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ENACTMENT AND IMAGINATION ENCODING CREATE FALSE MEMORIES OF SCRIPTED ACTIONS

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Abstract

The present study aims to extend our knowledge about the false memories from an adaptation of the DRM paradigm (Roediger & McDermott, 1995) in order to generate memory errors for everyday life action lists. In this perspective, the standard DRM task has been adapted, replacing the associated word lists with thematically related action lists. Each action list refers to a temporally connected action routine, i.e. a script. The sentences describing actions automatically involve visual and motor simulation of the scene. Therefore, the issue is to know whether the encoding conditions of enactment and motor imagery compared to verbal encoding (as control) impact false memories. Compared to the numerous studies on imagination effects on false memories, the enactment effect on the production of false memories of thematically related actions has not yet been tested. Therefore, we compared three experimental conditions: (1) a control condition, in which participants were asked to hear all lists attentively; (2) an imagery condition, where participants were instructed to visualize themselves performing each action, presented orally; (3) an enactment condition, participants had to mime each action heard as if they really were performing it. Then, without having been warned beforehand, all participants carried out a recognition test. The results confirmed the creation of false memories for associated action lists (scripted actions) and therefore valid this new version of the DRM task. However, false memories were of the same magnitude under all encoding conditions. These findings ask into question the classical models of memory, which assume that enactment and visual imagery should favour distinctive conceptual processing with the consequence of reducing false recognition. However, the field of embodied cognition might provide an alternative hypothesis that merit to be discussed and explored.

Keywords: *Actions, enactment, false memories, visual imagery, script.*

1. Introduction

Usually when we remember events, we visualize individuals, objects, in a sequence of actions (like to see her/himself closing the door or turning off the oven before leaving, etc.). In these circumstances, false memories might result from the memory of an event which never enacted or which was imagined. Compared to the numerous studies on imagination effects in false memories paradigms, few studies have investigated the enactment effects on false memories. Therefore, the present study aims to extend our knowledge about the false memories from an adaptation of the DRM paradigm (Roediger & McDermott, 1995) in order to generate memory errors for everyday life action lists. Script sentences describing actions semantically associated may involve visual and motor simulation of the scene, which may lead of increasing or reducing false memories.

Imagination as the cause of distorted memories is known as *imagination inflation*. The inflation of the imagination occurs when an imagined event strengthens individuals' certainty or belief that the event actually happened. For example, participants claim to have performed an action or seen an object, when they simply imagined them. Goff and Roediger (1998; Lindner & Echterhoff, 2015) confirmed this phenomenon by highlighting the repeated effects of imaging encoding process on the increase of false memories. The hypothesis was that the more an event is imagined, the closer it is to the perception (i.e. to a real event) and the more the individual will make an error on the origin of this information by declaring that the event was perceived while it was imagined. In the Goff and Roediger study (1998; Lindner & Echterhoff, 2015) the more the participants imagined themselves performing an action (e.g. throwing a ball), the more they produced source errors. Participants mistakenly believed that they had actually performed the actions when they had only imagined them. Overall, findings have shown that imagining actions makes them as vivid and real as their actual realization (Lyle & Johnson, 2006; Mitchell & Johnson, 2009). In contrast, few studies have shown a reduction of false memories for imagined action sentences (Maraver et al., 2021).

Whereas imagination effect has been widely examined with word lists or action lists in false memories paradigms, few studies have investigated the enactment effect. Nevertheless, Sauzéon et al. (2016) found an increase in correct recognition performance and a reduction in false recognition in a source memory task, where participants had to virtually move through a space. Thus, although the benefits of the motor activity (enactment effect) on memorization, compared to a condition of motor imagery or verbal encoding have been widely demonstrated (Horstein & Mulligan, 2004; Koriat et al., 2003), the enactment effect on the production of false memories of thematically related actions has not yet been tested. Therefore, it was interesting to compile evidence and explore the impact of enactment and motor-imagery on the false memories.

This study aimed to explore the effects of the visual-motor imagery and of the enactment on the false memories for actions thematically associated. It is well known that visual-motor imagery and the enactment encoding strategies increase correct memorization performances. However, in accordance with the distinctiveness heuristic hypothesis (Dodson & Schacter, 2001; Schacter et al., 1999), we hypothesis a reduction of false memories after the visual-motor imagery or the enactment as encoding strategies compared to a control condition (listen the action lists). Indeed, the distinctiveness heuristic hypothesis suggests that reductions in false recollection result from the monitoring decision based on a distinctive detail of the encoding context, which allows participants to decide whether the action has been previously experimented. When sufficient distinctive features have been encoded participants call upon a strict decision criterion, i.e. one that demands access to the distinctive features (Israel & Schacter, 1997; Schacter et al., 1999). Therefore, we expected that imagined or enacted actions provide more distinctive details increasing the memorization of studied actions and thus, precluding false memories. The impact of imagined or enacted actions on the creation of false memories was not investigated with the DRM task. Therefore, the Deese-Roediger-McDermott paradigm (DRM, Roediger & McDermott, 1995) considered, as the most robust in the false memories field, has been adapted. Moreover, the validation of this experimental device would make it possible to bring to the DRM an ecological dimension, which in a later version could be intended for the evaluation of false memories in a clinical context.

2. Method

2.1. Participants

Ninety undergraduates of Nantes University (excluding students in psychology) were randomly assigned to one of the following conditions: control; enactment; motor-imagery. Thus, three groups of 30 participants were established. They were between 18 and 41 years of age (*M* = 24.32; *SD* = 5.48; 42 women and 48 men) and all were native French speakers. The sample size was determined using G*Power analysis (Faul et al. 2007) that yielded a total sample size equal to 54 for statistical analyses (for alpha = .05, power = .95, number of groups = 3, a medium size effect = .25 for the Anova repeated measures within-between interaction). In compliance with the declaration of Helsinki, all participants gave their written informed consent, freely consented to participate and were able to withdraw whenever they wished. Exclusion criteria were significant neurological or psychiatric illness, and major motor, visual, or auditory difficulties.

2.2. Material

The action lists consisted of 8 lists, each corresponding to a script, comprising 12 sentences of associated actions converging on the most central action, the title of the script corresponding to the action lure. The scripts were: "to make a home-move", "to make a coffee", "to do the housework", "to do the garden", "to wash his/her hair", "withdraw cash to the ATM ", " to change a flat tire" and "to write a letter". These action lists were selected from norms validated in French by Corson (1990). The selected actions were the more central and distinctive of each script. The recorded actions of each script were presented in a chronological order at the rate of one action per 5,000 ms (see Goff & Roediger, 1998).

The recognition task consisted of a list of 52 actions distributed randomly: 24 studied actions (the 1st, 5th and 11th action) selected in each script; 8 actions lures corresponding to the titles of the 8 scripts, which were never presented; 20 false alarms from 5 scripts not studied corresponding to the 5 script titles and 15 actions (the 1st, 5th and 11th action) selected in each script.

The recognition of each action sentence consisted in evaluating on a 4-point scale the certainty with which the participant estimated to have heard or not the action sentence: 1 point "I am sure not to have heard this action"; 2 points "I am almost sure that I haven't heard this action"; 3 points "I am almost sur that I heard that action"; 4 points "I'm sure I heard that action". We used the same scale as in our previous studies with DRM wordlists (see Robin et al., 2015; 2021). Then, whatever their answer, participants had to indicate their level of consciousness in responding to the Remember/know test (Tulving, 1985). They checked "R" when they remembered details associated with the encoding situation (a conscious recollection) and "K" when they felt that the sentence sounded familiar, having simply the feeling of already it heard, without being able to give the slightest detail.

2.3. Procedure

The participants carried out the task individually. First, they completed a consent form, and then, in all three experimental conditions, participants were instructed to listen carefully the recorded 8 lists of 12 actions each. In the control condition, participants had to listen carefully the action lists. In the imagery condition, for each sentence heard, they had to imagine themselves performing the actions, as if they were actually performing them. An example was provided: "if you hear the sentence, driving a nail with a hammer, you must imagine yourself with a hammer in your hand and imagine the movements that one usually makes when driving a nail with a hammer, all by feeling the sensations (muscular and articular) associated with this movement. Imagine that you are actually driving a nail with a hammer." In the enactment condition, the instruction explicitly invited participants to mime each action as if they were actually performing it. Here again an example was provided. For practical reasons, mime rather than real activity (i.e. with real objects) was proposed and because of the negligible impact of the presence of real objects on memorization compared to mime (see Engelkamp & Cohen, 1991). Then, participants filled out a demographic questionnaire for about 5 minutes. Then, without to be warned before, they completed the recognition test. At the end of this test, participants had to specify what they thought about the objectives of the study in order to discard all participants who expected a study on false memories.

3. Results

3.1. Confidence ratings on the 4-point scale

An ANOVA with repeated measures was carried out with Action type as a within-subject factor (studied actions, lures and false alarms) and Condition as a between-subject factor (control, imagery and enactment). Table 1 presents the mean rating confidence for each encoding condition and each action type. The effect of Condition was not significant, $F(2, 87) = 1.15$, $p = .32$, $n^2_p = .03$. The analyses revealed a significant effect of Action type, $F(2, 174) = 211.14$, $p < .001$, $n^2_p = .71$. The analyses also reported a significant Condition x Item interaction effect, with $F(4, 174) = 3.41$, $p = .02$, $n^2_p = .07$. Post-hoc analyses (*Bonferroni*) indicated that mean rates of recognition for the studied actions were significantly higher than recognitions of lures and false alarms, p_s <.001. In contrast, recognitions rates for lures were so high than false alarms rates ($p = .72$).

Table 1. Mean confidence ratings (standard deviation) on 4-point scale for each action type (studied; lures; false alarms) in each experimental condition (control, imagery, enactment).

	Studied actions	*Lures*	*False alarms*
Control	*3.27 (0.30)*	*2.26 (0.70)*	*2.33 (0.69)*
Imagery	*3.62 (0.15)*	*2.38 (0.74)*	*2.28 (0.28)*
Enactment	*3.65 (0.30)*	*2.32 (0.79)*	*2.10 (0.09)*

3.2. Comparisons of "old" responses

An ANOVA with repeated measures was carried out with the mean proportions of "old" responses (responses 3-4) associated to each Action type. The mean percentages of recognition are presented in Table 2.

Table 2. Mean percentage of old responses (responses 3 and 4) for each action type (studied; lures; false alarms) in each experimental condition (control, imagery, enactment).

	Studied actions	*Lures*	*False alarms*
Control	*78.33 (11.29)*	*40.00 (28.12)*	*8.28 (13.75)*
Imagery	*90.28 (5.40)*	*42.08 (27.36)*	*3.33 (4.55)*
Enactment	*90.42 (9.49)*	*41.67 (29.05)*	*2.89 (4.17)*

Note. Standard deviation in parentheses.

The analyses revealed a significant effect of Action type, $F(2, 174) = 554.86$, $p < .001$, $n^2_p = .86$, which supported the presence of false memories in the DRM paradigm. Indeed, post-hoc analyses (*Bonferroni*) indicated that rates of veridical recognition for the studied words were significantly higher than false recognitions of action lures ($p < .001$). False recognitions of lures were higher than false recognitions of false alarms ($p <.001$). The effect of Condition was not significant, $F(2, 87) = 0.62$, $p = .54$, $n^2_p = .01$. However, the analyses reported a significant Condition x Action interaction effect, with $F(4, 174) = 2.76$, $p < .03$, $n^2_p = .06$.

Post-hoc analyses (*Bonferroni*) showed that correct recognitions rates of studied actions were higher in the enactment condition than in the control condition, $p < .001$. False recognitions rates of lures were also significantly higher in the imagery conditions imagery condition compared to the control ($p <.001$). Nevertheless, correct recognitions rates were not significantly different between both, the enactment and imagery conditions. Surprisingly, the rates of false recognition of lures were high in the three conditions, all $p_s = 1.000$. Lastly, false recognitions of false alarms were the lowest rates and did not vary significantly among the encoding conditions, all $p_s > .670$.

3.3. Responses remember vs know

The mean responses R/K in each encoding condition for each action type are presented in Table 3.

Table 3. Mean number of responses Remember vs. Know for each action type (studied actions, lures and false alarms) in each encoding condition conditions (control, enactment, imagery).

REMEMBER	*Studied actions*	*Lures*	*False alarms*
Control	*14.30 (4.99)*	*3.93 (2.39)*	*14.00 (5.75)*
Imagery	*18.60 (4.31)*	*5.00 (2.07)*	*14.20 (5.53)*
Enactment	*20.50 (3.18)*	*5.53 (1.98)*	*18.10 (0.75)*

KNOW	*Studied actions*	*Lures*	*False alarms*
Control	*9.27 (4.82)*	*3.83 (2.34)*	*4.67(5.71)*
Imagery	*5.43 (4.31)*	*3.00 (2.07)*	*4.83 (5.53)*
Enactment	*3.47 (3.18)*	*2.43 (1.94)*	*0.90 (0.75)*

Note. Standard deviation in parentheses.

The analyses revealed a significant Condition x Action interaction effect, $F(2, 87) = 16.4$, $p < .001$, $n^2_p = .27$. Post hoc comparisons (*Bonferroni*) revealed that correct recognitions of studied actions lead to a recollection (responses Remember) instead of feeling of familiarity (responses Know), $p <.001$. However, the mean number of responses Remember were higher in the enactment and imagery conditions than in the control condition ($t(87) = 5.68$, $p < .001$; $t(87) = 3.88$, $p = .003$, respectively). Pearson's correlation revealed a strong and significant positive correlation between mean confidence ratings and mean Remember responses in all conditions, $r = .521$, $p <. 001$.

The analyses showed a significant Condition x Action interaction effect, $F(2, 87) = 3.90$, $p = .024$, $n^2_p = .08$. Overall, post hoc comparisons (*Bonferroni*) revealed that false recognitions of actions lures were related to more responses Remember ($p <.001$) compared to responses Know. Nevertheless, this effect was significant only in the action condition ($t(87) = 4.03$, $p = .002$). Pearson's correlation revealed a positive correlation between mean confidence ratings for lures and mean Know responses, $r = .240$, $p =. 022$ and a negative correlation between mean confidence ratings for lures and mean Remember responses, $r = -.228$, $p =. 031$. However, these correlations were weak.

The analyses showed a significant Condition x Action interaction effect, $F(2, 87) = 3.90$, $p = .024$, $n^2_p = .08$. Overall, post hoc comparisons (Bonferroni) revealed that false recognitions of false alarms lead to higher responses Remember in all conditions (all $p_s <.001$) compared to responses Know. The mean number of responses Remember were higher in the enactment condition than in the control and imagery conditions ($t(87) = 3.45$, $p = .013$; $t(87) = 3.29$, $p = .022$, respectively), there was no difference between the control and imagery conditions. In addition, responses Know were higher in the control and imagery conditions than in the enactment condition ($t(87) = 3.16$, $p = .032$; $t(87) = 3.30$, $p = .021$, respectively), there was no difference between the control and imagery conditions. Overall, Pearson's correlation revealed a strong and positive correlation between mean confidence ratings for false alarms and mean Know responses, $r = .506$, $p <. 001$ and a strong and negative correlation between mean confidence ratings for false alarms and mean Remember responses, $r = -.488$, $p <. 001$. These results indicated that correct rejection of false alarms as not being studied was correlated with a conscious recollection whereas false recognitions of false alarms were related to a feeling of familiarity.

4. Discussion

The present study aimed to evaluate the impact of the sensory-motor encoding on the false memories. The original DRM material (lists of words semantically associated with a thematic word) has been replaced by lists of actions semantically associated with a script. The results confirmed the validity of the experimental task with regard to the creation of false memories within stereotyped actions such as scripts. However, the enactment and visual-motor imagery did not reduce false memories as it was expected. A likely explanation might be that relational processing of semantically associated actions lists relies on sensory-motor representations. Within the standard DRM paradigm, Danker and Anderson (2010) have noted that the reactivation of sensory areas was more intense during the retrieval of correct information, but that this did not prevent participants from retrieving false memories. These observations could then account for our results. Indeed, it is likely that the emergence of script activates sensory-motor knowledge related to the actions as well as the context. Therefore, the processing of actions automatically might trigger the conceptual, sensorimotor, and experiential traces associated with prior experiences. Hence, the participants automatically would simulate the situation evoked by each action (see Zwaan & Yaxley, 2004). This assumption might explain the low rates of false alarms and the high rates of false and veridical memories in the enactment and imagery conditions as well in the control condition. To conclude, it turns out that the emergence of knowledge such as scripts relied on simulation forming a global multimodal trace, which is not free from false memories. It seems then crucial to explore the issue of false memories in the context of embodied cognition, our assumptions deserving further investigation.

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