Studia Psychologica, Vol. 64, No. 3, 2022, 283-294
https://doi.org/10.31577/sp.2022.03.854

False Memories and Cognitive Flexibility

Gökhan Şahin
Karadeniz Technical University, Department of Psychology, Trabzon, Turkey

This study examined false memories, which occur when people falsely recognize words on the test phase that are not presented to them during the study phase, along with cognitive flexibility, which is thought to be related to metacognitive processes such as attention, reasoning, and decision making. Performance in recognizing the critical words of the DRM lists of the high and low scoring groups of subjects, who had used the Cognitive Flexibility Inventory (Dennis & Vander, 2010), was compared. The data of 58 undergraduate students who volunteered for the study were analyzed. Subjects were asked to complete a remember/know assessment of their responses so that recognition memory processes could be examined. Due to the nature of cognitive flexibility, which involves selecting and using appropriate information and relation with metacognitive processes, people with high cognitive flexibility were expected to show fewer memory errors. The results showed that while there was no significant difference in revealing more false memories compared to low or high cognitive flexibility, there were significant differences in the remember/know assessment. Individuals with high cognitive flexibility were more likely to remember their correct answers than those with low cognitive flexibility. On the other hand, the low cognitive flexibility group reported more know responses about their correct answers. These results show that there may be a relationship between subjective consciousness processes and cognitive flexibility in retrieving information in recognition memory.

Key words: cognitive flexibility, Deese-Roediger-McDermott paradigm, false memories, remember/know

Cognitive Flexibility

According to a simple definition, cognitive flexibility is the ability to reconstruct information in different ways depending on changing situational demands (difficulty or complexity of the situation) (Spiro et al., 2013). Cognitive flexibility can be defined as the ability of individuals to change and adapt their cognitions according to changing conditions. CF is critical in restructuring and adapting mental processes (Ionescu, 2012; Martin & Rubin, 1995; Van Heil et al., 2016). CF enables people to tailor

Correspondence concerning this article should be addressed to Gökhan Şahin, Karadeniz Technical University, Department of Psychology, Trabzon, Turkey. E-mail: gsahin@ktu.edu.tr

Received December 17, 2021

sequential inferences or responses to changing task demands by selecting information about tasks that may change in unpredictable ways (Deák, 2004). CF is inextricably linked to attentional processes, as it represents the ability to adapt cognitive processes to new and often unexpected conditions. (Cañas et al., 2003). As can be seen, while there are many definitions of cognitive flexibility in the literature and no single definition, the commonality among these definitions is that they point to the ability of people to rearrange information depending on the situation.

Scales assessing cognitive flexibility are performance-based measures such as the Wisconsin Card Sorting Test (Berg, 1948) and the Stroop Color Test (Golden, 1975), and the Cognitive Flexibility Scale (Martin & Rubin, 1995); and the Cognitive Flexibility Inventory (Dennis & Vander, 2010) can be classified as self-report scales. Most performance-based measures of cognitive flexibility describe cognitive flexibility in terms of a behavioral measure such as response regulation and suppression. Neuropsychological assessment instruments, in addition to scales and questionnaires, are used in the assessment of cognitive flexibility. In their study, Johnco, Wuthrich, and Rapee (2014) compared the assessments of cognitive flexibility with neuropsychological and self-report scales and observed that although both measures are suitable for use in the measurement of cognitive flexibility, they measure different aspects of cognitive flexibility. In their study, where they compared clinical and non-clinical samples, they observed that the clinical sample showed lower cognitive flexibility levels compared to the non-clinical sample in both measurement styles. Although they have different aspects, one of the advantages of self-report measures in terms of measuring the level of cognitive flexibility can be considered as their brevity, ease of application and scoring (Dennis & Vander, 2010). In general, cognitive flexibility is thought to be related to executive functions and metacognitive processes such as reasoning and decision making (Buttelmann & Karbach, 2017). In addition to these processes, it can be said to be highly related to some other cognitive processes, including planning, inhibition, and working memory (Miyake et al., 2000). Also the studies examining the relationship between cognitive flexibility and emotions, mood disorders, particularly anxiety, depression, and panic disorder (Lieberman et al., 2016), as well as the relationship with emotion regulation processes, suggest that cognitive flexibility plays an important role in these processes. (Hildebrandt et al., 2016). Some recent studies showed that especially positive emotion could enhance cognitive flexibility (Wang et al., 2017).

We can define cognitive flexibility as a skill to reconstruct cognition in cognitive processes such as thinking, understanding, and problem solving (Spiro & Jehng, 1990). In other words, it explains the changes arising from the cognitive evaluation of the individual in the face of various situations. We might expect that a more cognitively flexible person would be better able to suppress certain aspects of the stimulus, better organize information, and use certain memory strategies to focus on the more important aspects of the stimulus.

False Memory and DRM

One of the most popular topics among studies dealing with memory errors is false memories. False memories are defined as “remembering events that never happened in reality as if they really happened, or remembering real events that were different from what they were” (Roediger & McDermott, 1995a). The method of Deese, Roediger, and McDermott (DRM) (1995b) is the most common method in studies aimed at observing memory errors using word lists. Roediger and McDermott further developed the work of Deese (1959) and introduced the method that is commonly used today. In the DRM method, lists of words associated with each other are presented in the learning phase and assessed in the testing phase with a free recall or recognition task. A word that is most associated with lists is called a critical word. Although critical words are not actually presented in the learning phase, they are misremembered in the testing phase. This situation is called false memory. Furthermore, when Tulving's (1985) remember/know method is applied to observed false memories, it is found that mostly remembering is evaluated (Roediger & McDermott, 1995b). In other words, individuals say that they not only remember the critical word that was not presented to them incorrectly, but also can recall the moment it was presented in detail when rating it as remember/know. Tulving argued that in the remember/know paradigm, the rating of responses reflects two distinct processes of consciousness. Gardiner (1988) then contributed to this paradigm by defining remembering as "consciously recalling the detailed details of the initial presentation of the stimulus" and knowing as "being known to the person without details about the stimulus." In terms of the processes of recognition memory as hypothesized in the literature, it is reasonable to assume that remembering represents recollection and know represents familiarity (Wixted & Mickes, 2010). But also one model that challenges dual processing models is the memory strength based explanation which is based on signal detection theory. According to this explanation, remember/know assessments reflect different dimensions of memory strength, not different memory processes (Wixted & Mickes, 2010). In Dunn's (2004) review of remember/know answers based on the dimension of confidence, specifically suggested that R(remember) answers correspond to a confidence level between "high" and "very high", while K(know) answers correspond to a confidence level between "low" and "high". As a result, most of the studies examining memory using DRM lists in the literature use the R/K method to better analyze the recognition memory processes.

The fact that the DRM method has gained serious attention and popularity in memory studies is due to its ease of application in the experimental setting, its openness to manipulation and control (Gallo, 2010).

Cognitive Flexibility and DRM

In their review study, Isen and Labroo (2012) examined the effects of positive affect on decision-making processes, highlighting the effects of cognitive flexibility associated with positive affect. In another study researchers argued that attentional control and working memory capacity, which develop in the context of positive affect, contribute to source tracking and thus reduce false memories (Yang et al., 2015). It can be said that positive affect promotes cognitive flexibility (Isen & Labroo, 2012) and this reduces misidentification, especially in tasks where participants are made aware of the relationship between list words and critical words. It has been observed that knowledge of the relationship between related words and critical words in DRM lists reduces false memories by limiting the use of kernel-based information (Libby & Neisser, 2001). Considering cognitive flexibility as an individual's ability to adjust his or her approach to the problem according to the changing demands of the task, it is possible that cognitive flexibility contributes to a reduction in false memories when learning sequentially presented association lists.

The aim of this study is to investigate the relationship between cognitive flexibility and false memories revealed by DRM lists. In this study, cognitive flexibility was measured using Dennis and Vander Wal's (2010) Cognitive Flexibility Inventory. In light of the literature, it is expected that individuals with high cognitive flexibility will report fewer false memories. Another aim of the study is to evaluate the use of DRM lists, a simple method for detecting false memories, by adapting them to simple online tools (Google forms). The method, which cannot be applied in a standard laboratory environment during the pandemic process, was adapted to Google forms that can be applied through mobile phones. In this way, the usefulness of the DRM method in the observation of false memories is evaluated.

Recognizing an item as old can be based on two processes in recognition memory; familiarity and recollection (Rajaram, 1993; Yonelinas, 2002). One way to distinguish between the two is to ask participants to give a remember or know response for the test item. In studies examining memory using the DRM paradigm, critical words which are falsely remembered are also evaluated with the high remember response. (Miller & Wolford, 1999; Roediger & McDermott, 1995). In this study, the processes of false memory recognition will be investigated by allowing individuals to give a "remember/know" rating of their responses.

Method

Participants

An analysis was conducted using the G*Power program to determine the required sample size (Faul et al., 2007). Examination of previous studies using similar experimental methods and word lists (Goodman et al., 2011; Maulina et al., 2021) revealed an average effect size value of 0.198. An a priori power analysis using G*Power (repeated measures, within-subject, group number: 1, number of measures: 4, correction between repetitions: 0.5) yielded a total sample size of 57.

58 participants, 3 of whom were men, were included in the experiment. Since it was planned to compare the two groups based on the scale scores applied, one more person (58) was included in the study to keep the number of groups equal. The mean age of the participants was 21.32 years and the standard deviation was 1.93.

Announcements about the research were made using the online pages of psychology courses when face-to-face education was suspended under COVID19 pandemic conditions. Participants in the sample are members of the sociology department. Participation was completely voluntary. The ethical suitability of the study was approved by the Karadeniz Technical University Social and Human Sciences Ethics committee

Measures

DRM lists

In this study, the DRM method of Deese, Roediger, and McDermott (1995b) was used. To create lists of Turkish words using this method, the lists created by Şahin and Tekman (2019) were used by using the words whose imagination and concreteness scores were determined in the studies on Turkish word norms by Tekcan and Göz (2005). Each list consists of a total of 8 words, 7 of which are related and 1 critical word that has the most associations with the list. A total of 12 lists were used, including two unrelated lists of 8 words each.

Cognitive Flexibility Inventory (CFI)

The original scale was developed by Dennis and Vander Wal (2010). CFI was created with the aim of determining people's abilities to work out alternative solutions, think in a balanced way, be aware of appropriate options, and behave in situations they encounter in life, over a period of time or in difficult situations. The Turkish version of the scale was adapted by Gülüm and Dağ (2012). The 20-item inventory has two subscales. The "Alternatives" subscale, which consists of 13 items, and the 7-item "Control" subscale determines the perception of control over difficult situations. (Gülüm & Dağ, 2012). Exploratory factor analysis supported the two-factor structure. Two factors explained 49.8% of the total variance. Factor loadings ranged from .39 to .82. The internal consistency coefficient of the scale was determined as .90 (Gülüm & Dağ, 2012).

Procedure

The data for the study were collected online using Google Forms. When the number of samples determined by power analysis was reached, participation was terminated. On the first page of the Google Form prepared for the study, participants provided demographic information such as age and gender. Since the study was an online experimental study, participants were asked to enter the time information at the beginning of the experimental phase to control for the amount of time spent on the experiment and also to provide a little motivation to prevent participants from disconnecting from the experiment. At the end of the entire experiment, they were asked to re-enter the time data so that an attempt was made to determine the total time spent on the experiment. The average time spent completing the experiment (12 minutes) by all participants was within the range of the estimated time (10-15 minutes) given to them in the instructions.

After answering the demographic information and recording the start time, participants answered the CFI questions. After answering this questions, word lists were learned. After reading the instructions for this phase, the word lists were presented.

To control for primacy and recency effects, two lists were presented at the beginning and end of the word lists that were unrelated to each other and to the list words. With the presentation of 12 lists of 8 words and a total of 96 words, the learning phase was complete.

Before proceeding to the test phase, individuals were asked to count and write 5 digits from 895 as 9 digits backwards. Then the testing phase was started. Instead of the yes/no procedure, to focus on sensitivity for an explanation for memory errors we use the two alternative forced choice (2AFC) response method in the recognition phase (Green & Swets, 1966). In 2AFC test in each trial of the test an old word would be presented together with a new word (Şahin & Tekman, 2019). Participants are asked to choose which of the options is old. After reading the instruction, people were presented with two words in each response step in accordance with the 2AFC, and they were asked to choose one. After this choice, they were asked to give remember/know response. At the end of the 20 word pairs and the subsequent rating of remember/know, the testing phase was completed. Of the 20 word pairs presented in the test phase, 5 were critical words, 5 were related words, and 10 were unrelated words. One of the pairs is a word that was already presented in the learning phase of the same word type (critical, related or unrelated), while the other is a new word. After answering the questions and entering the time data at the end of the experiment, the experiment was finished.

Since there is no standard in the literature for the cut-off point of CFI, the group below the average of 58 individuals *(M = 80, Min =*

Table 1 *Averages of cognitive flexibility groups*

CF group	*CFI mean*	*Age*	*Total duration (min)*
High	87.17 (5.41)	21.51	12.55 (5.35)
Low	73.07 (6.02)	21.14	12.24 (3.58)

54, Max = 98) to whom the scale was applied was classified as a low cognitive flexibility group, while those above the average were classified as a high cognitive flexibility group. Independent sample *t*-test results also showed that there was no significant difference between the two groups for age, $t(56) = 0.74$, $p = .464$, and total duration, $t(56) = 0.26$, $p = .796$. The averages of the groups are presented in Table 1. The collected data were analyzed using the program JASP 0.14.1 (JASP Team, 2018).

Results

Correct Answers between Groups by DRM Lists Word Type

The participants' correct answers for three word types (critical, related, unrelated) were analyzed. The averages of the correct answers obtained when they differentiated the words they had actually seen during the learning phase from the two words presented to them during the testing phase were analyzed by repeated measures analysis of variance for three word types. The results of the ANOVA showed that word type had a significant effect on correct responses ($F(1.73, 97.32) = 10.29$, $p < .001$, $\eta p^2 = .15$). In other words, the success in differentiating the word they had previously seen from the words on the screen during the test phase varied depending on which word type it was. According to the results of the Bonferroni post-hoc test conducted to see between which word types this significant difference occurred, it was found that the mean scores of correct responses for critical words were significantly different from the mean scores of correct responses for related and unrelated words. The lowest correct responses among the word types were for critical words. While the average of correct responses for critical words was .58, it was .69 for related words and .74 for unrelated words. The average scores are shown in Figure 1.

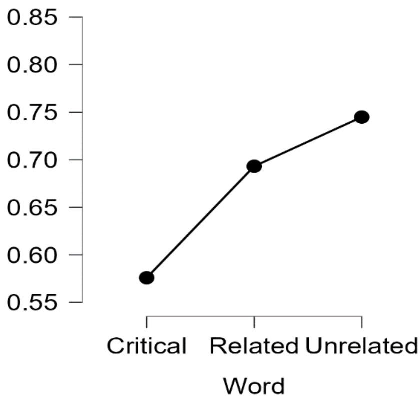

Figure 1 Correct answer rates by word type.

No statistically significant difference was found when comparing the overall hit rate of the high and low groups as determined by the scores obtained on the Cognitive Flexibility Inventory ($F(1, 56) = 0.08$, $p = 0.77$, $\eta p^2 = .001$).

These results also indicate that DRM lists adapted to simple online data collection methods allow for the observation of false memories, as expected.

Remember Responses for Word Type and Correct/Incorrect Answers

To examine the processes of recognition memory in the subjects' responses to the words, they were asked to indicate whether they remembered or knew that they had studied that word in the pair. After choosing one of the two words presented to them, the performances rated for that choice were examined. For the remember responses, the effect of the word (critical, related, unrelated) x correct/incorrect responses was examined with repeated ANOVA measures. Individuals who were classified into high and low groups based on the Cognitive Flexibility scale scores were included in the analysis as a between-subject variable.

The correct and incorrect response rates for the three word types in the remember responses are shown in Table 2. The results of the ANOVA showed that the word type has a significant effect on the remember responses ($F(2, 112) = 24.72$, $p < .001$, $\eta p^2 = .306$). The remember responses that subjects gave for the words they chose differed significantly by word type. The remember response was most frequent for the critical words, then related words and lastly unrelated words. According to the results of the Bonferroni post-hoc test, the mean scores of the three word types differed significantly from each other.

According to the results of the analysis, it was found that correct and incorrect answers had a significant influence on the remember responses ($F(1, 56) = 66.71$, $p < .001$, $\eta p^2 = .544$). While the average of remember scores for correct answers is 0.34, it is 0.13 for incorrect answers. Participants gave more "remember" answers for correct answers than for incorrect answers.

When the results were examined by word type, it was found that most remember responses for critical words were given for both correct and incorrect responses. After selecting the critical word that was actually present-

Table 2 *True/false rates by word type in remember responses*

Word type	*HitFalse*	*CFI*	*Mean*	*SD*
Critical	Hit	High	0.379	0.264
		Low	0.317	0.248
	False	High	0.297	0.276
		Low	0.193	0.210
Related	Hit	High	0.441	0.269
		Low	0.297	0.237
	False	High	0.110	0.137
		Low	0.097	0.115
Unrelated	Hit	High	0.369	0.274
		Low	0.207	0.231
	False	High	0.041	0.095
		Low	0.038	0.078

ed to them by giving the correct answer, they gave remember response and reported that they had detailed information about the moment when the word was presented to them. And also they gave a high remember response after selecting the critical words that were not presented to them incorrectly. In other words, they indicated that they remembered the moment when the critical words that were not presented to them were presented on the list.

According to the results of the analysis, the interaction of words and true/false answers was significant for the remember responses ($F(1.65, 92.37) = 6.30$, $p = .007$, $\eta p^2 = .084$). According to the results of Bonferroni post-hoc test, the rating of remember after false answers for critical words was significantly different from the other two types of words. False responses for critical words were rated as remembered at a high rate.

As a result of the analysis, it was found that there was a significant difference between high and low cognitive flexibility groups in terms of remember responses ($F(1, 56) = 5.15$, $p = .015$, $\eta p^2 = .101$). It was observed that individuals with high cognitive flexibility gave more remember responses than individuals with low cognitive flexibility. Bonferroni post hoc tests showed individuals with high cognitive flexibility were more likely to report remembering correct answers than individuals with low flexibility ($M = .123$, $SE = .041$), $t = 2.99$, $p = .021$.

Know Responses for Word Type and Correct/Incorrect Answers

To examine the processes of recognition memory in people's responses to words, the results of know responses were examined. For know responses, the effect of word (critical, related, unrelated) x true/false responses was examined with repeated ANOVA measures. Individuals who were classified into high and low groups based on the Cognitive Flexibility scale scores were included in the analysis as a between-subject variable.

The rates of correct and incorrect responses for the three word types in the know responses are shown in Table 3. According to the results of the ANOVA, it was found that the word type had a significant effect on know responses ($F(2, 112) = 24.72$, $p < .001$, $\eta p^2 = .306$). The responses given for the words like know differed significantly. The most "know" responses were given for unrelated words, followed by related words and least critical words. According to the results of the Bonferroni post hoc test, the mean scores of the three word types differed significantly from each other.

Table 3 *True/false response rates by word type in know answers*

Word	*Hit/False*	*CFI*	*Mean*	*SD*
Critical	False	High	0.138	0.221
		Low	0.228	0.212
	Hit	High	0.186	0.213
		Low	0.262	0.234
Related	False	High	0.200	0.220
		Low	0.207	0.236
	Hit	High	0.248	0.198
		Low	0.400	0.278
Unrelated	False	High	0.214	0.148
		Low	0.217	0.171
	Hit	High	0.376	0.228
		Low	0.538	0.226

According to the results of the analysis, it was found that correct and incorrect answers had a significant impact on know ratings ($F(1, 56) = 28.237$, $p < .001$, $\eta p^2 = .335$). While the average of the know rating for correct answers is 0.33, this average for incorrect answers is 0.20. Participants gave more know responses for correct answers than for incorrect answers.

As a result of the analysis, the interaction of words and correct/wrong answers was found to be significant ($F(2, 112) = 6.17$, $p = .003$, $\eta p^2 = .099$). According to the results of Bonferroni post hoc test, the know response after correct answers to unrelated words is significantly different from other types of words.

The results of the between-subject analysis comparing the groups with high and low cognitive flexibility scores on know responses according to correct and incorrect answers were found to be significant ($F(1, 56) = 6.30$, $p = .015$, $\eta p^2 = .101$). Bonferroni post hoc tests showed that the group with a low cognitive flexibility was significantly more likely to give a know response than the group with a high cognitive flexibility score. ($M = -0.130$, $SE = .041$), $t = -3.15$, $p = .013$.

Discussion

In the study, after answering the questions of the Cognitive Flexibility Inventory (Dennis & Vander, 2010), subjects studied DRM lists in the learning phase and answered the word pairs presented in the testing phase using the forced-choice method. Finally, making a remember/know assessment regarding their answers they completed the experiment.

When the results of the total correct answers were examined by choosing the word that was actually presented during the learning phase from the two words presented to the people during the test phase, the lowest correct answers were given in the critical words, which is consistent with other research findings using the DRM list and 2AFC method in the literature (Şahin, 2020; Weinstein et al., 2010; Westerberg & Marsolek, 2003). In other words, people made the most errors for critical words among the word pairs presented to them.

False responses to critical words were rated as remembering at a high rate. While remember responses reflect a mental reliving of the experience, know responses do not (Roediger & McDermott, 1995b). In other words, after responding to the critical words that were not actually presented to them incorrectly, participants rated their responses as remember and indicated that they were able to relive the moment when they saw the critical word on the list.

When examining the results of the know ratings made after the subjects' responses to the pairs of words presented to them, it was found that most of the know ratings were made significantly for the unrelated words. While know ratings for related and unrelated words differed significantly for correct and incorrect responses, it was observed that know ratings did not differ significantly after correct and incorrect responses for critical words. This finding indicates that people who cannot distinguish whether critical words are actually presented to them or not, give know response after a forced choice answer. Based on this finding, the view that false memories are more related to familiarity than recollection is supported (Yonelinas, 2002), considering that the know answers are related to familiarity (Wixted & Mickes, 2010).

According to the definition of Spiro et al. (2013), cognitive flexibility includes the selection and use of appropriate information, that is, the initial understanding of a situation and decision-making processes. All the characteristics mentioned in the definition can also be considered in the context of memory processes. However, there are not many studies in the literature that address the relationship between false memory and cognitive flexibility. The DRM lists have been used to address issues of false memory and cognitive flexibility. The false memory rates obtained with the applicable processed form on Google forms are consistent with those obtained when DRM lists are used in the experimental setting and via experimental computer programs (Akdoğan et al., 2020; Şahin, 2011; Şahin & Tekman, 2019).

When the results were examined, it was found that there was no significant difference between the low and high cognitive flexibility groups in terms of revealing more false memories when comparing correct answers. However, when examining the remember/know responses, there was a significant difference between the two groups. Individuals with high cognitive flexibility were more likely to remember their correct answers than individuals with low cognitive flexibility. On the other hand, the group with low cognitive flexibility gave know responses more for correct answers. When comparing the total responses, no significant difference was found by level of cognitive flexibility in terms of false recall rates, but this finding in the know responses shows that the recognition memory processes of people with low cognitive flexibility differs. Considering Dunn's (2004) approach, it can be thought that people with high cognitive flexibility also have more confidence, and low confidence may be related to more know responses with low cognitive flexibility.

The fact that the familiarity process associated with false memories is related with the know responses and the fact that people with low cognitive flexibility give more know responses indicate that there is a need for further research on this topic. Of course, considering that this study is a quasi-experiment and it exploratorily deals with the relationship between cognitive flexibility and false memories, there is a need for more comprehensive studies on cognitive flexibility in terms of recognition memory processes and false memories.

Although the false memory rates seem compatible with the literature in the study, which was carried out completely online due to pandemic conditions, repeating the study in a standard experimental environment may be beneficial for observing the relationship between cognitive flexibility and memory error. The fact that the number of participants is not balanced in terms of gender is a limitation related to the sample, although there is no gender difference in cognitive flexibility. It is recommended that future studies be conducted with more balanced samples.

Author's ORCID
Gökhan Şahin
https://orcid.org/0000-0002-6479-7018

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