Chapter #24

THE IMPACT OF ENACTMENT AND IMAGERY ENCODING ON FALSE MEMORY

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ABSTRACT
The standard DRM task (Roediger & McDermott, 1995) has been adapted in order to generate memory errors for everyday life action lists (i.e. daily routines like "to make a coffee"). Therefore, the associated word lists have been replaced with thematically-related action lists. Each action list refers to a temporally-connected action routine, i.e. a script. In addition, we examined the effects of enactment and motor imagery encoding on false memories. Compared to the numerous studies on imagination effects on false memories, the enactment effect on the creation 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 listen to all lists attentively; (2) an imagery condition, where participants were instructed to visualize themselves performing each action, presented orally; (3) an enactment condition, in which participants had to mime each action heard as if they were really performing it. The results confirmed the creation of false memories for associated action lists (scripted actions). Nevertheless, false memories were high and of the same magnitude under all encoding conditions. These findings are discussed in the light of the classical models of memory and embodied cognition theory.

Keywords: actions, enactment, false memories, visual imagery, script.

1. INTRODUCTION

Usually when we remember events, we visualize individuals and objects in a sequence of actions (such as seeing oneself 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 was never enacted and was imagined. Compared to the numerous studies on imagination effects in false memory paradigms, few studies have investigated enactment effects on false memories. Therefore, the present study aims to extend our knowledge of 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 semantically-associated actions may involve visual and motor simulation of the scene, which may lead to the production of false memories.

Imagination as the cause of distorted memories is known as *imagination inflation*. Inflation of the imagination occurs when an imagined event strengthens an individual's 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. Some authors (Goff & Roediger, 1998; Lindner & Echterhoff, 2015) have confirmed this phenomenon by highlighting the repeated effects of the imaging encoding process on the increase of false memories. The hypothesis was that the more an event is imagined, the closer it is to perception (i.e. to a real event) and the more the individual will make an error regarding the origin of this information by declaring that the event was perceived, although it was imagined. In the Goff and Roediger study (1998) the more the participants imagined themselves performing an action (e.g. throwing a ball), the more source errors they produced. 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, Lapa, Garcia-Marques, Carneiro, & Raposo, 2021).

Whereas imagination effect has been widely examined with word lists or action lists in false memory paradigms, few studies have investigated the enactment effect. Nevertheless, Sauzéon, N'Kaoua, Pala, Taillade, and Guitton (2016) found an increase in correct recognition performance and a reduction in false recognition in a source memory task in which participants had to follow a path in a virtual environment. Thus, although the benefits of motor activity (enactment effect) on memorization compared to motor-imagery or verbal encoding have been widely demonstrated (see Horstein & Mulligan, 2004; Koriat & Pearlman-Avnion, 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 false memories.

This study aimed to explore the effects of visual-motor imagery and enactment on false memories of thematically-associated actions. It is well known that visual-motor imagery and enactment-encoding strategies increase correct memorization performances. In accordance with the distinctiveness heuristic hypothesis (Dodson & Schacter, 2001; Schacter, Israel, & Racine, 1999) explaining the effects of visual imagery encoding on DRM false memories (see Foley, 2012; Robin, Ménétrier, & Beffara-Bret, 2021), we expected that visual-motor imagery and enactment as encoding strategies compared to a control condition (listening to the action lists) should reduce false memories. 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 an event has been previously experienced. 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 imagined and enacted actions to provide distinctive details that increase the memorization of studied actions and thus preclude false memories. The impact of imagined and enacted actions on the creation of false memories was not investigated within the DRM task. Therefore, the Deese-Roediger-McDermott paradigm (DRM, Roediger & McDermott, 1995), considered to be the most robust in the field of false memories, was adapted. Moreover, the validation of this DRM task adaptation would make it possible to bring an ecological dimension to the DRM, 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, France (excluding students in psychology) were randomly assigned to one of the following conditions: control; enactment; motor-imagery. 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 enough sensitive, the G*Power analysis yielding 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 eight 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 move home", "to make a coffee", "to do the housework", "to do the garden", "to wash one's hair", "to withdraw cash from the ATM ", "to change a flat tyre" and "to write a letter". These action lists were selected from script norms validated in French by Corson (1990). The selected actions were the most central and distinctive in each script. The recorded actions of each script were presented in 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 action lures corresponding to the titles of the eight scripts, which were never presented; 20 false alarms from five 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 believed they had or had not heard the action sentence: 1 point "I am sure I did not hear this action"; 2 points "I am almost sure that I didn't hear this action"; 3 points "I am almost sure that I heard that action"; 4 points "I'm sure I heard that action". We used the same scale as in previous studies with DRM wordlists (see Robin & Mahé, 2015; Robin et al., 2021). For each answer, participants had to indicate their level of consciousness by 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, simply having the feeling they had already heard it or not, 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 to the recorded eight lists of 12 actions each. In the control condition, participants had to listen carefully to 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, 'hammering a nail', you must imagine yourself with a hammer in your hand and imagine the movements that one usually makes when hammering a nail, all by feeling the sensations (muscular and articular) associated with this movement. Imagine that you are actually hammering a nail." 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. Mime rather than real activity (i.e. with real objects) was proposed for practical reasons, 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 five minutes. Then, without prior warning, 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 had 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 Action type interaction effect, with $F(4, 174) = 3.14$, $p = .02$, $n^2_p = .07$. Post-hoc analyses (*Bonferroni*) indicated that mean rates of recognition for the studied actions were significantly higher than recognitions of lures and false alarms: all p_s <.001 (respectively, Cohen's $d = 2.30$; Cohen's $d = 2.46$). In contrast, recognition rates for lures were as high as for false alarm rates ($p = .72$, Cohen's $d = 0.16$).

Table 1.
Mean confidence ratings (standard deviation) on a 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)*	*5.09 (8.46)*
Imagery	*90.28 (5.40)*	*42.08 (27.36)*	*2.63 (3.59)*
Enactment	*90.42 (9.49)*	*41.67 (29.05)*	*2.28 (3.30)*

Note: standard deviation in parentheses.

The analyses revealed a significant effect of Action type, with $F(2, 174) = 588.44$, $p < .001$, $n^2_p = .87$, which supported the presence of false memories. Indeed, post-hoc analyses (*Bonferroni*) indicated that rates of veridical recognition for the studied actions were significantly higher than false recognitions of action lures ($p < .001$, Cohen's $d = 2.59$). False recognitions of lures were higher than false recognitions of false alarms ($p <.001$, Cohen's $d = 2.59$). The effect of Condition was not significant: $F(2, 87) = 1.11$, $p = .33$, $n^2_p = .02$. The Condition x Action interaction effect was marginally significant, with $F(4, 174) = 2.13$, $p = .08$, $n^2_p = .05$.

Post-hoc analyses (*Bonferroni*) showed that correct recognition rates of studied actions were higher in the enactment and imagery conditions than the control condition (all $p_s < .001$, Cohen's $d = 0.69$; Cohen's $d = 0.69$). Correct recognition rates were not significantly different between both the enactment and imagery conditions. Surprisingly, the rates of false recognition of lures were high in all three conditions, with all $p_s = 1.000$. Lastly, false recognitions of false alarms were the lowest rates and did not vary significantly among the encoding conditions, with all $p_s = 1.000$.

3.3. Responses Remember vs Know

The mean proportion of responses R/K in each encoding condition has been calculated for each action type which has been recognized as "old" (responses 3 and 4). An ANOVA with repeated measures was carried out with the mean proportions of R/K responses associated to each Action type. The mean percentages and standard deviations are presented in Table 3.

Table 3.
Mean percentage of responses Remember vs. Know for old responses (3 and 4 on the recognition scale) for each action type (studied; lures; false alarms) in each experimental condition (control, imagery, enactment).

REMEMBER	*Studied actions*	*Lures*	*False alarms*
Control	*51.94 (20.55)*	*19.16 (20.69)*	*2.10 (5.28)*
Imagery	*73.61 (17.72)*	*30.41 (25.57)*	*0.70 (1.82)*
Enactment	*79.02 (15.61)*	*30.00 (26.79)*	*0.70 (1.82)*

KNOW	*Studied actions*	*Lures*	*False alarms*
Control	*26.94 (18.46)*	*20.83 (21.36)*	*2.81(4.73)*
Imagery	*17.36 (15.71)*	*13.33 (15.37)*	*1.75 (2.88)*
Enactment	*11.39 (11.58)*	*12.08 (14.49)*	*1.40 (2.74)*

Note: standard deviation in parentheses.

The analyses revealed a significant R/K effect: $F(1, 87) = 103.71$, $p < .001$, $n^2_p = .54$; a significant Action type effect: $F(2, 174) = 633.56$, $p < .001$, $n^2_p = .88$; a significant interaction Condition x R/K effect: $F(2, 87) = 10.42$, $p < .001$, $n^2_p = .19$; a significant R/K x Action type interaction effect: $F(2, 174) = 115.17$, $p <.001$, $n^2_p = .57$. The Condition effect was not significant: $F(2, 87) = 1.39$, $p = .254$, $n^2_p = .031$.

Overall, Remember response rates were higher than Know response rates. Post-hoc comparisons (*Bonferroni*) revealed that Remember response rates were higher for studied actions than action lures and false alarms, $t(87) = 16.10$, $p < .001$; $t(87) = 78.90$, $p < .001$, respectively. Remember responses were also more frequent for action lures than false alarms ($t(87) = 14.00$, $p < .001$).

The Remember responses were higher in the enactment and imagery conditions than in the control condition ($t(87) = 3.94$, $p = .002$; $t(87) = 3.40$, $p < .015$, respectively). There was no difference between the enactment and the imagery conditions.

Post-hoc comparisons (*Bonferroni*) revealed that correct recognitions of studied actions lead to a recollection (Remember responses) instead of a feeling of familiarity (Know responses): $t(87) = 14.47$, $p < .001$. False recognitions of action lures were associated with higher Remember than Know responses, $t(87) = 3.26$, $p < .024$. For false alarm rates, there were no differences between Remember and Know responses, $t(87) = 1.81$, $p =1.000$.

Respectively, we expected that high rates of correct recognition of studied actions and high rates of false recognition of action lures would be positively correlated with a detailed source memory, that is, a high rate of Remember responses. In contrast, the low rates of false recognitions of false alarms should be positively correlated with a high feeling of familiarity, that is, Know responses, or else the alternative was a positive correlation by chance, with Remember vs Know responses. Pearson's correlation revealed a strong and significant positive correlation between confidence ratings for studied actions (responses 3-4) and Remember responses in all conditions: $r = .659$, $p <. 001$. Correlations between confidence ratings and Know responses were low and negative: $r = -.234$, $p <. 05$. According to the Fisher *r*-to-*z* transformation, the *z* value revealed a significant difference between these two correlation coefficients, with $z = 3.57$, $p <.0001$, suggesting that participants' confidence in the correct recognition of studied actions was systematically based on a recollection. High false confidence rates that action lures had been studied were highly and positively correlated with Remember responses, $r = .772$, $p <. 001$; correlation with Know responses was also significant: $r = .450$, $p <. 001$. Nevertheless, it appeared that false memories were more related to detailed memories than a feeling of familiarity, as was usually demonstrated in the DRM task with word lists ($z = 3.57$, $p <. 0002$). Finally, as has been studied, low false confidence rates for false alarms were highly and positively correlated by chance ($z = 0.05$, $p = .48$) with Remember and Know responses, $r = .786$, $p <. 001$; $r = .783$, $p <. 001$, respectively.

4. DISCUSSION

The present study aimed to evaluate the impact of sensory-motor encoding on false memories. The original DRM material (consisting of word lists semantically associated with a thematic word) was replaced by action lists 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 results showed that enactment and visual-motor imagery did not reduce false memories, contrary to what was expected. These findings led us to question the classical models of memory which assume that the enactment effect and visual imagery favour distinctive conceptual processing to the detriment of relational processing, with the consequence of reducing false recognitions (see Foley, 2012; Goff & Roediger, 1998; Robin & Mahé, 2015; Robin et al., 2021).

Another likely explanation might be that the encoding of contextually-associated action lists relies on a multi-sensorial simulation (Barsalou, 1999; Barsalou, Santos, Simmons, & Wilson, 2008). Indeed, according to the embodied cognition theory, it might be that the processing of actions could automatically trigger the perceptual, sensorimotor, and experiential traces associated with prior experiences. Hence, the participants may automatically simulate the situation evoked by each action (i.e. the script). Zwaan and Yaxley (2004) evidenced that shape and orientation of the objects were depicted in the mental simulation after the processing of sentences describing actions. Kan, Barsalou, Solomon, Minor, and Thompson-Schill (2003) have observed an activation of visual areas during semantic processing without the participants having explicitly received an imagery instruction.

In the present study, the combination of the multimodal traces might have led to an elaborate simulation, rich in specific details, reinforcing the correct recognition of the studied actions while increasing the probability of creating false memories. This might explain the high rates of false and veridical memories in the enactment and imagery conditions as well in the control condition. Therefore, the emergence of knowledge such as scripts might be based on simulation experiences in which contextual and sensory-motor traces form a global multimodal trace, which is not free from false memories.

Addressing the potential effects of sensory-motor and imagery encoding on the creation of false memories, from the embodied cognition approach, assumes that multimodal processing and integration of information mobilize a single episodic memory system. This conception considers cognitive functioning in a dynamic and systemic way where the conceptual, perceptual and contextual dimensions are in constant interaction. From this viewpoint, memories are more often subject to a phenomenon of reconstruction and in fact can move away from the source memory (i.e. the original). It therefore seems crucial to explore the issue of false memories but also confabulations within the theories of embodied cognition in order to specify their mechanisms; consequently, the assumptions resulting from this study merit further investigation.

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