International Journal of Neuroscience, 120, 211–216, 2010

ISSN: 0020-7454 print / 1543-5245 online
DOI: 10.3109/00207450903506510

informa
healthcare

Is there a Recognition Memory Deficit in Parkinson's Disease? Evidence from Estimates of Recollection and Familiarity

Brigitte Weiermann,[1] Marianne A. Stephan,[2] Alain Kaelin-Lang,[2] and Beat Meier[1,*]

[1]*Department of Psychology, University of Bern, Bern, Switzerland*

[2]*Movement Disorders Center, Department of Neurology, Inselspital, Bern University Hospital, University of Bern, Bern, Switzerland*

ABSTRACT

There is conflicting evidence whether Parkinson's disease (PD) is associated with impaired recognition memory and which of its underlying processes, namely recollection and familiarity, is more affected by the disease. The present study explored the contribution of recollection and familiarity to verbal recognition memory performance in 14 nondemented PD patients and a healthy control group with two different methods: (i) the word-frequency mirror effect, and (ii) Remember/Know judgments. Overall, recognition memory of patients was intact. The word-frequency mirror effect was observed both in patients and controls: Hit rates were higher and false alarm rates were lower for low-frequency compared to high-frequency words. However, Remember/Know judgments indicated normal recollection, but impaired familiarity. Our findings suggest that mild to moderate PD patients are selectively impaired at familiarity whereas recollection and overall recognition memory are intact.

Keywords Episodic memory, Remember/Know procedure, word-frequency mirror effect

INTRODUCTION

Parkinson's disease (PD) is a progressive neurological disorder primarily characterized by motor deficits such as resting tremor, bradykinesia, rigor, and postural instability. In addition, even nondemented PD patients often exhibit cognitive impairments (Zgaljardic, Borod, Foldi, & Mattis, 2003). In this study we focus on the domain of memory, in particular on explicit episodic memory. While there is consistent evidence that nondemented PD patients are impaired at free recall (e.g., Allain et al., 1995; Appollonio et al., 1994; Breen, 1993), there is mixed evidence for recognition memory. Some studies found intact recognition memory performance (e.g., Appollonio et al., 1994; Breen, 1993; Flowers, Pearce, & Pearce, 1984), but other studies found an impairment (e.g., Beatty et al., 2003; Higginson, Wheelock, Carroll, & Sigvardt, 2005; Whittington, Podd, & Kan, 2000). It remains unclear whether the impairment is attributable to a deficit in familiarity or in recollection, that is, the cognitive processes assumed to underlie recognition memory (Davidson, Anaki, Saint-Cyr, Chow, & Moscovitch, 2006; Edelstyn, Mayes, Condon, Tunnicliffe, & Ellis, 2007). The goal of the present study was to investigate recognition memory in PD patients with particular focus on the contribution of recollection and familiarity.

Recollection is defined as the mental reinstatement of a prior event which is associated with a vivid memory for contextual details. *Familiarity* is the awareness or feeling that an event has been experienced before, without recalling the particular encoding context (Reder et al., 2000; Yonelinas, 2002). Many models of recognition memory assume that these processes can contribute independently to recognition performance with recollection as an all-or-none process and familiarity as a process that can vary on

Received 14 October 2009

corresponding author: Beat Meier, Department of Psychology, Muesmattstr. 45, 3000 Bern 9, Switzerland. E-mail: beat.meier@psy.unibe.ch

a continuum (Yonelinas, 2002). The contribution of recollection and familiarity to recognition performance can be addressed with different procedures. Here we focus on the word-frequency mirror effect and the Remember/Know procedure.

The word-frequency mirror effect refers to the phenomenon that in a recognition test hit rates (i.e., correct recognition of old, previously presented items) are increased and false alarm rates (i.e., incorrect "recognition" of new, not previously presented items) are decreased when performance of low-frequency words is compared to performance of high-frequency words (Reder et al., 2000). Thus, the pattern of hits is mirrored in the pattern of false alarms (Glanzer & Adams, 1990; Reder et al., 2000). The word-frequency mirror effect is assumed to emerge because hit rates and false alarm rates are differentially dependent on recollection and familiarity. Because high-frequency words have higher baseline familiarity compared to low-frequency words, new high-frequency words are more likely to produce familiarity-based false alarms than new low-frequency words. In addition, low-frequency words have fewer contextual associations than high-frequency words and the situation-specific activation during the study episode provides for a more distinctive memory trace. Therefore, compared to high-frequency words, recollection of low-frequency words is typically increased, resulting in a higher hit rate. Consequently, hit rates of low-frequency words can be considered as an estimate of recollection and false alarm rates of high-frequency words can be considered as an estimate of familiarity (Reder et al., 2000).

Using the word-frequency mirror effect combined with the Remember/Know procedure, Davidson et al. (2006) investigated recollection and familiarity in 19 PD patients and a healthy control group. The Remember/Know procedure is based on the subjective retrieval experience for an item recognized as "old." A *Remember* response is thought to reflect recollection, and a *Know* response is thought to reflect familiarity. Davidson et al. (2006) asked the participants to give either a Remember or a Know response when they thought the word had been presented before, or a "no" response when they thought the word was new. The results showed that patients and healthy controls were comparable in their hit rates for both low- and high-frequency words. In contrast, the patients made slightly more false alarms to high-frequency words compared to the control group. This resulted in poorer recognition performance for high-frequency words. In addition, the results from the Remember/Know procedure indicated that the patients showed intact recollection, but impaired familiarity. These findings were supported by a second experiment, in which the process dissociation procedure was used to estimate familiarity and recollection. Davidson et al. (2006) concluded that the somewhat reduced recognition memory performance of PD patients was primarily due to an impairment of familiarity.

However, a different pattern of results was reported by Edelstyn et al. (2007). They investigated recollection and familiarity in 17 PD patients and a healthy control group using a two-step response procedure. After each "yes" response, subjects were asked to give a Remember or Know judgment. Overall, the pattern of hit rate and false alarm rate did not differ between groups. However, PD patients were impaired at recollection as indicated by lower discrimination for Remember responses, but no group difference was found for familiarity. These results are in sharp contrast to the findings of Davidson et al. (2006). This discrepancy may be due to methodological differences. While Davidson et al. (2006) used a single-step response procedure for the recognition test, Edelstyn et al. (2007) used a two-step procedure and it is possible that in a single-step decision the Remember and Know judgments are used to indicate strong and weak memory rather than recollection and familiarity (Edelstyn et al., 2007).

To test this possibility, we combined the word-frequency mirror effect (as in Davidson et al., 2006) with a two-step Remember/Know response procedure (as in Edelstyn et al., 2007). If these methodological differences are sufficient to explain the discrepant findings as suggested by Edelstyn et al. (2007), we would predict a deficit in recollection. In contrast, if the familiarity deficit reported by Davidson et al. (2006) is more general in nature, we would predict a deficit in familiarity.

METHOD

Subjects

Fourteen idiopathic PD patients (11 male, 3 left-handed) were recruited from the file of the Department of Neurology at the Inselspital Bern, Switzerland. Exclusion criteria were global cognitive deterioration as indicated by performance below a cut-off of 27 points on the Mini Mental State Examination (Folstein, Folstein, & McHugh, 1975), and insufficient command of the German language. Their age ranged from 53 to 75 years ($M = 63.2$) and their education ranged from 9 to 15 years ($M = 12.7$). Verbal intelligence was assessed by the MWT-B, a German equivalent to the National Adult Reading Test (Lehrl, Merz, Burkhard, & Fischer, 1991). The scores ranged from 23 to 35 ($M = 29.2$). All patients signed an informed consent. The study was approved by the local ethics committee.

Nine patients were in stage 2, 1 patient in stage 2.5, and 4 patients in stage 3 according to Hoehn and Yahr staging of PD (1967). The duration of disease was defined as the time between the appearance of the first symptoms of PD reported by the patient and the present study ($M = 9.43$, range 3–18). The score on the activity of daily living scale (Schwab & England, 1969) ranged between 70 and 100 ($M = 89.6$). All patients were treated with dopaminergic therapy and were taking their routine medication regiments when tested. One participant was treated with deep brain stimulation. The exclusion of this patient did not alter the results of the statistical analyses. The patients were screened for depression (CES-D; Radloff, 1977), and did not differ from controls in their depression scores ($p > .05$).

A control group matched for gender, handedness, age ($M = 62.2$, range 53–77), educational level ($M = 13.6$ years, range 9–18), and verbal intelligence (MWT-B score: $M = 30.4$, range 19–35) was recruited. Independent *t*-tests revealed no significant difference between the two groups, neither for age, educational level nor verbal intelligence (all $p > .05$).

Materials

Materials and procedure were composed according to the method used by Balota, Burgess, Cortese, and Adams (2002). Forty-eight high-frequency and 48 low-frequency words, all concrete nouns, were selected from the vocabulary database of the University of Leipzig (http://wortschatz.uni-leipzig.de). The mean frequency class was 8.90 ($SD = 1.51$) for low-frequency words and 15.06 ($SD = 1.55$) for high-frequency words, $t(94) = 19.8$, $p < .001$. The words ranged from 3 to 10 letters and were matched in length across frequency categories. Half of the items within each frequency category were chosen to form the study list, and the remaining half of the items were used as lure items on the recognition test. The assignment of words to the study list was counterbalanced across subjects such that each word occurred both as a study item and as a lure item.

Procedure

In the study phase, subjects were instructed to read aloud a list of words presented on the screen one at a time and to try to remember them for a later memory test. Words were presented at the center of the screen and in randomized order. They were written in black font on white background and disappeared after 2000 ms. There was a 30-min retention interval during which subjects performed an unrelated activity.

In the test phase, words were presented in randomized order at the center of the screen, one at a time, and remained until the subject responded. Subjects were informed that some of the words were old words from the study phase and some were new words not presented before. They were instructed to indicate whether the word was old or new. After a "new" decision, the next word appeared immediately. After an "old" decision, subjects were asked to give a Remember or Know judgment. They were instructed to give a Remember response when they were able to recollect the word from the study episode and to give a Know response when they were not able to recollect the word, but nevertheless believed that they had studied it before. After a response was given, the next word appeared. For the patients and most of the controls the experimenter pressed the response keys to prevent mistakes due to motor disabilities.

Analyses

For all statistical analyses, an alpha level of.05 was used. Effect sizes are partial η^2 values. *Df*s were adjusted for independent sample *t*-tests when the assumption of equal variances was violated.

RESULTS

The Word-Frequency Mirror Effect

Results are shown in Table 1. To test overall recognition memory, the discrimination score P_r was calculated (i.e., hits minus false alarms; Snodgrass & Corwin, 1988). A 2 × 2 mixed analysis of variance (ANOVA) with group (patients vs. controls) and frequency category (high vs. low) revealed better discrimination for low- than high-frequency words, $F(1, 26) = 70.581$, $p < .01$, $\eta^2 = .731$. The effect of group and the interaction were not significant, indicating normal overall recognition performance in patients. For hit rates, the same 2 (group) × 2 (frequency category) ANOVA revealed higher hit rates for low- than high-frequency words, $F(1, 26) = 5.165$, $p < .05$, $\eta^2 = .166$. The effect of group and the interaction were not significant. For false alarm rates, the same 2 × 2 ANOVA revealed higher false alarm rates for high- than low-frequency items, $F(1, 26) = 45.196$, $p < .01$, $\eta^2 = .635$. The effect of group and the interaction were not significant. These analyses confirmed that the word-frequency mirror effect (higher hit rates and lower false alarm rates for low-frequency words) occurred in both healthy controls and patients.

Table 1. Recognition performance of healthy controls and PD patients

	Healthy controls Mean (*SD*)	PD patients Mean (*SD*)
P_r (hits minus false alarms)		
Low frequency	.55(.15)	.50(.14)
High frequency	.26(.24)	.22(.13)
Hit rate		
Low frequency	.69(.19)	.71(.18)
High frequency	.61(.26)	.64(.25)
False alarm rate		
Low frequency	.15(.14)	.21(.15)
High frequency	.35(.43)	.42(.22)
Subjective Remember/Know judgments d'		
Remember	1.40(.45)	1.22(.45)
Know	.36(.50)	−.07(.37)*

*$p<.05$ between groups.

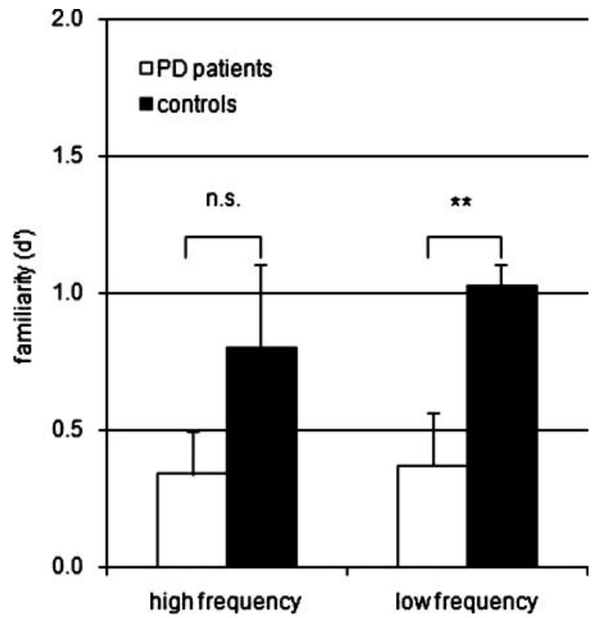

Figure 1. Estimates of familiarity from the Remember/Know judgments (following Yonelinas et al., 1998). Error bars represent standard errors.

Remember/Know Judgments

A measure of sensitivity (*d'*) was computed for Remember and Know responses. Independent *t*-tests showed that the two groups did not differ in Remembering ($p > .45$), but that the patients were significantly impaired in Knowing, $t(26) = 2.626$, $p < .05$. Estimates of recollection and familiarity were computed with the formulae of Yonelinas, Kroll, Dobbins, Lazzara, and Knight (1998). Recollection for high-frequency words was.34 ($SD = .25$) for patients, and.24 ($SD = .26$) for controls. Recollection for low-frequency words was.57 ($SD = .18$) for patients, and.52 ($SD = .21$) for controls. The 2 (group) × 2 (frequency category) mixed ANOVA revealed higher recollection for low- than high-frequency words, $F(1, 26) = 36.990$, $p < .01$, $\eta^2 = .587$. All other effects were not significant, indicating normal recollection in patients. Estimates of familiarity are shown in Figure 1. The 2 (group) × 2 (frequency category) mixed ANOVA revealed impaired familiarity in PD patients, $F(1, 26) = 7.268$, $p < .05$, $\eta^2 = .218$. The effect of frequency and the interaction were not significant. Additional independent *t*-tests showed that the groups did not differ in familiarity for high-frequency words ($p > .15$), but that the patients were significantly impaired in familiarity for low-frequency words, $t(16.745) = 3.119$, $p < .01$.

DISCUSSION

The goal of this study was to investigate recognition memory in PD with focus on the contributions of recollection and familiarity. We combined the word-frequency mirror effect with a two-step Remember/Know procedure in order to test whether diverging results of Davidson et al. (2006) and Edelstyn et al. (2007) are attributable to methodological differences. The finding of intact overall recognition memory performance in mild to moderate PD patients is consistent with both studies (Davidson et al., 2006; Edelstyn et al., 2007) and indicates that nondemented PD patients have an intact ability to discriminate between old and new stimuli. Recollection was normal in PD patients irrespective of measurement. In the mirror effect, normal hit rates for low- and high-frequency words in PD patients indicate intact recollection. Furthermore, the patients' performance in Remember judgments revealed no deficit. With regard to familiarity the results were less conclusive. Whereas normal false alarm rates for high- and low-frequency words indicate intact familiarity, the patients' performance in Know responses suggests a deficit. Especially the estimate of familiarity of low-frequency words was impaired.

Our Remember/Know results are in line with findings of Davidson et al. (2006) who also found intact recollection but impaired familiarity in PD, but with a one-step procedure. Therefore, the familiarity deficit is not dependent on the specific method used to assess Remember/Know judgments (i.e., one-step or two-step). However, these findings differ from those of Edelstyn et al. (2007) who reported impaired recollection but intact familiarity in PD patients. Whereas the patients of Edelstyn et al. (2007) displayed executive dysfunction, those of Davidson et al. (2006) did not. Therefore, the recollection deficit observed by Edelstyn et al. (2007) may be associated with executive dysfunction, which is in line with evidence indicating impaired recollection in frontal lobe patients (Hay, Moscovitch, & Levine, 2002).

One limitation of our study is that we have not systematically assessed executive functioning. The reason is a simple misunderstanding. We supposed that all the patients in the file of the Department of Neurology underwent a routine neuropsychological examination. However, we noticed only after having finished the study that this was only true for four out of our sample of 14 PD patients. Three patients were tested with the Stroop test (mean z score = –0.4, SD = 0.4), and all of them were tested on the word fluency test (mean z score = –0.35, SD = 1.5). The results suggest that these patients scored within the normal test range. We compared their performance on the recognition memory test with the remaining sample. The pattern of the results was similar in both groups and the statistical analyses revealed no differences between groups. This corroborates our interpretation that the main results of this study, that is, intact recollection but impaired familiarity is not attributable to a deficit in executive functions. In addition, a similar pattern of intact recollection but impaired familiarity was observed in the study of Davidson et al. (2006) whose PD patients showed intact frontal lobe functions.

In sum, the PD patients were neither impaired in general recognition memory performance nor in the estimate of recollection. When the patients experienced recollection for an item, they were able to use this information adequately for discriminating between old and new words. However, they were not able to differentiate between old and new words based on their Know responses, resulting in a deficit in familiarity. As familiarity arises primarily from bottom–up processes this would indicate that the reactivity of PD patients to subtle incidental, or implicit cues is reduced. This interpretation would be in line with findings of impaired implicit learning in PD patients (Siegert, Taylor, Weatherall, & Abernethy, 2006). In early stages, PD patients may be selectively impaired at taking advantage of environmental cues by means of automatic processes. However, when relying on more conscious and controlled processes, their performance is still intact. It is possible that in later stages a decline in executive functions also results in a decline of recollection. For this reason, it is important to distinguish recollection and familiarity when investigating recognition memory in PD.

ACKNOWLEDGEMENT

We thank Sabine Weber for patient recruitment and for the patient assessment of clinical disability, and Josephine Cock for helpful comments on an earlier version.

REFERENCES

Allain, H., Lieury, A., Thomas, V., Reymann, J. M., Gandon, J. M., & Belliard, S. (1995). Explicit and procedural memory in Parkinson's disease. *Biomedicine & Pharmacotherapy*, *49*, 179–186.

Appollonio, I., Grafman, J., Clark, K., Nichelli, P., Zeffiro, T., & Hallett, M. (1994). Implicit and explict memory in patients with Parkinson's disease with and without dementia. *Archives of Neurology*, *51*, 359–367.

Balota, D. A., Burgess, G. C., Cortese, M. J., & Adams, D. R. (2002). The word-frequency mirror effect in young, old, and early-stage Alzheimer's disease: Evidence for two processes in episodic recognition performance. *Journal of Memory and Language*, *46*, 199–226.

Beatty, W. W., Ryder, K. A., Gontkovsky, S. T., Scott, J. G., McSwan, K. L., & Bharucha, K. J. (2003). Analyzing the subcortical dementia syndrome of Parkinson's disease using the RBANS. *Archives of Clinical Neuropsychology*, *18*, 509–520.

Breen, E. K. (1993). Recall and recognition memory in Parkinson's disease. *Cortex*, *29*, 91–102.

Davidson, P. S. R., Anaki, D., Saint-Cyr, J. A., Chow, T. W., & Moscovitch, M. (2006). Exploring the recognition memory deficit in Parkinson's disease: Estimates of recollection versus familiarity. *Brain*, *129*, 1768–1779.

Edelstyn, N. M. J., Mayes, A. R., Condon, L., Tunnicliffe, M., & Ellis, S. J. (2007). Recognition, recollection, familiarity and executive function in medicated patients with moderate Parkinson's disease. *Journal of Neuropsychology*, *1*, 131–147.

Flowers, K. A., Pearce, I., & Pearce, J. M. (1984). Recognition memory in Parkinson's disease. *Journal of Neurology, Neurosurgery & Psychiatry*, *47*, 1174–1181.

Folstein, M. F., Folstein, S. E., & McHugh, P. R. (1975). Mini-mental state: A practical method for grading the cognitive state of patients for the clinician. *Journal of Psychiatric Research*, *12*, 189–198.

Glanzer, M., & Adams, J. K. (1990). The mirror effect in recognition memory: Data and theory. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *16*, 5–16.

Hay, J. F., Moscovitch, M., & Levine, B. (2002). Dissociating habit and recollection: Evidence from Parkinson's disease, amnesia and focal lesion patients. *Neuropsychologia*, *40*, 1324–1334.

Higginson, C. I., Wheelock, V. L., Carroll, K. E., & Sigvardt, K. A. (2005). Recognition memory in Parkinson's disease with and without dementia: Evidence inconsistent with the retrieval deficit hypothesis. *Journal of Clinical and Experimental Neuropsychology*, *27*, 516–528.

Hoehn, M. M., & Yahr, M. D. (1967). Parkinsonism: Onset, progression and mortality. *Neurology*, *17*, 427–442.

Lehrl, S., Merz, J., Burkhard, G., & Fischer, B. (1991). *MWT-A: Mehrfachwahl-Wortschatz-Intelligenztest. Parallelform zum MWT-B*. Erlangen, Germany: Perimed.

Radloff, L. S. (1977). The CES-D scale: A self-report depression scale for research in the general population. *Applied Psychological Measurement*, *1*, 385–401.

Reder, L. M., Nhouyvanisvong, A., Schunn, C. D., Ayers, M. S., Angstadt, P., & Hiraki, K. (2000). A mechanistic account of the mirror effect for word frequency: A computational model of remember-know judgments in a continuous recognition paradigm. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *26*, 294–320.

Schwab, J. F., & England, A. C. (1969). Projection technique for evaluating surgery in Parkinson's disease. In F. J. Gillingham and M. C. Donaldson (eds.), *Third Symposium on Parkinson's Disease*. Edinburgh, UK: E and S Livingstone.

Siegert, R. J., Taylor, K. D., Weatherall, M., & Abernethy, D. A. (2006). Is implicit sequence learning impaired in Parkinson's disease? A meta-analysis. *Neuropsychology*, *20*, 490–495.

Snodgrass, J. G., & Corwin, J. (1988). Pragmatics of measuring recognition memory: Applications to dementia and amnesia. *Journal of Experimental Psychology: General*, *117*, 34–50.

Whittington, C. J., Podd, J., & Kan, M. M. (2000). Recognition memory impairment in Parkinson's disease: Power and meta-analyses. *Neuropsychology*, *14*, 233–246.

Yonelinas, A. P. (2002). The nature of recollection and familiarity: A review of 30 years of research. *Journal of Memory and Language*, *46*, 441–517.

Yonelinas, A. P., Kroll, N. E. A., Dobbins, I., Lazzara, M., & Knight, R. T. (1998). Recollection and familiarity deficits in amnesia: Convergence of remember-know, process dissociation, and receiver operating characteristic data. *Neuropsychology*, *12*, 323–339.

Zgaljardic, D. J., Borod, J. C., Foldi, N. S., & Mattis, P. (2003). A review of the cognitive and behavioral sequelae of Parkinson's disease: Relationship to frontostriatal circuitry. *Cognitive and Behavioral Neurology*, *16*, 193–210.