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Script memory for typical and atypical actions: controls versus patients with severe closed-head injury

ELI VAKIL†, TALI SHAROT†, MALI MARKOWITZ†, SARA ABERBUCH‡§ and ZEEV GROSWASSER‡§

† Psychology Department, Bar-Ilan University, Ramat-Gan, Israel
‡ Loewenstein Rehabilitation Hospital, Ra'anana, Israel
§ Section Sackler Faculty of Medicine, Tel-Aviv University, Tel-Aviv, Israel

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Objective: When typical and atypical information about a situation is presented, the latter is usually better recognized. This phenomenon is referred to as the 'typicality effect'. It is claimed by most theories that typical and atypical information are mediated by automatic and effortful processes, respectively. Previous studies reported that patients with closed-head injury (CHI) are impaired only on memory tasks that required effortful but not automatic processes. Accordingly, it was hypothesized that these patients would not show the typicality effect when presented with scripts composed of typical and atypical actions.

Method: Twenty-two patients with CHI and 23 matched controls listened to two scripts which consisted of typical and atypical activities.

Results: As predicted, the findings of the present study revealed impaired typicality effect for patients with CHI as compared with controls. The advantage of the control group over the CHI group was more pronounced in the recognition of atypical than typical actions.

Conclusions: The results are discussed in terms of the limited attentional capacity or passive learning strategy, characteristic of memory impairment in patients with CHI.

Introduction

An important concept relating to the processing of new information is the 'schema'. Schema is an abstract generic knowledge structure representing the necessary and characteristic attributes of a conceptual system, as well as the typical relations among such attributes [1]. The schema becomes consolidated as more experience with the object, concept, or situation is acquired. The schema also allows for relatively automatic perception and encoding of similar events. Therefore, effortful processing of each element is not necessary. In effect, the appearance of only a small number of typical elements is necessary to activate the appropriate schema. This automatic processing allows for the freeing of cognitive resources in working memory for

Correspondence to: Eli Vakil, PhD, Department of Psychology, Bar-Ilan University, Ramat-Gan, 52900 Israel. e-mail: vakile@mail.biu.ac.il

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the processing of new information that is atypical and, therefore, not consistent with generic schematic expectations [2, 3].

The level of typicality of new information has a differential influence on memory ability for the information; that is, atypical details are better recognized than typical, expected details. The latter phenomenon is referred to as the 'typicality effect' or the 'consistency effect', and has been found to exist in various areas, such as in the study of pictures [2], scripts [1, 4, 5], and daily living scenes [3, 6].

The present study focuses on the typicality effect as it specifically relates to scripts. A script is defined as a common and well known activity which is comprised of a sequence of typical actions. For example, 'getting up in the morning' consists of a number of typical actions such as brushing teeth, getting dressed, eating breakfast, etc. The typicality effect may be observed in the area of scripts, i.e. irregular actions that are atypical to the script are remembered better than the typical actions [1, 4, 5].

Hess [4] and Hess and Slaughter [7] argue that two types of associations are probably involved in this task: script-based association and contextual association. Script-based association is an automatic process, which is activated during presentation and is involved in the memory of typical information. However, contextual association is an effortful process, which is necessary for distinguishing between the different types of information, and is involved in the memory of atypical information. Bobrow and Norman [8] offered a similar approach, known as the attention-elaboration hypothesis. Under the assumption that atypical actions attract more attention than typical actions, these atypical actions undergo deeper and more elaborate (i.e. effortful) processing which leads to better recognition.

Schank and Abelson [9] proposed the 'Script Pointer + Tag' hypothesis to describe the nature of the encoding process responsible for the typicality effect. Unlike the previous models, it is assumed that typical and atypical actions are encoded via automatic memory processes. They suggest that each typical action is represented in memory by a single pointer that relates it to the generic script ('script pointer'). By contrast, a separate functional-organizational unit ('tag') represents every atypical action. When a given schema is activated, so are the highly probable script actions; therefore, the participant has difficulty differentiating between typical actions that were previously mentioned and those that were not. In this way, the false alarm rate for typical actions is greater than the false alarm rate for atypical actions (for discussion of the different theories explaining the typicality effect, see [10]).

Following closed-head injury (CHI), most patients show an impaired ability to learn new verbal or visual material (for review, see [11, 12]). Limited attentional capacity has been suggested as a possible underlying mechanism for the memory deficit observed in patients with CHI. This claim is consistent with reports that patients with CHI are impaired on memory tasks that require effortful processes but are preserved on tasks based on automatic processes [13–15]. Other researchers have stressed a different source of difficulty in patients with CHI. Although studies demonstrate that semantic knowledge and its organization is intact in patients with CHI, these individuals seem to have a passive approach to learning, so that they do not spontaneously apply deep encoding [16, 17]. These approaches are not necessarily contradictory, and probably complement each other.

Consistent with both explanations presented above as to the difficulties associated with CHI, memory for typical actions is predicted to be preserved, since it is primarily dependent on automatic processes. The prediction regarding the atypical actions depends on whether it is assumed these actions are processed effortfully [4, 7, 8] or automatically [9]. If atypical actions are processed effortfully, CHI patients are predicted to be impaired in the recognition of atypical actions, and will, therefore, not show the typicality effect. However, if atypical actions are processed automatically, then CHI patient performance should not differ from that of the control group, thus showing the typicality effect.

Taking into account the confidence rating of the participants could help to detect the contribution of the groups' response bias to their memory performance [18]. Thus, in this study, two methods of memory measures were applied: in the first method, confidence rating was not taken into account in memory judgement performance; in the second method, participants' confidence ratings were used to weight their memory judgement answers.

Method

Participants

Two groups participated in the present study: a control group (non-brain damaged) and a CHI group. The control group consisted of 23 volunteers (18 males and five females) ranging in age from 18–35 years ($M = 23.57$, $SD = 4.82$). Their education ranged from 11–15 years ($M = 12.48$, $SD = 1.04$) of schooling. This group was comprised primarily of undergraduate students from Bar-Ilan University (Israel), who participated in this study as part of their course requirement. The CHI patients were recruited for the study from a population of patients admitted to the Loewenstein Hospital (Israel) for rehabilitation following severe head injury. This group was composed of 22 patients (19 male and three female) ranging in age from 18–38 years ($M = 24.45$, $SD = 5.77$). Their education ranged from 11–15 years ($M = 12.14$, $SD = 0.71$) of schooling. The groups did not differ significantly either in age, $t(43) = 0.56$, $p > 0.05$, or in education, $t(48) = 1.28$, $p > 0.05$. The time after onset ranged from 2–96 months ($M = 21.10$, $SD = 26.47$). The length of coma ranged from 1–99 days ($M = 17.43$, $SD = 22.81$). The Glasgow Coma Scale scores ranged from 4–9 ($M = 6.50$, $SD = 1.71$). Hence, patients would be considered as severe CHI patients due to the fact that they were in coma for at least 1 day and the Glasgow Coma Scale did not exceed the score of 9 [19]. An interdisciplinary team from the head trauma department evaluated referred patients at least 1 month prior to the study, as being beyond post-traumatic amnesia. Thus, patients' intellectual and linguistic functioning was at a level enabling adequate responsiveness to the task requirements based on the tests conducted. Participants in both groups had no history of mental illness, alcoholism or drug abuse.

Materials

The scripts applied in the present study were a Hebrew translation of the scripts taken from the Bower *et al.* [20] study. The two scripts consisted of two scenarios: 'eating in a restaurant' and 'shopping at the supermarket'. There were two versions of each script. In each version there were 16 activities, of which 12 were typical of the given situation and four were atypical of the given situation.

The defining of typicality/atypicality of actions was derived from a pre-test of 30 undergraduate psychology students, in which they were asked to rate the typicality of a list of 37 actions for each script, on a range from '1' (very typical) to '6' (very atypical). Thirty-two actions were chosen from the results of this pre-test, 24 of which had been rated as typical, and eight of which had been rated as especially atypical.

Two recognition tests were administered, one for each script. Each recognition test included 32 actions in random order—16 from the script just presented and 16 actions as distractors taken from the second version. A questionnaire concerning personal demographic information was used as a distractor task.

Procedure

Participants were individually tested and were told that the experiment deals with memory ability. Instructions were as follows: 'I am going to read you a story that is about 20 sentences long. Try to remember as many details as you can, because afterwards you will be asked some questions concerning the story'. Participants were then told the title of the first script ('eating in a restaurant' or 'shopping at the supermarket') and the script was read out loud to them. Subsequently, participants filled in the personal questionnaire. In addition to the gathering of demographic information about each participant, the questionnaire also served as a distractor task. Immediately following the questionnaire, the second script was presented in the same manner as outlined above. The order of the script presentations was counter-balanced, as was the specific version of each script. After reading the second script, participants were administered the digit forward and digit backward sub-test of the WAIS-R [21] as a distractor task. Following the distractor task, the participants were told the following: 'I am about to read you 32 sentences. Your task is to decide, for each sentence, whether the sentence appeared in the "eating in the restaurant"/"shopping at the supermarket" story. You are to rate the level of your certainty on this scale'. The scale ranged from '1' (certain that the sentence appeared) to '5' (certain it did not appear). Sentences were then read one at a time to the participants, who upon hearing the sentence made their recognition and rating judgements.

Results

A preliminary analysis of the results indicated that memory for each of the two scripts did not differ, nor did the order of presentation have a differential effect. Thus, the results of both scripts in the different orders of presentation were combined. Participants' recognition of the scripts (each consisting of 16 sentences) was scored in two ways: either with or without taking their confidence rating scores into account. The difference between the two sets of measures is in the mapping of scores onto ratings. The 'unweighted' measure assigns scores for new and old items based on a single cutting point in the confidence rating, while the 'weighted' measure reflects the full range of confidence rating.

Table 1. Mean (and standard deviations) of percent unweighted HR, FA and CHR scores of typical and atypical actions for both groups

	Score					
	HR		FA		CHR	
Group	Typical	Atypical	Typical	Atypical	Typical	Atypical
Control ($n = 23$)	79.12 (10.57)	88.24 (09.49)	37.86 (13.58)	07.07 (08.28)	41.26 (11.68)	81.17 (14.11)
CHI ($n = 22$)	67.14 (22.40)	60.14 (29.66)	44.13 (26.44)	10.80 (17.80)	23.02 (19.22)	49.34 (35.95)

HR = Hit Rate; Fa = False Alarms rate; CHR = Corrected Hit Rate (HR-FA).

Unweighted recognition scores

Unweighted recognition scores were calculated in the following way: The scale ranged from '1' (certain that the sentence appeared) to '5' (certain it did not appear). For each action, scores of '1' and '2' were considered as 'yes' (i.e. a hit). Accordingly, three dependent measures for each one of the scripts were derived and analysed: Hit rate (HR)—percentage of correct responses, that is number of 'yes' responses out of the 16 old actions that were presented at the learning stage. False alarms rate (FA)—percentage of erroneus, 'yes' responses to 16 new actions which were not presented at the learning stage. A corrected hit rate (CHR) was derived by substracting the FA score from the HR score. Mean (and standard deviations) of percentage unweighted HR, FA and CHR score of typical and atypical actions for both groups are presented in table 1.

A mixed design ANOVA was conducted on the unweighted recognition scores, to analyse the effect of group (control vs CHI) by the typicality of the sentences (typical vs atypical). The former is a between-subjects factor, and the latter is a within-subjects factor. In the analysis of the HR scores, overall the control group had a higher HR than the CHI group, $F(1, 43) = 15.92$, $p < 0.001$. The typicality effect did not reach significance, but the Group $\times$ Typicality interaction reached significance, $F(1, 43) = 6.94$, $p < 0.05$. Follow-up analysis using *t*-test for independent-samples revealed that HR scores were higher for controls compared to the CHI group in typical, $t(43) = 2.31$, $p < 0.05$, and atypical actions, $t(43) = 4.32$, $p < 0.001$. As can be seen in table 1, while the control group's HR was higher in the atypical as compared with the typical condition, the opposite pattern was observed for the CHI group.

Typicality effect was the only effect that reached significance in the analysis of the FA scores, $F(1, 43) = 146.19$, $p < 0.001$. As can be seen in table 1, the FA rate was similarly much higher for both groups, for typical vs atypical actions. The control group was more accurate overall than the CHI group, $F(1, 43) = 19.24$, $p < 0.001$, as measured by the CHR score. Typicality effect, $F(1, 43) = 98.53$, $p < 0.001$, and the interaction, $F(1, 43) = 4.15$, $p < 0.05$, reached significance. Follow-up analysis using *t*-test for independent-samples revealed that CHR scores were higher for controls compared to the CHI group in typical, $t(43) = 3.87$, $p < 0.001$, and atypical actions, $t(43) = 3.94$, $p < 0.001$. Although performance for both groups was more accurate with the atypical as compared to the typical actions (i.e. typicality effect), this effect appeared significantly stronger in the control group, as indicated by the significant interaction.

Weighted recognition scores

As with the unweighted recognition scores, three measures were analysed: Percentage HR, FA, and CHR. The 'weighted' measure reflects the full range of confidence rating. For each one of the 16 old sentences (HR) and the 16 new sentences (FA), when participants rated their confidence as '1'—'certain that the sentence appeared'—they were given the score of '4' for that answer. On the other extreme, when the rating was '5'—'certain that the sentence did not appear'—the score of '0' was given. Thus, the rating of 1–5 was converted respectively to a score of 4–0. Mean (and standard deviations) of percentage weighted HR, FA, and CHR scores of typical and atypical actions for both groups are presented in table 2.

A mixed design ANOVA was conducted on the weighted recognition scores to analyse the same effects as with the unweighted scores. The analyses of the weighted scores revealed the same pattern of results found in the unweighted scores. In the analysis of the HR scores, the control group had a higher overall HR than the CHI group, $F(1, 43) = 15.91$, $p < 0.001$. The typicality effect did not reach significance, but the Group $\times$ Typicality interaction reached significance, $F(1, 43) = 9.78$, $p < 0.005$. Follow-up analysis using *t*-test for independent-samples revealed that HR scores were higher for controls compared to the CHI group in typical, $t(43) = 2.08$, $p < 0.05$, and atypical actions, $t(43) = 4.36$, $p < 0.001$. As can be seen in table 2, while the control group's HR was higher in the atypical as compared with the typical condition, the opposite pattern was observed for the CHI group. Typicality effect was the only effect that reached significance in the analysis of the FA scores, $F(1, 43) = 181.25$, $p < 0.001$. As can be seen in table 2, the FA rate in both groups was similarly much higher for typical than for atypical actions. The control group was more accurate overall than the CHI group, $F(1, 43) = 20.21$, $p < 0.001$, as measured by the CHR score. Typicality effect, $F(1, 43) = 89.36$, $p < 0.001$, and the interaction, $F(1, 43) = 4.37$, $p < 0.05$, reached significance. Follow-up analysis using *t*-test for independent samples revealed that CHR scores were higher for controls compared to the CHI group in typical, $t(43) = 4.06$, $p < 0.001$, and atypical actions, $t(43) = 3.98$, $p < 0.001$. Although performance for both groups was more accurate

Table 2. Mean (and standard deviations) of percent unweighted HR, FA and CHR scores of typical and atypical actions for both groups

	Score					
	HR		FA		CHR	
Group	Typical	Atypical	Typical	Atypical	Typical	Atypical
Control ($n = 23$)	80.53 (08.07)	89.14 (08.29)	42.12 (11.76)	11.68 (09.98)	38.41 (11.15)	77.46 (15.06)
CHI ($n = 22$)	71.59 (18.87)	62.55 (28.00)	51.28 (23.15)	17.33 (17.16)	20.31 (18.07)	45.22 (35.69)

HR = Hit Rate; Fa = False Alarms rate; CHR = Corrected Hit Rate (HR-FA).

with the atypical as compared to the typical actions (i.e. typicality effect), this effect appeared significantly stronger in the control group, as indicated by the significant interaction.

Discussion

Previous studies reported that the performance of patients with CHI, on a variety of cognitive tasks, is better preserved when dependent on automatic rather than effortful processes [13–15]. Memory for the typical actions is assumed by all theories explaining the typicality effect to be processed automatically. Hence, it was predicted to be preserved in CHI patients. According to theories assuming that atypical actions require effortful processing [4, 7, 8], CHI patients are expected to be impaired. However, according to theories that assume that atypical actions, just like typical actions, are processed automatically [9] it would be predicted that the CHI group should not differ from the control group, and should, therefore, show the typicality effect.

Two findings clearly indicate that the results obtained are not due to a different response bias of the groups, but a genuine difference in memory: first, the weighted and unweighted scores revealed the same pattern of results; and secondly, the groups did not differ on their FA rate.

The findings of the present study revealed impaired typicality effect of the patients with CHI as compared with controls. As can be seen in tables 1 and 2, the advantage of the control group over the CHI group was more pronounced in the atypical than in the typical actions, as measured either by the HR or CHR scores. The assertion that effortful processes are more vulnerable to closed-head injuries than automatic processes is well established [13–15]. Therefore, the present finding that CHI patients' memory of atypical actions was primarily impaired is more readily explained by theories assuming that atypical actions are mediated by effortful processes [4, 7, 8] than automatic processes [9]. Similarly, previous studies have demonstrated that the typicality effect is affected by divided attention [22] and by cognitive elaboration [10]. Such results are predicted by theories claiming that atypical actions are processed effortfully [4, 7, 8]. However, such results are not predicted by theories which claim that atypical actions are processed automatically [9], since neither divided attention nor cognitive elaboration are expected to affect automatic processes.

The present findings are consonant with previous reports in which patients with CHI demonstrated intact semantic knowledge, but seem to have a passive approach to learning [16, 17] and difficulties in conceptual as opposed to perceptual memory tasks [17]. It remains for future research to determine exactly whether the source of the difficulties observed here in the performance of the patients with CHI is due to limited attentional capacity, or to passive learning strategy, or both. In any case these difficulties are associated with dysfunction of the frontal lobes. This is consistent with assertions made by researchers who have emphasized the cardinal role of lesions to the frontal lobes as an explanation for the behavioural sequelae typically observed following closed-head injuries [24–26].

It is important to note that the control group also outperformed the CHI group on memory of typical actions, although to a lesser degree than atypical actions. This result was unexpected since the latter are presumed by all theories to be processed automatically [4, 7–9] and as such to be preserved in patients with CHI. One possible explanation is that, even though automatic processes in these patients are better preserved than effortful processes, they are nevertheless impaired to some degree as compared to controls. An alternative explanation is that, although typical actions are primarily processed automatically, there is still an effortful component, which raises difficulties for the CHI patients (see Jacoby's [27] distinction between 'recollection' and 'familiarity' processes in recognition). Further research is required to test these alternative explanations.

Finally, this study demonstrates the importance of qualitative analysis of the different components of the memory task in order to characterize better the nature of memory impairment following closed-head injuries.

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