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Is working memory working against suggestion susceptibility? Results from extended version of DRM paradigm

Abstract: *The paper investigates relationship between working memory efficiency, defined as the result of its' processing & storage capacity (Oberauer et al., 2003) and the tendency to (1) create assosiative memory distortions (false memories, FM); (2) yield under the influence of external, suggesting factors. Both issues were examined using extended version of Deese-Roediger-McDermott procedure (1959, 1995), modified in order to meet the study demands. Suggestion was contained in an ostentatious feedback information the participants (N=88) received during the DRM procedure. Working memory (WM) was measured by standardized tasks (n-back, Jaeggi et al., 2010; automatic-ospan, Unsworth et al., 2005). Study included 3 conditions, differing in the quality of suggestion (positive, negative or neutral). Participants were assigned into 3 groups, depending on results they achieved completing the WM tasks. Obtained results alongside the previously set hypothesis, revealed that (1) WM impacts individuals' tendency to create false memories in DRM and (2) that the individuals showing higher rates in WM tasks are less willing to yield to suggestion compared to those with lesser ones. It also showed that the greater amount to shift (Gudjonsson, 2003), emerges under the negative suggestion condition (collating positive). Notwithstanding that the interaction effect did not achieve saliency, both analyzed factors (WM and suggesting content) are considered as meaningful to explain memory suggestion susceptibility in presented study. Although, obtained results emphasize the crucial role of WM efficiency, that is believed to decide the magnitude of feedback that is influential in every subject. Therefore, issue demands further exploration.*

Key words: *false memories, working memory, memory, suggestion, feedback, DRM*

Introduction

The way people proceed and memorize information determine the way they create representations of an outward reality in their own minds (Johnson et al., 2012; Sternberg & Mio, 2009). The accuracy and exactness of such traces seems crucial to determine individual's susceptibility to a wide range of memory distortion (including the tendency to create false memories) and willingness to yield to suggestion contained in ostentatious feedback information (Bartlett & Bartlett, 1995; Murphy & Balzer, 1986; Schacter et al., 1998; Schacter & Coyle, 1997). Many studies demonstrate that individual's showing greater results in cognitive tasks are able to remember events more precisely, commit less of memory lapses as well as show a lower tendency to create a wide range of memory distortions that emerge as a consequence of trace deficits as compared to those with lesser results (Hirst & Echterhoff, 2012; Kiyonaga, Egner & Soto, 2013; 2012; Maciaszek, 2013a).

Despite the fact some individuals are more vulnerable than others, there is a general agreement that people present a tendency to create vivid, long-lasting false memory traces (Atkins & Reuter-Lorenz, 2008; Tse & Neely, 2005). Distortions occurring within the semantic memory, (e.g. inducted by associations, Ulatowska & Olszewska, 2013a) are believed to be transferred into the episodic memory and remembered in a similar way to the real ones, filling the lapses of "true" memory traces (Maciaszek, 2015; Meadea et al., 2007; Zhu et al., 2012).

In accordance with this, conducting a study focused on individual cognitive factors essential for this process seems justified. What is worth emphasizing, recent studies show crucial role of working memory (WM) determining individuals vulnerability to a wide range of memory errors, such as misleading information effect (Zhu et al., 2013; 2010), SMF errors (Johansson & Stenberg, 2002; Purić & Lalović, 2010), suggestion susceptibility (Dasse et al., 2015; Gheorghiu et al., 2012; Polczyk, 2007), as well as false memories (Roediger et al., 2014).

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This paper presents results delivered from experimental study of false memory phenomena (FM), evoked by modified DRM procedure (list of words related; Deese, 1959; Roediger & McDermott, 1995) and its relationship to individual's suggestion vulnerability in reference to participant's working memory efficiency (Alberts, 2010; Atkins & Reuter-Lorenz, 2008).

Working memory

WM is believed to be one of the most important cognitive processes, responsible for quality of people's everyday functioning, taking part in all the daily activities. It is also involved in much more demanding affairs e.g. problem solving (Orzechowski & Maciaszek, in press; Orzechowski, 2012; Orzechowski et al., 2009). Working memory efficiency is most commonly defined by its processing and storage capacities (Oberauer et al., 2003). However it is generally agreed WM impacts human functioning in many ways, (e.g. individuals with higher WM rates are able to maintain desirable information selectively and inhibit the activation of irrelevant ones (in order to not interrupt the main task performance, Druey & Hübner, 2008), some aspects of WM are presumably more expected to be more relevant within the process of creating memory distortions than the others.

Alberts (2010) adverts the leading role of WM in explaining memory distortion phenomenon, claiming that the capacity to control (defined as a possibility to keep balance between activated and inhibited representations among limited working memory resources) is crucial to perform a task correctly. These findings are congruent to previously conducted study that shows a significant impact of working memory efficiency (within its executive function, strongly connected with inhibitory control, IC, in view of Alberts) to a tendency to create false memories by subjects. Participants with higher working memory efficiency rates demonstrated lesser tendency to create false traces – average difference was about 14.6%, compared to individuals with lower WM functioning (meaning rate of false memories for high-WM participants was 2.85 and for low ones: 4) (Maciaszek, 2014a; 2015).

False memories

Importance of individual differences among cognitive processes, in order to explain memory distortion susceptibility is emphasized in recent studies. According to Johansson and Sternberg (2002; similarly to Pimentel & Albuquerque, 2013), resemblances of enumerated phenomenon may be caused by source monitoring factor (SMF) errors, in general: lapses in executive control within the attentional and working memory processes (Miyake & Friedman, 2004). Smith and Engle (2011) present another point of view, emphasizing the relevance of cognitive resources involved in particular data processing operation (see also: Smith, Hunt & Gallagher, 2008). They claim that more resources engaged to code information in memory, enable proceeding on a deeper level (Craik & Lockhart, 1972). That assures higher precision, better quality and greater amount of remembered details, which means lower probability of creating a false memory trace (Flegal & Reuter-Lorenz, 2014).

The complex way to explore the mentioned phenomenon and measure its magnitude is to evoke FM under laboratory conditions, e.g. using the DRM paradigm (list of words related; Deese, 1959; Roediger & McDermott, 1959). Basing on an assumptions of semantic memory network theory (Collins & Quillian, 1969), it is possible to foresee that the similarity of words presented to participant during the procedure and non-presented critical items (which are strongly connected), would cause an appearance of such words in succeeding memory test (Collins & Loftus, 1975; Maciaszek, 2013b; 2014). Recognition of critical item is regarded as a false memory creation (Dehon, 2012; Mao, Yang & Wang, 2010; Monds et al., 2013). In current study DRM procedure was applied to investigate whether individual differences in working memory efficiency affect varied FM rates under the influence of suggesting feedback.

Compellingly, many researcher point that individual sensibility to yield external cues while recalling the material (in opposite to be guided by internal cues, e.g. Dehon, Laroi & Linden, 2011) leads to a greater rate of false memory traces. Moreover the correlation between a tendency to produce FM, and undergo suggestion and misleading information effect also appears (Chaiwutikornwanich, 2005; Nichols, 2014; Zhu et al., 2013). Such findings stay in line with supposition that factors impeding appropriate identification of information source, may cause the failure of distinction between internal (memory-originated) and external (contextual) stimuli within the memory traces (e.g. a „context confusion phenomenon", Baddeley, Kopelman & Wilson, 2002). As an effect, various types of memory mistakes and distortions, including false memory traces emerged. These findings are congruent to the thesis presented by Dehon, Laroi & Linden (2011), including correlation of subjects' tendency to be directed by external memory cues (while recollecting earlier memorized stimuli) and higher memory distortion susceptibility, compared to individuals often using internal cues. What is interesting, the "vulnerable participants" have shown significantly lower working memory capacity. The tendency to be directed by external information, usually an outward stimuli, contrary to internal memory traces is related to poorer cognitive functioning.

To sum up, recent findings led to set the following hypothesis, which will be verified using regression analysis.

H1: *Working memory efficiency (in order to its proceeding and storage capacities) affects a tendency to create false memories. Individuals showing better WM are able to create less FM comparing to poorer ones.*

Suggestion susceptibility

Suggestibility, usually defined as a degree of personal willingness to accept suggestion of others, along with a tendency to act accordingly to its content (Collins Dictionaries, 2014), is often explained by lapses in source monitoring factor (SMF, e.g. Kopelman & Wilson, 2002),

connected with working memory executive functions (Miyake & Friedman, 2012; Johansson & Stenberg, 2002). Researchers suspect that individual disposition to commit such errors may be related to a different influence vulnerability, by link to external-internal cues dependence (Dehon et al., 2011). In other words, individuals strongly depending on external cues demonstrate greater tendency to yield suggesting information, compared to internal-cues driven (Kopelman & Wilson, 2002). What is compelling, if such mechanism appears, the way of introducing suggestion (social, para-social, or non-social) shouldn't affect significant differences (see also: Szpitalak et al., 2015). Thus, results delivered from research with use of non-social (impersonal) influence, as applied in presented study, may be recognized on a general field of suggestion susceptibility.

Worth mentioning is that many researchers claim the outward factors play a significant role in deciding about individual's vulnerability to a wide range of distortion, including FM phenomena, suggestion susceptibility etc. (e.g. Zhu et al., 2013). Outward factors are often being defined as extrinsic to a subject, emerging from an outward situation (see also: Szpitalak & Polczyk, 2012; 2014).

Interestingly, some studies show that suggestion vulnerability may be viewed as a psychosocial phenomenon, focusing on individual's tendency to change (behavior, answering pattern or decision-making strategy) under the influence of external factors (e.g. information provided to participants during the experimental procedure). As many aspects of this issue remains unexplored, presented study purpose is to shed a light on suggestibility in order to elicit vulnerability by manipulating an informational feedback, strengthened by some additional affect (Fiedler, Lundy & Sheehan, 2012).

Results analog to described above, came from a great number of studies over false memories, suggestion and misinformation susceptibility (e.g. Eisen et al., 2002; Jachinski & Wentura, 2002). What is appealing, some experimental data reveals that the content of suggestion matters as well as the way that it is presented – according to Storbeck (2013), negatively affective cues observed during the DRM experiment increase monitoring processes, by drawing attention to distinctive information which finally lets subjects to reduce false memories (thanks to very precise encoding and high level of control in a memory test). Interestingly, Zhu et al. (2013) observed an occurrence of significant correlation among subjects' vulnerability to wide range of memory distortions, including false memory traces, suggestion and a misinformation effect that may be explained in terms of "general discrimination ability". Nevertheless, recently published evidence is too weak to be considered as conclusive at this part of a studies. In line with this, setting hypothesis 2 seems appropriate:

H2: *Working memory efficiency is related to individuals' tendency to yield to suggestion.*

To examine this issue in a comprehensive way, various methods of data analysis, including descriptive statistics, correlation coefficients and ANOVA and UNIANOVA will be applied. Hypothesis 2 itself will be verified using variance analysis. Worth mentioning is that the additional purpose of presented studies is to establish whether the suggestion content (positive, negative or neutral) affects different rates of FM and if there is a relationship between size of an effect and WM efficiency rates. This assumption will be verified by comparing results of WM tests for individuals showing low, medium or high rates to FM rates.

Method

Participants

The data was collected from 88 undergraduate university students. As two of them did not follow the procedure, they were excluded from analysis, so the final sample consists 86 subjects (22 men and 64 women) in age 18–25 (average: 20.91; SD=1.89). Participants, informed about taking part in an anonymous, scientific research measuring memory skills, signed an agreement before the experiment began. After that they were randomly divided into the one of three experimental group conditions. At the beginning all the participants received an instruction to perform each of three cognitive tasks as quick, but also as precise as possible.

Design and materials

The experiment took place at the Jagiellonian University Experimental Psychology Laboratories. All the necessary actions were executed with the use of Millisecond Inquisit Software. Procedure includes 3 stages, conducted in the same order by all the participants. Stage 1 and 2 consists standard WM tasks: n-back (Jaeggi et al., 2010) and automatic o-span (Unsworth et al., 2005), measuring cognitive variables such as summary number of correct reactions to the stimuli, total error rate, reaction times (RTs) etc. What is worth emphasizing, is that both tools require memorizing some specific stimuli, which should be recognized afterwards. Stage 3 was designed to look similar to 1 and 2 for participants (with some irrelevant exceptions), which was important to conceal the real purpose of the study. In fact, stage 3 consists a modified version of DRM procedure, previously translated, re-written and implemented to the C++ language system requirements, in order to conduct whole procedure with use of computer. The aim of experiment design was to collect rigorously precise data, being able to compare the results derived from WM tests and a DRM-evoking FM procedure, under the diversified external influence conditions (suggestion content).

In general, DRM procedure was designed to measure an occurrence of false memories (FM, Roediger et al., 2001). Recently, the phenomena is commonly viewed as an tendency to create FM, differing among individuals. In line with this, few modifications were brought into to the original experiment design. Total rate of critical lures,

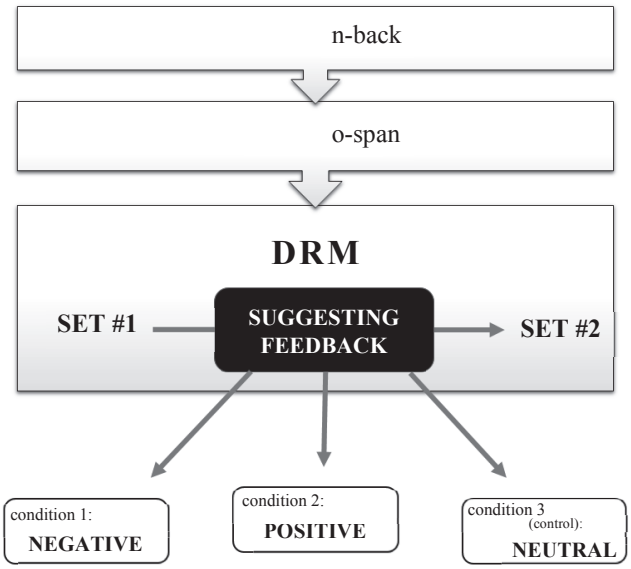
recognized by participants after a presenting a set of lists including words-related was – invariably – a measure of a tendency to create false memories.

In Deese–Roediger–McDermott paradigm experiments the participant studies the list of semantically related words (usually 12 to 15) divided in few sets. It is assumed that remembering words from each list activates the semantic network – if the activation is strong enough, it spreads automatically onto the other words related with those presented while studying (Collins & Loftus, 1975; Collins & Quillian, 1969). The point is to construct the procedure in a way that enables to elicit a resemblance of a specific, predictable memory trace – critical lure, that appears in the later memory test as one of the words presented before. In DRM paradigm each list of words has (but not always; see: Beato & Arndt, 2014) a potential to create one critical lure, that becomes a false memory trace (participant reports the sense of remembering presentation of particular word, so it is claimed that it was transferred into the episodic memory; see also: Maciaszek, 2015; Meadea et al., 2007; Monds et al., 2013; Sergi et al., 2014). Due to experiment design (specified in the next paragraph), it was expected to find some additional relations among standardized rates. Firstly, unlike the previous studies, two sets of DRM list were used, separated by the suggesting feedback information. Such design enables to look follow at least three independent variables: (1) the number of FM after first set, (2) the number of FM after the second set and (3) index of change among the answering pattern – the "shift" rate, calculated by subtracting rates from the first and the second part of a study (lures created by participants after #set1 and #set2 memory test), is believed to be the main factor defining suggestion vulnerability in this study. The tool's reliability evaluation has been discussed in paragraph "Results", in reference to present findings. However, such design was clearly inspired by *Gudjonsson's Scale of Interrogative Suggestibility* (GSS, 1984a; 1997, see also: Polczyk & Dukała, 2013), factors expected to cause change in participants' answering pattern remain slightly different. Main assumption of GSS is to measure subjects' willingness to make false confessions, supported by a tendency to accept false allegation as a consequence of interrogate behavior during the subsequent questioning (Gudjonsson, 2003). Despite some similarities to presented research, GSS procedure, typically used in forensic cases, remains focused on social factors responsible for subjects tendency to change answering patterns among succeeding memory tests (e.g. larger distance between subject and the experimenter in terms of competence, power and control causes higher suggestibility, Gudjonsson, 1984b). Moreover, GSS measures only change inducted by a negative feedback information provided by interrogate (Wojciechowski, 2015; Polczyk et al., 2004). Apart from that, current study is dedicated to investigate a role of sole suggestion influence, which participants are exposed to as an effect of positive suggesting feedback information as well. Such manipulation is believed to show a comprehensive impact on their performance in the next stage of procedure.

Procedure

As mentioned, WM tasks were performed by participants before the DRM procedure starts. WM is presumed to balance individuals tendency to yield FM-evoking context (lists of semantically related words) with its' capability to control the magnitude and the coverage of spreading activation effect (and appearing FM as a consequence). WM measurements were implemented into the experimental design in order to define participant's cognitive properties (in particular). However, in reality, the crucial part of the experiment was the manipulation conducted during the DRM procedure. Figure 1 presents the general scheme of experiment, including the differences in suggesting information condition.

Figure 1. Detailed scheme of conducted study



In order to conduct the presented study, it was necessary to design a computer version of DRM lists of words related paradigm. The procedure similarly to the original version consisted of presentation lists of words, semantically related to each other and to a non-presented critical item. After a presentation, including 2 sets (8 list x 15 words related each), participants completed a memory test, in which they were asked to distinguish items presented and non-presented, by pushing "yes" or "no" buttons on a keyboard.

Participants were randomly divided into 3 experimental conditions. Condition 1 and 2 include receiving ostentatious feedback information that is strongly suggesting (respectively: 1 – positive and 2 – negative). Participants subjected to the procedure under the 3rd condition, received feedback information voided from suggestion (control group): the message they received between DRM sets #1 and #2 presentation was neutral. It was expected to observe change in performance of DRM task in suggested, compared to non-suggested group. The measure of this change was considered to be the measure of susceptibility to suggestion incorporated in the feedback information.

In general, each group received feedback information that included short information about the level of participants' performance in actual task, comparison to the average rate and a purposive instruction how to perform next part of the procedure. It is worth emphasizing that all the messages were ostentatious – dependent on condition, not participants' real level of performance. After the procedure ended, participants were debriefed and informed about the real purpose of the procedure. Differences in conditions are presented in table 1.

Note that ostentatious feedback information given to subjects, was automatically generated by the computer and the rate of "accuracy" was random within certain interval in each group.

Results and discussion

According to hypothesis 1, it was expected to find significant impact of individual's working memory efficiency and a tendency to create false memories. Table 1 displays descriptive statistics for all the measures used in analyses, for both the false memory and the working memory rates.

Due to previous studies (Maciaszek, 2013a; 2015) as well as other researchers findings (Bixter & Daniel, 2013; Jaschinski & Wentura, 2002), WM was expected to play a significant role in FM-creating process.

In order to verify hypothesis 1 and evaluate the influence WM's efficiency (referring to its proceeding and storage capacities; Jaeggi et al., 2010; Oberauer et al., 2003) on individual's tendency to yield FM phenomena, regression analysis was performed. A multiple regression was run to predict FM rates after the first set of DRM lists (worth reminding is that at this point of experiment all the participates run the same procedure – there was no external influence before this part). Predictions were made from variables: (1) WM storage capacity (defined as a summary number of errors in n-back task) and (2) WM proceeding capacity (mean rates of reaction time to correctly response trials in n-back task). Model 1, explaining about 12.5% of the variance in the dependent variable is presented in table 2.

The dependent variable was a number of false memories after the first part of the experiment (correlations for all measures used in analyses – see: appendix). Both of the tested variables: (1) total number of errors and (2) mean reaction time in n-back procedure, turned out to be significant independent predictors of FM rate in the analysis. Such results led to a straightforward conclusion, that WM affects individual's tendency to create FM, what confirms hypothesis 1. Such results stand in accordance with other research findings, forms part of a broader research direction, highlighting the role of individual differences among cognitive processes in the process of creating FM (Johnson et al., 2012; Roberts, 2002; Silbermann, 2007).

Modifications implemented to the original DRM procedure and re-writing it into the full-computer version, demand the evaluating the measurement validity. However, Cronbach's alpha was .91, further analysis

Table 1. Differences in experimental conditions due to the content of ostentatious feedback information

	Condition 1 (–)	Condition 2 (+)	Condition 3 (0)
Feedback	positive	negative	Neutral
Accuracy	0–30%	70–100%	–
Comparison to 'standard' task performance	above average	below average	average
Instruction	memorize better	memorize as well as previously	memorize material as precisely as possible

Note. The assumption of equivalence between DRM sets #1 and #2 was made due to previous results, showing no significant difference between the potential of each list to evoke FM (Olszewska & Ulatowska, 2013a).

Table 2. Multiple regression analysis for the criterion: number of false memories (rate: „lures #1") after presentation first set list of words related

	FM (lures #1)			
Independent variable	**B**	**SE**	**β**	**t**
Constant	6.69	.95		7.13
WM storage	-.04	.01	-.27	-2.58
WM proceeding	-.00	.01	-.27	-2.57
R^2=.124, F(2, 83) = 5.88; p < .01				

were executed. The t-test was conducted separately for each group to establish whether presence of suggestion affects participant's tendency to change answering pattern (shift index). The test showed only participants in control condition (M1=4, SD1=1.34; M2=4, SD2=1.88) did not differ generating FM between set#1 and set#2, t(24)=0.53, n.s. Both experimental groups showed significant differences between these rates. In condition 1 the mean result after set#1 was 3 (38% of maximum possible produced lures; SD=1.96) and after set#2 – 5 (63%; SD=1.67), which was statically salient t(30)=-3.37, p<0.01 (SD=2.03). Respectively, for condition 2, set#1 elicited mean rate of 4 FM (50%; SD=1.23) and set#2 – 5 (63%; SD=1.76), t(29)=-2.79 (SD=1.52). Interestingly, the shift index showed similar properties: post-hoc analysis revealed it was significantly differing between suggested and non-suggested participants (see: table 3).

Such analysis could be also prosecuted by comparing results of undertaken studies to criterion derived from a previous research (criterial accuracy) or by providing a variance analysis to collate the results under the criterion of congruency to researcher expectations (discriminatory accuracy). Presented method meets both the criteria. The mean rate of FM without influence of suggestion (after set #1) is exactly the same as the mean rate revealed in DRM experiments conducted before, with use of paper-pencil method (M=4; see also: Maciaszek, 2012, 2014). Such result should be interpreted as a confirmation of reliability of the computer version of DRM procedure.

What is more compelling is that the important variable – the "shift" index, originally presented in a current study, turned out to be a reliable index of an individuals' tendency to change the answering pattern, as the variance analysis shown (F(2,83)= 4.31; p<0.05). Significant differences among this rate were observed in both suggested groups (respectively; negative and positive conditions), contrary to non-suggested control group ("neutral") (see also: table 3).

To verify hypothesis 2, the relationship between WM efficiency and subject's vulnerability to yield to suggesting feedback information in-between group analysis was examined. Participants executing procedure in condition 1 (negative suggestion) were expected to have an increased FM rate (from set #1 to #2) as a consequence of internalizing the information content. Also it was supposed that subjects with positive-suggestion condition (2) would be able to lower their FM rates after receiving a message of an outstanding result of their performance (Ling, Ismail & Abdullah, 2015). On the other hand, such predictions were not supported by any empirical findings, so that hypothesis 2 includes only the assumption that some changes between different experimental conditions would be observed and connected with subjects WM efficiency. In order to investigate this issue, apart from 3 different experimental conditions, participants were subdivided into 3 groups, alternatively by dependence of their WM span (correlation matrix displayed connection between this factor and a "shift" index – r=0.29; p<0.01). Obtained results included only participants receiving a suggestion during the procedure (conditions 1 and 2) – control group was excluded from this analysis due to lack of suggestion that may cause a "shift" between two sets of DRM task. Study results revealed that subjects showing low, medium and high WM efficiency differ significantly on willingness to undergo suggesting feedback (F(2,83)=6.58; p<0.01). What is appealing, only high WM subjects were able to avoid internalizing suggesting feedback information – positive shift rate means that they created lesser FM under the influence (set 2), than without it (set 1; however, this effect

Table 3. Descriptive statistics values for measures used in analyses

Condition	N	Lures #1	%	Lures #2	%	t	df	Shift	N-back errors	N-back RTs (ms)
Negative suggestion	31	3 (1.96)	38	5 (1.67)	63	-3.37 (2.03)*	30	-1[b] (2.63)	13 (13.86)	649 (125.33)
Positive suggestion	30	4 (1.23)	50	5[a] (1.76)	63	-2.76 (1.52)*	29	-1[c] (1.52)	16 (6.15)	590 (105.29)
Neutral (control)	25	4 (1.34)	50	4[a] (1.88)	50	0.53 (0.38)	24	0[b c d] (1.89)	17 (7.86)	557 (117.86)
Negative + positive suggestion	61	4 (1.68)	50	5 (1.70)	63	-4.34* (1.78)	60	-1[d] (1.80)	15 (10.70)	603 (118.38)
Total	86	4 (1.58)	50	5 (1.81)	63	-3.16 (1.90)*	85	-1 (1.90)	16 (9.94)	600 (118.49)

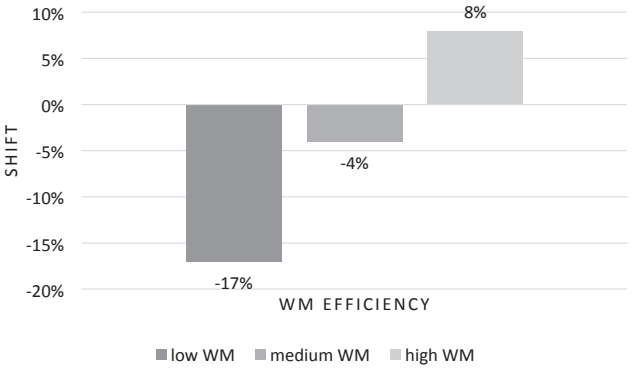
Note: *Lures #1* – number of false memories generated by participants after first set of DRM lists presentation; *lures #2* – after second set; *shift* – tendency to change answering pattern as a function of experimental condition; *n-back errors* – a mean number of errors committed in n-back task; *n-back RTs* – a mean time of proper reactions during n-back task trials. Standard deviations in parentheses.

[a, b, c, d] – means differ significantly (NIR test post hoc analysis at the level of p<.05).

* – groups differ significantly (t statistics) at the level of p<.01

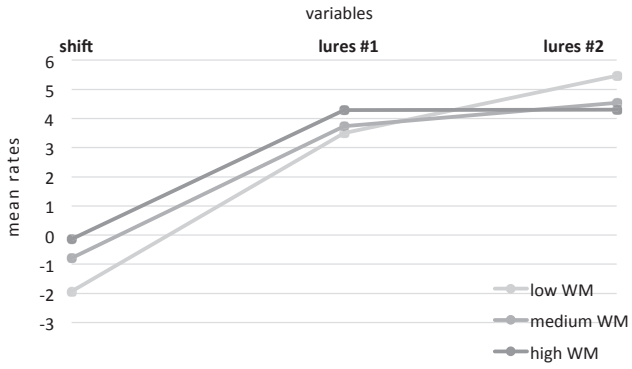
wasn't significant). Visualization of this results demonstrate figure 2. As well, figures 3 and 4 compare observed relation to other variables measured in experiment.

Figure 2. The magnitude of differences among "shift" index within diversified WM efficiency participants



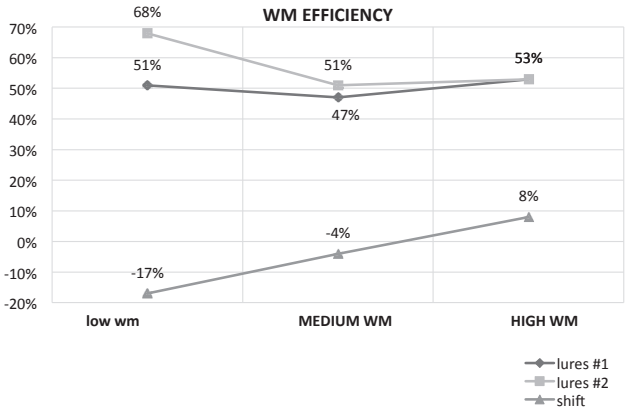
Note: only experimental conditions (1 and 2) were analyzed. Higher rates of "shift" index indicate increasing number of FM between set#1 and #2 DRM list of words related, lower – decrease. It is clearly shown participant with low and medium WM are willing to yield suggesting feedback, contrary to high-WM individuals, which are able to resist such influence.

Figure 3. Tendency to generate false memories (rates: *lures 1*, *lures 2*) and change answering pattern (rate: *shift*) by participants as a function of WM efficiency



Moreover as it turned out the proportion of critical lures was dependent on suggestion content as well as cognitive skills (see: tables 2 and 3). Significantly, substantial differences in the rate of FM were observed, arising immediately after presenting a second set of DRM lists in positive-suggestion condition (increase from 50% to 63% lures) compared to control (50% in both parts of the experiment). It may mean that – contrary to intuition – positive suggestion impacts participants immediately, causing a significant increase of FM under the influence of positive feedback information. On the other hand, negative feedback is being processed longer, due to individual differences, so it's influence could be observed only while analysis considered an impartial indicator of change – shift index in present study increased significantly in both conditions. Longer processing causes deeper encoding and explains the pattern of results, in which negative suggestion affected change in FM rates in size of 15% and positive – 9% (the level of change in control condition remains insignificant). In line with presented explanation seems reasonable (see also: Olszewska & Ulatowska, 2013b). Visual presentation of obtained results is shown on figures 2 and 3.

Figure 4. Relationship between a tendency to create false memories (rate: *lures #1*) and participant's willingness to yield suggestion (rates: *lures 2*; *shift*) in dependence WM efficiency



Note: analysis include only participant receiving suggestion (condition 1 and 2).

Results in groups differing WM efficiency were significant, so the hypothesis 2 may be confirmed.

Obtained results could be interpreted in reference to lack of cognitive resources that are required to encode information effectively. Further findings may lead to a conclusion, that the more cognitive resources are available for individual, the less costly it is to divide them to specific task demands (Nęcka & Chuderski, 2010). The total amount of resources is believed to be WM-dependent (Baddeley, 2002; Kahneman, 1973). Thus, high WM rates make an individual able to avoid unappropriated influence of suggestion thanks to accessibility of resources that may be allocated to inhibition (IC, referring to Alberts, 2010).

However, another explanation seems more convincing. Having enough cognitive resources in disposal allows the cognitive system to choose a proper reaction strategy, accurate to current task demands. It also decides about the level of executive control intensity in dependence of expedience (Bednarek, 2011; Maciaszek, 2013b). Therefore, strategy defined as an "unreflective" relates to a tendency to yield to an impact of exterior cues as a consequence of low level of cognitive engagement. That includes control, resources etc., but is also believed to cause high memory distortion vulnerability. It is contrary to "reflective" decision-making strategy that, despite being distinctively more costly and requiring strong executive control processes engagement, provides better results in majority of cognitive tasks. (Maciuszek, 2012; see also: Maciaszek, 2013a; 2015). Presumably, such effects occur as a consequence of cognitive effort involved in performing

particular tasks (Lindsay, 2014; Śpiewak, 2013). Estimation the amount of cognitive resources required to perform the task effectively, depends on working memory. Moreover, evidence derived from a previous studies show that participants handling a reflective strategy show significantly lower tendency to create false memories, compared to impulsive ones (which were discriminated by high strategy index and quick reaction for the stimuli): $t(92)= -2.54$; $p<0.05$) (Maciaszek, 2014a; 2013b).

To provide further investigation of relationship between WM, suggestion content and a tendency to yield to FM phenomena, a GLM univariate test was conducted, utilizing a 2 (suggestion content: positive vs. negative) x 3 (WM efficiency – low vs. medium vs. high) mixed design (see: table 4).

The analysis revealed a main effect for "WM efficiency", $F(2,81)=3.97$, $p<0.05$. The main effect of "condition" as well as the "WM efficiency" and "condition" interaction effect, did not achieved significance. Such results led straightly to a conclusion, that WM plays a crucial role in FM generating process. As presented data shows, WM is not only an important factor to determine if FM could be inducted, but is also related to individuals tendency to yield to suggesting feedback information (see: figures 2 and 3).

In general, data-driven analysis revealed that subjects showing greater WM efficiency create less false memories after receiving the suggesting feedback information, compared to those with poorer efficiency. This dependency was found both at positive as negative suggestion conditions, what could be explained that every suggestion, independently of its content focuses subject's attention, so the stimuli could not be proceed at the optimal level. Memory trace, emerging as a result of too narrow processing, remains uncompleted, so that – in line with early experimental findings – there is a necessity to supplement it (Bartlett, 1932; Roediger et al., 2014). Individuals showing high rates of WM are capable to encode memory trace more precisely, ignore the distraction and – as an effect – became less vulnerable to create FM as well as yield to suggestion (thus, being sure of memory accuracy, they feel no need to search for external cues).

On the other hand, obtained results show that the negative suggestion (condition 1) led to a greater amount of FM (however, the difference between positive-suggested group wasn't significant), what meant that the negative information is being proceed in more permanent, long-lasting and sustainable way, so its influence on subjects displays as a higher level of willingness to change (shift). High WM rates enables avoiding lapses caused by a lack of complete memory traces, but – obviously – doesn't give a guarantee (only a possibility, making individuals more or less vulnerable).

Conclusions

The phenomenon of creating false memories is considered by many researchers to be a fascinating experimental problem itself. What is compelling, strong empirical evidence show the significant role of cognitive factors (working memory, in presented study) to explain this phenomena. The assumption that the issue is related to other kinds of memory distortion, as well as general sensibility to be guided by external cues (especially, suggesting feedback information) is appealing.

As using the DRM paradigm, researchers often focus on particular lists (or even words) and their properties, (e.g. "FM-evoking potential"; Gallo, 2013), or a number of words that are necessary to activate semantic memory association network (Atkins & Reuter-Lorenz, 2008; Beato & Díez, 2011; Roediger et al., 2014; Tse & Neely, 2005), still little is known about factors inducting memory distortions among humans' cognitive processes. Conducted study showed that working memory efficiency plays a crucial role in this process. Individuals achieving better results in WM tasks were able to control the process

Table 4. A GLM univariate test on the effect of WM efficiency (3 levels) and suggestion content (2 levels) on a tendency to yield false memory phenomenon

Source	df	F	p	eta^2
Corrected model	8	2.42	<.05	.20
Constant	1	7.25	<.01	.09
WM	**2**	**3.97**	**<.05***	**.09**
Condition	2	2.01	.14	.05
WM*condition	4	0.17	.95	.01
Error	77			
Total	86			
Corrected total	86			
R^2 = .201 (adjusted R^2 = .118); p<.05				

* p<.05

of spreading activation in more effective way and as a consequence – create less FM. In general, the better WM, the less FM occur in one's memory (hypothesis 1) (Maciaszek, 2013a; 2015). Accordingly, between-group analysis revealed, individuals showing better WM efficiency present lower vulnerability to yield suggestion (received during the procedure) and are less willing to change their answering pattern under the influential stimuli, compared to those with poorer ones (hypothesis 2). No interaction effect between experimental condition and participants' WM efficiency suggest the influential impact of working memory on a tendency to yield external factors, independently of external situation. Notwithstanding, the magnitude of this effect may be dependent on individuals WM efficiency. Thus, the issue demands further studies.

Enriching this topic by investigating the connection between tendency to yield FM-evoking external context (associations spreading automatically over the semantic memory network), suggestion susceptibility and relationship to individual cognitive abilities, seems worth attending. Regarding the limitations of presented study (e.g. a low number of participants, that hinders the use of complex methods of data analyzing), obtained results, staying in consonance with actual trends in cognitive science, has an additional value by developing existing knowledge in a field of basic research in experimental psychology.

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