

Klinger, E. (1978). Modes of normal conscious flow. In G.E. Schwartz & D. Shapiro (Eds.), *Consciousness and self-regulation: Scientific investigations into the flow of human experience* (pp. 225-258). New York: Plenum.

Klinger, E. (1996). The contents of thoughts: Interference as the downside of adaptive normal mechanisms in thought flow. In I.G. Sarason, B.R. Sarason, & G.R. Pierce (Eds.) *Cognitive interference: Theories, methods, and findings* (pp. 3-23). Hillsdale, NJ: Erlbaum.

Kolańczyk, A. (2008). Wpływ samokontroli na wartościowanie treści związanych z zadaniem [The effect of self-control on evaluation of meanings related to a task]. *Czasopismo Psychologiczne, 14,* 201-214.

Kowalczyk, M. (1999). Efekt pogorszenia pamiętania treści związanych z wymogami problemu a hipoteza przedświadomej selekcji pomysłów [Impaired recall of problem-related words and the hypothesis of preconscious selection of solution ideas]. *Czasopismo Psychologiczne, 5*, 109-127.

Kowalczyk, M. (2006). Memory for words related to demands of a problem solved prior to encoding: An investigation into inhibitory mechanisms of defence against distraction. *Polish Psychological Bulletin, 37*, 154–171.

Kowalczyk, M. (2007). *Myśli oderwane od zadania. Geneza dystrakcji i mechanizmy obrony.* [*Task-unrelated thoughts. The origins of distraction and mechanisms of defence*]. Poznań: Wydawnictwo Naukowe UAM.

Lustig, C., May, C.P., Hasher, L. (2001). Working memory span and the role of proactive interference. *Journal of Experimental Psychology: General, 130,* 199-207.

Martin, L.L., & Tesser, A. (1996). Some ruminative thoughts. In R.S. Wyer, Jr. (Ed.), *Ruminative Thoughts. Advances in Social Cognition* (Vol. 9, pp. 1-47). Mahwah: Erlbaum.

McCabe, D.P., Roediger III, H.L., & Karpicke, J.D. (2011). Automatic processing influences free recall: converging evidence from the process dissociation procedure and remember-know judgments. *Memory & Cognition, 39*, 389-402.

McVay, J.C., & Kane, M.J. (2009). Conducting the train of thought: working memory capacity, goal neglect, and mind wandering in an executive-control task. *Journal of Experimental Psychology: Learning, Memory and Cognition, 35*, 196-204.

McVay, J.C., & Kane, M.J. (2010). Does mind wandering reflect executive function or executive failure? Comment on Smallwood and Schooler (2006) and Watkins (2008). *Psychological Bulletin, 136*, 188-197.

McVay, J.C., & Kane, M.J. (2012). Why does working memory capacity predict variation in reading comprehension? On the influence of mind wandering and executive attention. *Journal of Experimental Psychology: General, 141*, 302-320.

Nikula, R., Klinger, E., & Larson-Gutman, M.K. (1993). Currrent concerns and electrodermal activity: Responses to words and thoughts. *Journal of Personality, 61*, 63-84.

Pashler, H., & Shiu, L.-P. (1999). Do images involuntarily trigger search? A test of Pillsbury's hypothesis. *Psychonomic Bulletin & Review, 6,* 445-448.

Ratcliff, R. (1993). Methods for dealing with reaction time outliers. *Psychological Bulletin, 114*, 510-532.

Raymond, J.E., Fenske, M.J., & Tavassoli, N.T. (2003). Selective attention determines emotional responses to novel visual stimuli. *Psychological Science, 14*, 537-542.

Raymond, J.E., Fenske, M.J., & Westoby, N. (2005). Emotional devaluation of distracting patterns and faces: A consequence of attentional inhibition during visual search? *Journal of Experimental Psychology: Human Perception and Performance, 31*, 1404-1415.

Redick, T.S., Heitz, R.P., & Engle, R.W. (2007). Working memory capacity and inhibition: Cognitive and social consequences. In D.S. Gorfein & C.M. MacLeod (Eds.), *Inhibition in cognition* (pp. 125-142). Washington, DC: American Psychological Association.

Riemann, B.C., & McNally, R.J. (1995). Cognitive processing of personally-relevant information. *Cognition & Emotion, 9*, 325-340.

Rosen, V.M., & Engle, R.W. (1998). Working memory capacity and suppression. *Journal of Memory and Language, 39,* 418-436.

Shiffrin, R.M., & Schneider, W. (1977). Controlled and automatic human information processing: II. Perceptual learning, automatic attending, and a general theory. *Psychological Review, 84*, 127-190.

Szymańska, B., & Kolańczyk, A. (2002). Zmiana afektywnego znaczenia pojęć w kontekście zadania w przypadku osób twórczych i nietwórczych [Modification of the affective meaning of words in the context of task in case of high and low levels of creativity]. *Studia Psychologiczne, XL*, 151-160.

Tulving, E. (1985). Memory and consciousness. *Canadian Psychology, 26*, 1-12.

Turner, M.L., Engle, R.W. (1989). Is working memory capacity task dependent? *Journal of Memory and Language, 28*, 127-154.

Unsworth, N. (2007). Individual differences in working memory capacity and episodic retrieval: Examining the dynamics of delayed and continuous distractor free recall. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 33*, 1020-1034.

Unsworth, N., & Brewer, G.A. (2010). Variation in working memory capacity and intrusions: Differences in generation or editing? *European Journal of Cognitive Psychology, 22*, 990-1000.

Unsworth, N., & Engle, R.W. (2007). The nature of individual differences in working memory capacity: active maintenance in primary meomory and controlled search from secondary memory. *Psychological Review, 114*, 104-132.

Unsworth, N., & McMillan, B.D. (2012). Mind wandering and reading comprehension: Examining the roles of working memory capacity, interest, motivation, and topic experience. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 39*, 832-842.

Unsworth, N., Brewer, G.A., & Spillers, G.J. (2010). Variation in working memory capacity and forgetting over both the short and the long term: An application of the Population Dilution model. *Journal of Cognitive Psychology, 23*, 243-255.

Unsworth, N., Heitz, R.P., & Engle, R.W. (2005). Working memory capacity in hot and cold cognition. In R.W. Engle, G. Sedek, U. von Hecker, D.N. McIntosh (Eds.) *Cognitive limitations in aging and psychopathology* (pp. 19-43). New York: Cambridge University Press.

Unsworth, N., Heitz, R.P., Schrock, J.C., & Engle, R.W. (2005). An automated version of the operation span task. *Behavior Research Methods, 37*, 498-505.

Veling, H., Holland, R.W., & van Knippenberg, A. (2007). Devaluation of distracting stimuli. *Cognition and Emotion, 21*, 442-448.

Whelan, R. (2008). Effective analysis of reaction time data. *The Psychological Record, 58*, 475-482.

Yonelinas, A.P. (2002). The nature of recollection and familiarity: A review of 30 years of research. *Journal of Memory and Language, 46*, 441-517.

Appendix

Words in the Classification Task and the Corresponding Cue Words in the Recall Task

BLOCK	TARGET WORD	CUE WORD
Beginning	motyl *butterfly*	łąka *meadow*
	urna *urn, ballot box*	wyborca *voter*
	studnia *well*	wiadro *bucket*
	igła *needle*	ścieg *stitch*
1	grzechotka *rattle*	niemowlę *baby*
	pług *plough*	traktor *tractor*
	stragan *stall (in a market)*	targ *market*
	sejf *safe*	bank *bank*
	żeton *token (a round piece of metal)*	automat *slot machine*
2	czajnik *kettle*	kuchenka *stove*
	lupa *magnifying glass*	soczewka *lens*
	pestka *seed (in fruit)*	owoc *fruit*
	witraż *stained glass window*	mozaika *mosaic*
	meteor *meteor*	gwiazda *star*
3	szabla *sabre*	broń *weapon*
	narta *ski*	kombinezon *suit (a special purpose garment)*
	wiosło *oar*	spływ *(canoeing or rafting down a river)*
	smyczek *bow (for playing musical instrument)*	nuty *notes (in music)*
	tyczka *pole (a long stick)*	podpora *support*
4	broszka *brooch*	ozdoba *decoration*
	globus *globe (a sphere with a map on it)*	równik *equator*
	schody *stairs*	piętro *storey, floor (level of a building)*
	ulotka *leaflet*	reklama *advertisement*
	zegarek *watch*	sekundnik *second hand (of a watch)*
5	dzwon *bell*	gong *gong*
	peron *platform (at a railway station)*	bagaż *luggage*
	pieczątka *stamp (a tool for printing)*	zaświadczenie *certificate*
	pomnik *statue*	marmur *marble*
	szyszka *cone (the fruit of a pine or fir tree)*	las *forest*
Ending	asfalt *asphalt*	szosa *road*
	cegła *brick*	mur *wall*
	żarówka *light bulb*	abażur *lampshade*
	kurtyna *curtain (in a theatre)*	teatr *theatre*