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Habota, T., Cameron, J., Thompson, D. R., & Ski, C. F. (2022). Prospective Memory Impairment in Chronic Heart Failure: A Replication Study. *Psychology, Health and Medicine*, 27(6), 1277-1285.
<https://doi.org/10.1080/13548506.2020.1867317>

Published in:
Psychology, Health and Medicine

Document Version:
Peer reviewed version

Queen's University Belfast - Research Portal:
[Link to publication record in Queen's University Belfast Research Portal](#)

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Prospective Memory Impairment in Chronic Heart Failure: A Replication Study

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Word count for abstract – 176

Word counts for manuscript – 2745

Abstract

Cognitive deficits are common in patients with chronic heart failure (HF), but little attention has been given to the investigation of prospective memory (PM) – the ability to execute delayed intentions. Importantly, many aspects of PM are crucial for patient implementation of HF self-care behaviours. Here we provide a replication of our original work involving PM in patients with HF. We compared a group of 51 HF patients to 41 closely matched controls. The primary outcome measure was a laboratory test of PM, Virtual week, which closely simulates PM tasks in daily life. A series of background cognitive tests were also administered. Consistent with our previous work, the HF group had significant PM impairment compared to controls, and these difficulties were generalised across different types of PM tasks. Surprisingly, we did not find any differences on the background cognitive tasks between groups. Compared to controls, the HF group had significant and similar sized deficits on all task parameters assessed (event, time, regular, irregular) of PM function, which likely impacts engagement in HF self-care.

Key Words: Chronic heart failure, cognitive function, prospective memory

proportion ranging from 0-1; higher scores reflected worse PM performance for *missed* analysis, but the inverse was true for *correct* analysis(Habota et al., 2015).

Procedure

At study recruitment, demographic and HF clinical characteristics were collected using patient self-report and medical record review. Neuropsychological testing was conducted during the sub-acute phase, approximately three months from recruitment. The ACE-R was administered, followed by the rest of the test battery in a standardised order. The key test – Virtual Week – was also completed during the same testing session. Participants were tested in a single session (about two hours) in a quiet room at their residence or hospital.

Results

Participant characteristics

The two groups did not differ in sex (59% female vs. 69% male; $\chi^2(1) = .62$; $p = .433$). The HF group had higher proportions of cardiac risk factors, except for hypercholesterolemia. Groups were matched in age, but the HF group had fewer years of education and lower estimated IQ, and self-reported slightly more symptoms of depression. There were no differences in performance between groups on tests of executive function, working memory, or verbal memory.

[Table 2 about here]

Analysis of prospective memory accuracy

The dependent variable, PM performance, was expressed as the proportion of Virtual Week tasks completed correctly for each of the four categories of tasks: regular event,

regular time, irregular event, and irregular time. Data were analyzed with a $2 \times 2 \times 2$ mixed analysis of variance (ANOVA) with the between-subjects variable of group (HF, control), and the within-subjects variables of PM task (regular, irregular) and PM cue (event-based, time-based). There was a main effect of group ($F(1, 90) = 13.45$; $p < .001$; $\eta_p^2 = .130$)¹, and no two-way interactions between group and any of the variables (both $F_s \leq 0.45$; $p_s \geq .505$), but there was a significant three-way interaction ($F(1, 90) = 4.47$; $p = .037$; $\eta_p^2 = .047$).

The three-way interaction was followed up by two separate 2×2 (Group $\times$ PM cue) ANOVAs for regular and irregular PM tasks. For regular tasks, PM cue was not a main effect and did not interact with group (both $F_s \leq 1.02$; $p_s \geq .314$), but group was a main effect, ($F(1, 90) = 8.56$; $p = .004$; $\eta_p^2 = .087$). The HF group performed worse ($M = .67$; $SD = .34$) than the control group ($M = .84$; $SD = .27$) on regular tasks. For irregular tasks, group was a main effect ($F(1, 90) = 11.01$; $p = .001$; $\eta_p^2 = .109$) and PM cue was a main effect ($F(1, 90) = 17.50$; $p < .001$; $\eta_p^2 = .163$), but group and PM cue did not interact ($F(1, 90) = 3.30$; $p = .073$; $\eta_p^2 = .035$). For irregular tasks, the HF group performed worse ($M = .47$; $SD = .30$) than the control group ($M = .66$; $SD = .33$), but all participants performed better on event-based PM tasks ($M = .63$; $SD = .32$) than time-based PM tasks ($M = .48$; $SD = .33$).

Analysis of missed prospective memory responses

The alternative index of PM performance was the proportion of Virtual Week tasks missed for each of the four categories of tasks: regular event, regular time, irregular

¹ We also ran sensitivity analyses excluding the three HF patients with a history of a cerebrovascular event and found that the group main effect remained significant ($F = 13.33$; $p < .001$).

event, and irregular time. Data were analyzed with a $2 \times 2 \times 2$ mixed ANOVA with the between-subjects variable of group (HF, control), and the within-subjects variables of PM task (regular, irregular) and PM cue (event-based, time-based). Group did not interact with any of the variables (all $F_s \leq .17$; $p_s \geq .678$) but the main effect of group was significant ($F(1, 90) = 5.67$; $p = .019$; $\eta_p^2 = .059$)²; the HF group missed more responses ($M = .21$; $SD = .28$) than the control group ($M = .12$; $SD = .22$).

There was also a main effect of PM task ($F(1, 90) = 15.00$; $p < .001$; $\eta_p^2 = .14$) but not for PM cue, and the two-way interaction between PM task and PM cue was also not significant (all $F_s \leq .34$; $p_s \geq .561$). The participants overall missed more irregular ($M = .23$; $SD = .26$) than regular tasks ($M = .11$; $SD = .26$).

Analysis of shared variance

Exploratory analyses were conducted to examine the potential role of other variables in the observed group difference on the proportion of missed PM tasks. Four $2 \times 2 \times 2$ mixed analyses of covariance (ANCOVAs) were conducted with the between-subjects variable of group (HF, control), and the within-subjects variable of PM task (regular, irregular) and PM cue (event, time), and one of the following variables entered as a covariate in each ANCOVA: global cognition, premorbid IQ, education, and depression. The dependent variable was the proportion of missed responses. Results showed that the medium effect size ($\eta_p^2 = .06$) dropped to .04 (education), .04 (premorbid IQ), .03 (global cognition), and .05 (depression), but remained the same (.06) for age. Thus, each of these variables individually covaried with the PM deficits

² We also ran sensitivity analyses excluding the three HF patients with a history of a cerebrovascular event and found that the group main effect remained significant ($F = 5.50$; $p = .019$).

observed in the HF group, but global cognition covaried the strongest. Covarying each of these variables reduced the statistical significance of the group main effect ($ps > .061$).

Discussion

Patients with HF have reduced cognitive function in a number of domains (Cameron et al., 2016; Cameron et al., 2016), but this study is only the second to have investigated PM function in this clinical group, compared to healthy controls. Using a different and larger sample, this replication of Habota et al. (2015) found that patients with HF had significant and similar sized deficits on all task parameters assessed (event, time, regular, irregular), suggesting that the cause of the observed PM impairment involves the prospective component particularly. If HF participants' poor performance was solely the result of retrospective memory failure, PM performance would have been weaker on the irregular tasks compared to the regular tasks. Notably, this sample was younger, had more cumulative years of education, and higher estimated premorbid IQ. Thus, even in this group of HF patients, who were higher functioning, pervasive deficits in PM were evident in the original ANOVA analysis. Our findings are consistent with the PM literature on other clinical groups, such as multiple sclerosis (Rendell, Jensen, & Henry, 2007) or stroke (Kim et al., 2009), who are affected by localised and diffuse brain pathology. More specifically, despite some variability across different clinical groups, a pattern of consistent deficits in PM, irrespective of PM task demands, is reported.

Surprisingly, we found no differences in performance between HF patients and healthy controls on any of the background cognitive tasks. Our findings suggest that compared to other more general cognitive processes, PM decline might be particularly sensitive to HF-related pathology. We found no differences in performance on

measures of working memory, executive function, and other aspects of memory, but *all* aspects of PM function were impaired in this HF group compared to healthy controls, findings consistent with Habota et al. (2015).

Exploratory analyses of the potential influence of key demographic factors showed that estimated premorbid IQ, global cognition, and depression overlapped substantially with the group difference in PM performance, as might be expected. The loss of statistical significance from the original ANOVA analysis may reflect loss of power; thus, we focused on effect sizes instead. The ANCOVA results showed that the effect size reduced by a small amount, but the degree of covariation was not substantial.

A key strength of this study is that participants with HF were thoroughly characterized on demographic, clinical, and cognitive features. Limitations were that whilst both groups were closely matched on age and sex, they were not equally matched, as intended, on other demographic variables known to affect cognitive function. The HF group had fewer years of education, lower estimated IQ, and higher self-reported symptoms of negative affect. Future studies should include a clinical control group matched on aspects of physical and affective functionality. The HF group was relatively high functioning; 79% had no, or only mild, HF symptoms and we excluded people with indicators of dementia. Further, although symptoms of negative affect were higher in the HF group, the extent of depressive symptoms did not quite meet clinical threshold. These are important considerations because in the wider population of patients with HF, where medical and emotional symptoms are often more severe, and global cognition is often more impacted, PM failures are also likely to be greater.

The investigation of PM in patients with HF deserves further attention as problems with PM cause more difficulties in daily living than other memory failures (McDaniel & Einstein, 2007). This is particularly relevant to HF patients due to the numerous and concurrent tasks involved in self-care, such as taking medications, daily weighing, which place a high load on their PM ability.

Acknowledgements

The authors gratefully acknowledge the contribution of Professor Peter Rendell. The study was funded by a Heart Foundation Vanguard grant (100262) and an Australian Government Collaborative Research Network programme grant (2013000375).

Conflict of interests

There are no conflicts of interest to declare.

Table 1. Demographic and clinical characteristics of the HF group

	%	<i>n</i>
NYHA classification		
Class I and II	78.4	40
Class III and IV	15.7	8
Heart failure type		
Systolic	78.4	40
Diastolic	21.6	11
Heart failure aetiology		
Ischemic	19.6	10
Non-ischemic	19.6	10
Idiopathic	41.2	21
Other	3.9	2
Prescribed medications		
Either on ACEI or ARB	17.6	9
Prescribed diuretic	9.8	5
Prescribed aldosterone antagonist	7.8	4
Prescribed beta blocker	17.6	9

Notes. ACEI, Angiotensin Converting Enzyme Inhibitor; ARB, Angiotensin II Receptor Antagonists; NYHA, New York Heart Association.

Table 2. Participant characteristics

	<i>HF group</i>		<i>Control group</i>						
	<i>n</i>	<i>%</i>		<i>n</i>	<i>%</i>		χ^2	<i>p</i>	
<i>Cardiac risk factors (%)</i>									
Hypercholesterolemia	23	45.1		15	36.6		0.68	.410	
Hypertension	22	43.1		3	7.3		14.74	<.001***	
Smoking	31	60.8		15	36.6		5.32	.021*	
Diabetes	24	47.1		0	0.0		26.10	<.001***	
Obesity	18	35.3		2	4.9		12.36	<.001***	
<i>Demographic (M)</i>									
		<i>M</i>	<i>SD</i>	<i>n</i>	<i>M</i>	<i>SD</i>	<i>t</i>	<i>p</i>	<i>d</i>
Age (years)	51	63.80	14.75	41	64.29	9.26	-0.19	.847	0.04
Education (years)	51	14.04	3.17	41	15.95	3.91	-2.59	.011*	0.54
Estimated IQ (NART)	50	114.42	4.99	40	117.15	4.49	-2.69	.009**	0.58
<i>Global cognition and mental health</i>									
Global cognition (ACE-R)	50	91.90	3.67	41	94.37	3.38	-3.31	<.01**	0.70
Anxiety (HADS)	38	5.16	3.46	41	5.39	3.26	-0.31	.760	0.07
Depression (HADS)	38	4.18	2.99	41	2.12	1.45	3.86	<.001***	0.88
<i>Working memory</i>									
One Back Task	51	30.43	4.34	41	30.66	1.89	-0.31	.758	0.07

Two Back Task	51	32.16	0.46	41	32.10	0.30	0.74	.461	0.15
<i>Executive function</i>									
Processing speed (Detection Task)	51	35.12	0.40	41	35.22	0.57	-1.02	.309	0.20
Visual learning (One Card Learning Task)	51	61.80	7.03	41	62.78	8.69	-0.60	.552	0.12
Visual attention (Identification Task)	51	30.10	0.36	41	30.12	0.51	-0.26	.793	0.05
<i>Verbal memory (HVLt-R)</i>									
Immediate recall	51	25.92	5.20	41	27.27	6.32	-1.12	.265	0.23
Delayed recall	51	8.84	2.49	41	9.56	2.74	-1.32	.192	0.28

Notes. Effect sizes: small = 0.2; medium = 0.5; large = 0.8

* $p < .05$

** $p < .01$

*** $p < .001$

ACE-R, Addenbrooke's Cognitive Examination – Revised; HADS, Hospital Anxiety Depression Scale; HVLt-R, Hopkins Verbal Learning Test – Revised, NART, National Adult Reading Test.

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