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Assessing neurocognitive symptoms in cancer patients and controls: psychometric properties of the FACT-Cog3

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Abstract

This study aimed to evaluate psychometric properties of Functional Assessment of Cancer Therapy Cognitive Version 3 (FACT-Cog3). Scoring was compared when including then excluding four multitasking items that the scale authors added after validating the scale. This was intended to improve guidance about use of FACT-Cog3 in both clinical and non-clinical samples. Data from previous studies in people with and without cancer were supplemented with a new sample, for a total of 205 participants with and 110 participants without a history of cancer. Factors, reliability, and validity were examined in conjunction with other relevant measures. Exploratory factor analysis results supported a four-factor solution (i.e., perceived cognitive impairment [PCI], comments from others, perceived cognitive ability [PCA], and quality of life) for both versions of the scale in a clinical sample. In the non-clinical sample, factor analysis results suggested a four-factor solution for the 37-item scale but not the 33-item version, suggesting that the scale may perform differently in a non-clinical sample. High reliability and validity were found for both samples in the 33-item and 37-item versions of the scale. To gain a comprehensive understanding of perceived cognitive functioning it is recommended that the 37-item FACT-Cog3 scoring should be used in research and clinical practice. Most importantly, regardless of which scoring is used, it is essential that users clearly disclose which scoring method for the FACT-Cog3 has been selected and it is recommended that subscales are labelled accordingly (e.g., PCI18, PCA20, PCA7, PCA9).

Keywords Cancer · Cognitive function · Self report · Patient reported outcome measures · Psychometrics

Cancer-related cognitive impairment (CRCI) is reported by people who have been treated for a wide range of non-central nervous system cancers (Bray et al., 2018; Myers, 2013; Pullens et al., 2010; Skaali et al., 2011). A recent systematic review of self-reported CRCI measures noted that this research has predominantly but not exclusively involved women with breast cancer, and that such self-report measures tend to show moderate to strong relationships with other patient-reported outcomes but weak or absent associations with neuropsychological tests (Bray et al., 2018). People affected by CRCI have emphasised its impact on quality of life (Tannock et al., 2004) due to limitations in activities such as work performance (Boykoff et al., 2009; Myers, 2013; Von Ah et al., 2013; Wagner et al., 2009), and family and social life (Green et al., 2019). Many researchers have found increases in self-reported CRCI to associate with increased psychological distress and fatigue (King & Green, 2015; Lai et al., 2009; Vardy & Dhillon, 2017); these bidirectional relationships indicate that it is important to consider broader function, such as emotional and physical wellbeing, in addition to neurological functioning (Costa et al., 2018; Green et al., 2005; Skaali et al., 2011).

Measurement issues have hampered research on self-reported CRCI, with a lack of measurement consistency across studies (Bray et al., 2018). The most frequently used measure of self-reported CRCI as found in a 2018 systematic review (Bray et al., 2018), the cognitive functioning subscale from the European Organisation for Research and Treatment of Cancer Core Quality of Life Questionnaire (EORTC-QLQ-C30) (Aaronson et al., 1993), has only two items and therefore has limited coverage of the construct and limited sensitivity. The second most frequently used measure (Bray et al., 2018)

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is the Functional Assessment of Cancer Therapy-Cognitive Function (FACT-Cog) questionnaire (Wagner et al., 2009). The current scale version, FACT-Cog3, is frequently recommended for research and/or clinical practice, given that it is a relatively brief yet comprehensive measure that was developed to assess the cognitive concerns reported by cancer survivors (Lange & Joly, 2017; Vardy & Dhillon, 2017). However, inconsistencies in how FACT-Cog3 is used, including variations in scoring, hamper comparative research and understanding of CRCI.

FACT-Cog3 is a self-report measure containing 37 items to assess perceived cognitive functioning in adult cancer samples. It comprises four subscales: *perceived cognitive impairment* (PCI), *perceived cognitive abilities* (PCA), *comments from others* (CFO), and *impact on quality of life* (QOL). For PCI and CFO subscales, the respondent reports the frequency of each situation over the past 7 days on a 5-point scale ranging from 0 "*never"* to 4 *"several times a day"*. The PCA and QOL subscales are rated on a different 5-point scale ranging from 0 *"not at all"* to 4 *"very much"*, based on respondent feedback about response wording during scale development. Subscale scores are computed such that higher scores reflect better perceived cognitive functioning and quality of life. PCI items measure cognitive problems, thus are negatively-worded, and PCA items assess the extent to which one is able to complete cognitive tasks and are positively-worded. An examination of the association between negatively-worded and positively-worded items found that these scales represent two separate factors, thus produce the most robust psychometric properties if scored separately (Lai et al., 2014). Based on this research, the PCI subscale score is recommended to be used as the "primary" score for the FACT-Cog3 in preference to computing a scale total (FACIT.org, 2009).

Multi-tasking items were added to the FACT-Cog version 2 to address an observed ceiling effect and were added after the scale was validated. The FACT-Cog3 authors have given two alternative scoring methods (FACIT.org, 2009), i.e., to either include or exclude the four items measuring multitasking (two PCI and two PCA subscale items) because the scale with multitasking items has not yet been validated. Current standard scoring instructions therefore recommend omitting the multitasking items from computation of subscales, or conducting internal validation checks within a study-specific sample in order to decide whether or not to include multitasking items in scoring (FACIT.org, 2009). Publications have shown a lack of clarity and consistency about scoring, with some authors explicitly reporting omission of multitasking items from calculations as per the standard scoring instructions (Bell et al., 2018; Park et al., 2015), some researchers not being explicit about whether these items are included in scoring (King & Green, 2015; Von Ah et al., 2018), and some using their own scoring procedures such as using a total score or creating their own set of subscales that differ from the scale authors' recommended 4 subscales (Cheung et al., 2013). This lack of consistency hampers comparisons across studies, such as the potential for meta-analysis. Furthermore, there is yet to be a study that has reported all key psychometric properties of FACT-Cog3 in English, with either the standard scoring (33 items) or expanded scoring (37 items). Whilst the FACT-Cog3 has been developed for use in a clinical sample, some studies have administered this measure in a non-clinical sample for comparison purposes, despite there being even less information about the psychometric properties of the measure in the general population (Lange et al., 2016; Myers et al., 2015; Pullens et al., 2010).

The FACT-Cog3 has been translated and validated for use in French (Joly et al., 2012), Chinese-speaking Singaporean (Cheung et al., 2013), and Korean (Park et al., 2015) populations. Translation studies have shown high internal consistency of the 33-item FACT-Cog3 in the French (Joly et al., 2012; Lange et al., 2016) and Korean (Park et al., 2015) adaptations, with Cronbach's alphas for subscales ranging from .70 to .95. Additionally, test-retest reliability has been assessed by Cheung et al. (2013) using both the English and Chinese translations of the scale in a Singaporean sample, showing consistency across FACT-Cog3 total scores after approximately 40 days, and satisfactory test-retest reliability for individual cognitive domains. However, since Cheung et al.'s study used scoring whereby PCI and PCA items were allocated into six cognitive domains instead of the two standard subscales (Cheung et al., 2013) it did not provide information about the internal consistency and test-retest reliability of the PCI and PCA subscales.

Translation studies have demonstrated concurrent validity through significant correlations of FACT-Cog3 subscales with the EORTC-QLQ-C30 cognitive subscale (Cheung et al., 2013; Park et al., 2015). Moreover, these studies found that FACT-Cog3 subscales displayed convergent validity through correlations with fatigue, anxiety, global health status (Cheung et al., 2013), and depression (Park et al., 2015). Whilst translation studies have provided insight into psychometric properties of FACT-Cog3 for use in French-, Korean-, or Chinese-speaking samples, these studies have not directly quantified reliability and validity of the instrument for use in an English-speaking sample. It would be expected that the FACT-Cog3 English language version would show similar reliability and validity to translated versions, but this has yet to be comprehensively evaluated and reported for either standard FACT-Cog3 scoring (i.e., 33 items only) or 37-item scoring.

Despite being a widely used measure, previously only one study conducted by Costa et al. (2018) has researched the factor structure of the full 37-item FACT-Cog3. Using a confirmatory factor analysis (CFA), Costa et al. assessed the scale for use in cancer patients, older adults, and undergraduate psychology students. Although fit for the four-factor structure

of the FACT-Cog3 was found to be "good" on a range of indices in the patient and older adult samples, results from the student sample (younger adults) did not indicate good fit on any index. Due to these mixed results, Costa et al. conducted an additional Exploratory Factor Analysis (EFA) indicating both eight- and four-factor solutions for the clinical sample and a three-factor solution for the student sample. These differences were suggested to be partly due to a greater ability of the psychology students to discriminate between cognitive experiences due to their pre-existing knowledge. Whilst Costa et al. covered a wide age range across samples, neither of the control samples (with mean ages of 21.34 and 63.5 years, respectively) was reflective of the age in the clinical samples (mean age of 53.75 years).

Additionally, Park et al. (2015) used CFA to assess the factor structure of the Korean 33-item FACT-Cog3 in 250 breast cancer patients. Whilst the results supported a four-factor solution as suggested by the scale authors (i.e., PCI, PCA, CFO, and QOL), the scale had been translated and adapted to be appropriate for a Korean sample and therefore did not directly represent the factor structure of the English version of FACT-Cog3. Cheung et al. (2013) conducted a study comparing the English version to a Chinese adaptation of the FACT-Cog3 for use in a Singaporean population; however, factor analyses in this study were conducted with subsets of items rather than evaluating factor structure of all 33- or 37-items together.

The present study provided the first evaluation of both the dimensionality and psychometric properties of the FACT-Cog3 in English, using both a clinical sample and a demographically-matched non-cancer sample. Factor structure was evaluated using the FACT-Cog3 scoring as suggested by the scale authors (33 items) and for the full scale, inclusive of the multitasking items (37 items). Subsequent analyses were conducted to assess the psychometric properties of the FACT-Cog3 subscales allowing for both the inclusion or exclusion of multitasking items. It was hypothesised that four factors would emerge and correspond with proposed subscales in both the 37-item version (Hypothesis 1a) and 33-item version (Hypothesis 1b) of the FACT-Cog3 in a clinical sample. Furthermore, it was hypothesised that multitasking items would load with respective subscales of the FACT-Cog3 for use in a clinical sample (Hypothesis 2). Additionally, the psychometric properties of the FACT-Cog3 (33-item and 37-item) were examined to determine its reliability and validity for measuring perceived cognitive function and quality of life in a clinical sample (Research Question 1). Finally, the factor structure (Research Question 2a) and psychometric properties (Research Question 2b) of the FACT-Cog3 were assessed for use in a non-clinical sample.

Method

Participants

Clinical participants ($N = 205$) had completed primary treatments for adult-onset cancer (e.g., surgery, chemotherapy, and/or radiotherapy), and non-clinical participants ($N = 110$) had no cancer history (Table 1). Some clinical participants ($n = 107$) came from three cognitive rehabilitation studies (Green et al., 2018; Mihuta et al., 2018a, b). Rehabilitation study participants had: (a) a history of adult-onset cancer, (b) completed all primary treatments a minimum of 6 months prior (excluding hormonal or targeted therapy, which could be ongoing), (c) self-reported cognitive complaints attributed to cancer or treatment, and (d) fluency in English. Ninety-eight additional clinical participants were recruited based on criteria (a) and (d), at a minimum of 3 months post-treatment completion (but remained eligible with ongoing hormonal or targeted therapy).

Twenty-nine non-clinical participants were included from a previous rehabilitation study (Mihuta et al., 2018a). Non-clinical participants were eligible if aged 35 years or above, with no previous cancer diagnosis, and fluent in English. A further 81 non-clinical participants, who met the same criteria as the rehabilitation sample, were recruited. Since the archival sample contained few males and comprised predominantly breast cancer survivors, analyses were conducted with female participants only and participants in the new sample were required to be female. Due to requirements of parallel studies for the new sample, recruitment predominantly targeted ages 18 to 64 years for clinical and 35 to 64 years for non-clinical participants, but three clinical participants aged 68 to 79 and 16 non-clinical participants aged 18 to 30 were included in analyses.

Materials

Cognitive Functioning Self-reported cognitive functioning was measured using FACT-Cog3 (Wagner et al., 2009). Earlier versions of FACT-Cog have shown high reliability and validity (Lai et al., 2009), as have translated versions (Cheung et al., 2013; Joly et al., 2012; Park et al., 2015). Psychometric properties of FACT-Cog3 were investigated as the focus of the present study.

Quality of Life EORTC-QLQ-C30 is a 30-item self-report measure containing five functional subscales, three symptom scales, and a global health and quality of life scale (Aaronson et al., 1993). Higher scores from functioning scales indicate better functioning, whereas higher scores on symptom scales indicate increased symptoms. Subscales used in the present study have shown acceptable internal reliability on Cronbach's alpha: Cognitive functioning .73, Fatigue .85,

Table 1 Demographic and Medical Data

Variable	Clinical					Non-clinical		
	In-person intervention (Green et al., 2018) (*n* =24)	Pilot (Mihuta et al., 2018a) (*n* =12)	RCT (Mihuta et al., 2018b) (*n* =71)	New (*n* =98)	Combined (*N* =205)	Pilot (Mihuta et al., 2018a) (*n* =38)	New (*n* =81)	Combined (*N* =110)
Age								
Mean, SD	49.75, 10.61	45.42, 10.30	55.48, 9.36	54.10, 8.71	53.56, 9.57	46.52, 8.83	44.78, 14.21	45.24, 13.00
Range	27–65	27–64	26–72	19–79	19–79	35–63	18–64	18–64
Years of Education								
Mean, SD	14.08, 2.28	14.83, 2.66	14.68, 2.44	14.87,2.68	14.71, 2.55	14.93, 2.52	13.69, 2.39	14.02, 2.48
Range	10–18	9–19	9–19	10–20	9–20	10–19	9–19	9–19
Born in Australia	19 (79.2%)	7 (58.3%)	57 (80.3%)	80 (81.6%)	163 (79.5%)	17 (58.6%)	55 (67.9%)	72 (65.5%)
First Language English	19 (79.2%)	11 (91.7%)	67 (94.4%)	96 (98.0%)	193 (94.1%)	23 (79.3%)	73 (90.1%)	96 (87.3%)
Cancer Classification								
Breast	24 (100%)	6 (50%)	70 (98.6%)	83 (84.7%)	183 (89.3%)			
Other Primary Malignancy	0 (0%)	6 (50%)	1 (1.4%)	7 (7.1%)	14 (6.9%)			
Multiple Primary Types	0 (0%)	0 (0%)	0 (0%)	8 (8.2%)	8 (3.9%)			
Months Since Diagnosis								
Mean, SD	22.63, 9.63	61.58, 45.97	57.92, 42.79	68.19 (48.64)	58.81, 45.55			
Range	7–47	14–134	9–180	4–240	4–240			
Months Since Treatment Ended								
Mean, SD	15.42, 9.08	52.50, 46.70	50.35, 42.29	53.26 (41.52)	47.78, 41.25			
Range	3–34	6–125	4–171	0–194	0–194			
Past Treatment								
Surgery	24(100%)	10 (83.3%)	70 (98.6%)	95 (96.9%)	199 (97.1%)			
Chemotherapy	22 (91.7%)	12 (100%)	60 (84.5%)	76 (77.6%)	170 (82.9%)			
Radiation	20 (83.3%)	7 (58.3%)	49 (69.0%)	62 (63.3%)	138 (67.3%)			
Hormone	18 (75%)	1 (8.3%)	54(76.1%)	65 (66.3%)	138 (67.3%)			
Targeted	6 (25%)	0 (0.0%)	14 (19.7%)	9 (9.2%)	29 (14.1%)			
Other	2 (8.3%)	0 (0.0%)	1 (1.4%)	9 (9.2%)	12 (5.9%)			

Note. Other primary malignancy = colorectal, melanoma, lung, gynaecological, haematological, sarcoma, or appendix. Multiple primary types were breast cancer plus one of melanoma, gynaecological, haematological, thyroid, or sarcoma

Pain .76, and Nausea and Vomiting .73 (Aaronson et al., 1993).

Distress Kessler Psychological Distress Scale (K10) is a 10-item self-report measure used to assess distress (symptoms of depression and anxiety) over a 4-week period, where higher scores indicate greater distress. The K10 shows high levels of internal consistency (Cronbach's $\alpha = .93$), concurrent validity, and discriminant validity (Kessler et al., 2002).

Procedure

Participants from rehabilitation studies were recruited through Breast Cancer Network Australia, Mater Cancer Care Centre, and Griffith University staff and students in 2015 and 2016. These participants viewed written informed consent materials, provided verbal consent via telephone, then completed a semi-structured telephone interview with demographic and medical questions, followed by an online assessment including FACT-Cog3, EORTC-QLQ-C30, and K10. Present analyses used baseline data from rehabilitation study participants (after screening and before any intervention), plus 6-week Time 2 data of 33 clinical (age $M = 56.47$; $SD = 9.36$) and 11 non-clinical (age $M = 45.64$; $SD = 6.58$) participants who had not received any intervention between the two assessments (Mihuta et al., 2018a, b). New participants were recruited in 2018 via broadcast email sent to Griffith University staff and students and Breast Cancer Network Australia's voluntary research pool. The email included a link to an anonymous survey consisting of medical and demographic items, followed by FACT-Cog3, EORTC-QLQ-C30, K10, and two other questionnaires administered for other studies (World Health Organisation Disability Assessment Schedule 2.0, and Life Orientation Test - Revised). Informed consent materials before the survey stated that by proceeding to answer questions, participants were indicating they consented to participate.

Statistical Analyses

Statistical analyses used SPSS version 25. Prior to analyses, 33 incomplete cases were removed. For several variables, missing or out of range values were substituted with plausible values. Such substitutions were made in age ($n = 2$), years of education ($n = 1$), months since diagnosis ($n = 6$), and months since treatment ended ($n = 3$). Relevant scores for FACT-Cog3, EORTC-QLQ-C30, and K10 were computed via scale author instructions. Additional PCI and PCA computations incorporated multitasking items (PCI20 and PCA9, with original scoring labelled as PCI18 and PCA7, respectively). Given ongoing uncertainty about FACT-Cog3 factor structure, especially with multitasking items and with non-clinical samples (Costa et al., 2018), exploratory factor analysis was used for FACT-Cog3. Principal axis factoring with oblique rotation was conducted separately for clinical and non-clinical samples with the number of factors determined using scree plots, eigenvalues greater than one, and theoretical coherence. Items with factor loadings of .40 and above were retained (Howard, 2016). Clinical and non-clinical group data were compared using t-tests. For FACT-Cog3 subscales in clinical and non-clinical samples respectively, internal reliability was assessed with Cronbach's alpha. Pearson correlations with FACT-Cog3 baseline subscale scores were used to assess test-retest reliability (correlation with scores after a 6-week gap); concurrent validity (with EORTC-QLQ-C30 cognitive function subscale); convergent validity (with EORTC-QLQ-C30 fatigue subscale and K10 psychological distress); and discriminant validity (EORTC-QLQ-C30 pain and nausea/vomiting subscales).

Results

Factor Structure for FACT-Cog3

Bartlett's test of sphericity (Bartlett, 1950) was significant in both clinical ($\chi^2 = 6696.22$, $p < .001$) and non-clinical ($\chi^2 = 3832.96$, $p < .001$) samples, using all 37 FACT-Cog3 items. The Kaiser-Meyer-Olkin measure of sampling adequacy (Kaiser, 1960) was .94 and .90 for the clinical and non-clinical samples respectively, confirming factorability (Tabachnick & Fidell, 1989; Worthington & Whittaker, 2006).

In the clinical sample, scree plot suggested two factors and eigenvalues >1 suggested six factors. Inspection of a six-factor solution indicated items without loadings and others with cross-loadings, and without clear theoretical underpinning (see Supplementary Table S1 for item loadings). After assessing alternative solutions, a four-factor solution was free from cross-loadings, inclusive of all items and proved most theoretically meaningful, and was therefore retained. The retained solution reflected the "PCI", "CFO", "PCA", and "QOL" subscales as proposed by scale authors and explained 65.00% of variance. All items, including additional multitasking items, loaded with proposed subscales except CogM9, which loaded with CFO instead of PCI. Item factor loadings and communalities for the clinical and non-clinical samples are in Table 2.

For non-clinical participants, scree plot indicated four factors whilst eigenvalues >1 indicated six factors. A four-factor solution reflecting PCI, CFO, PCA, and QOL was interpreted and accounted for 65.76% of variance. Three items attributed to PCI loaded with other factors, where CogM9 and CogF25 loaded with CFO, and CogC7 loaded with PCA. CogA1, CogA3, CogF23, CogC33c, and CogC31 did not load with any factor.

Table 2 Factor Loadings and Communalities of the 37-item FACT-Cog3 in Clinical and Non-Clinical Samples

Item	Clinical					Non-clinical				
	PCI	CFO	PCA	QOL	h_2	PCI	CFO	PCA	QOL	h_2
CogF23 (PCI)	.85				.76					.72
CogF19 (PCI)	.82				.59	.56				.59
CogF24 (PCI)	.79				.53	.50				.44
CogV13 (PCI)	.78				.67	.83				.65
CogA3 (PCI)	.74				.66					.54
CogM12 (PCI)	.71				.62	.61				.64
CogV15 (PCI)	.70				.80	.66				.63
CogC7 (PCI)	.69				.62			.40		.53
CogC31 (PCI)	.69				.79					.61
CogC32 (PCI)	.64				.68	.41				.80
CogC33c (PCI)	.62				.64					.47
CogA1 (PCI)	.60				.62					.52
CogC33a (PCI)	.60				.69	.68				.79
CogMT1 (PCI)	.59				.82	.41				.75
CogM10 (PCI)	.57				.55	.49				.79
CogF25 (PCI)	.56				.53		.66			.78
CogMT2 (PCI)	.55				.77	.40				.68
CogV16 (PCI)	.40				.43	.87				.83
CogV17b (PCI)	.40				.70	.70				.82
CogO3 (CFO)		.73			.82		.81			.74
CogO4 (CFO)		.70			.69		.69			.76
CogO2 (CFO)		.55			.52		.66			.47
CogO1 (CFO)		.54			.54		.54			.61
CogM9 (PCI)		.43			.36		.48			.42
CogPMT2 (PCA)			.85		.77			.79		.77
CogPMT1 (PCA)			.84		.81			.90		.82
CogPF1 (PCA)			.80		.66			.84		.79
CogPC1 (PCA)			.72		.72			.74		.67
CogPM1(PCA)			.67		.57			.65		.74
CogPM2 (PCA)			.63		.68			.71		.62
CogPV1 (PCA)			.62		.61			.63		.63
CogPCH1 (PCA)			.54		.85			.76		.66
CogPCH2 (PCA)			.53		.90			.71		.62
CogQ38 (QOL)				−.88	.80				.73	.84
CogQ41 (QOL)				−.85	.85				.76	.88
CogQ37 (QOL)				−.84	.70				.69	.89
CogQ35 (QOL)				−.73	.67				.74	.77

Factor analysis of the 33-item FACT-Cog3 revealed a similar pattern (see Supplementary Table S2). In the clinical sample, the scree plot indicated four factors reflecting the PCI, CFO, PCA, and QOL subscales. Most items loaded with their proposed subscales, except CogM9 which loaded with CFO instead of PCI. However, CogPCH1, CogPCH2, and CogV16 did not load with any factor. In the non-clinical sample, the scree plot indicated five factors representing high-frequency memory lapses (forgetting reason for walking into a room or location of keys/wallet), verbal deficits, CFO, PCA, and QOL, with a number of items loading with unexpected subscales or with no subscale.

Group Comparisons

Clinical participants reported significantly worse cognitive function than non-clinical participants on PCI18,

Table 3 Comparing Descriptive Statistics of the Clinical ($N = 205$) and Non-Clinical ($N = 110$) Samples

Variable	Clinical *M (SD)*	Non-Clinical *M (SD)*	*t*	*df*	*p*
FACT-Cog3					
PCI18	43.23(16.28)	55.03 (12.39)	−7.20	277.31	<.001
PCI20	48.01(18.32)	61.23 (14.09)	−7.13	275.31	<.001
PCA7	16.14 (6.10)	20.20 (5.76)	−5.75	313.00	<.001
PCA9	20.60 (7.95)	25.93 (7.50)	−5.78	313.00	<.001
CFO	14.29 (2.64)	14.70 (2.50)	−1.33	313.00	.184
QOL	10.83 (4.43)	13.33 (3.83)	−5.21	252.29	<.001
Predictors					
Cognitive Function	65.60 (23.69)	80.91 (19.53)	−5.80	313.00	<.001
Nausea/vomiting	6.26 (10.70)	7.12 (12.86)	−0.60	190.91	.550
Pain	28.13 (24.20)	20.61 (25.53)	2.58	313.00	.010
Fatigue	36.86 (20.38)	26.46 (19.51)	4.38	313.00	<.001
Distress	17.59 (7.51)	16.00 (7.01)	1.83	313.00	.068

PCI20, PCA7, PCA9 and QOL subscales (Table 3). Clinical participants also reported significantly worse EORTC-QLQ-C30 cognitive function, pain, and fatigue than non-clinical participants. Mean scores for CFO, nausea/vomiting, and psychological distress did not differ significantly between clinical and non-clinical participants.

Reliability

For clinical participants, Cronbach's alpha indicated high internal reliability (Nunnally & Berstein, 1994) for PCI, PCA, CFO, and QOL (Table 4). When including additional multitasking items, Cronbach's alpha for PCI remained at .96, whereas the alpha for PCA shifted from .87 to .91.

Table 4 Reliability and Validity of FACT-Cog3 Subscales in Clinical ($N = 205$) and Non-Clinical ($N = 110$) Samples

	Reliability			Concurrent Validity		Convergent Validity				Discriminant Validity			
	Cronbach's Alpha	Test-retest reliability[a]				Fatigue		Distress		Pain		Nausea/vomiting	
Sample	α	*r*	*p*	*r*	*p*	*r*	*p*	*r*	*p*	*r*	*p*	*r*	*p*
Clinical													
PCI18	.96	.92	<.001	.75	<.001	−.56	<.001	−.58	<.001	−.39	<.001	−.09	.227
PCI20	.96	.92	<.001	.76	<.001	−.57	<.001	−.58	<.001	−.39	<.001	−.09	.224
PCA7	.87	.87	<.001	.62	<.001	−.39	<.001	−.38	<.001	−.29	<.001	−.09	.031
PCA9	.91	.89	<.001	.62	<.001	−.38	<.001	−.36	<.001	−.30	<.001	−.09	.200
CFO	.84	.88	<.001	.41	<.001	−.27	<.001	−.35	<.001	−.30	<.001	−.07	.352
QOL	.92	.79	<.001	.61	<.001	−.51	<.001	−.57	<.001	−.39	<.001	−.07	.323
Non-clinical													
PCI18	.94	.79	.004	.72	<.001	−.42	<.001	−.58	<.001	−.31	.001	−.55	<.001
PCI20	.95	.81	.002	.73	<.001	−.42	<.001	−.59	<.001	−.31	.001	−.55	<.001
PCA7	.90	.61	.049	.63	<.001	−.38	<.001	−.41	<.001	−.09	.330	−.32	.001
PCA9	.93	.65	.030	.65	<.001	−.42	<.001	−.43	<.001	−.12	.228	−.34	<.001
CFO	.86	.87	<.001	.51	<.001	−.26	.007	−.53	<.001	−.17	.079	−.36	<.001
QOL	.95	.73	.011	.69	<.001	−.44	<.001	−.63	<.001	−.30	.001	−.52	<.001

Note. Higher scores represent better functioning on FACT-Cog3 and cognitive functioning subscale. Higher scores represent worse functioning on the fatigue, distress, pain, and nausea/vomiting measures. [a] Test-retest was conducted at 6-week follow up using clinical ($n = 33$) and non-clinical ($n = 11$) samples

Similarly, in the non-clinical sample, Cronbach's α indicated high internal reliability for PCI, PCA, CFO and QOL and when including additional multitasking items, internal consistency for PCI and PCA increased. In both the clinical ($n = 33$) and non-clinical ($n = 11$) samples, scores showed significant test-retest correlation between initial and 6-week measures for CFO, QOL, PCI18, PCI20, PCA7 and PCA9 (Table 4).

Validity

For both clinical and non-clinical samples, concurrent validity was demonstrated via worse EORTC-QLQ-C30 cognitive functioning correlating significantly with worse CFO, QOL, PCI18, PCI20, PCA7 and PCA9. In the clinical and non-clinical samples, convergent validity was shown by worse fatigue and distress correlating significantly with worse CFO, QOL, PCI18, PCI20, PCA7 and PCA9.

When assessing discriminant validity, in the clinical sample, higher pain showed a significant correlation with worse CFO, QOL, PCI18, PCI20, PCA7 and PCA9. However, there was no significant correlation between the nausea/vomiting subscale and all FACT-Cog3 subscales. In the non-clinical sample, higher pain showed a significant correlation with worse QOL, PCI18, PCI20, but was uncorrelated with CFO, PCA7, and PCA9. Higher nausea/vomiting in non-clinical participants correlated with worse CFO, QOL, PCI18, PCI20, PCA7 and PCA9.

Discussion

The present study aimed to better understand the factor structure and psychometric properties of the FACT-Cog3 in English, with particular attention to the role of multitasking items that were added after the scale authors' validation of FACT-Cog3. As hypothesised (H1a), 37-item scoring yielded a four-factor solution reflective of the authors' proposed subscales, free from cross-loadings, when used in a clinical adult sample who had received cancer treatment. Furthermore, the additional multitasking items loaded with the expected subscales (H2) as proposed by the scale authors (Wagner et al., 2009). However, CogM9, regarding problems finding one's way to a familiar place, loaded with the CFO subscale instead of PCI. Corroborating these findings, previous analyses have found CogM9 to deviate from the PCI subscale (Cheung et al., 2013; Costa et al., 2018) and had suggested the performance of this item to be due to its ambiguous nature and that it may be indicative of severe cognitive impairment rather than subtle deficits cancer survivors more typically report.

The factor structure of the 33-item FACT-Cog3 supported a four-factor solution (H1b); however, there were some discrepancies from the proposed subscales. As seen in the 37-item version, CogM9 loaded on the CFO subscale instead of PCI. Three items from PCA did not load with any subscale (Howard, 2016). This showed that the full 37-items produced a factor structure better aligned to scale authors' intentions compared to the 33-item version.

When used in a non-clinical sample, the factor structure of the FACT-Cog3 showed conflicting results (RQ2a). In the 37-item scale, the factor structure mostly supported a four-factor solution, with some minor discrepancies whereby a number of items loaded with alternative subscales. In contrast, the 33-item version indicated five factors, reflecting high-frequency memory lapses, verbal communication deficits, CFO, PCA, and QOL. Results showed multiple items loading on other subscales, cross-loading, or not loading. Supporting these findings, Costa et al. (2018) found that the FACT-Cog3 behaved differently when used in a non-clinical sample. Therefore, it is important that researchers and clinicians recognise and consider these differences when using comparative data, particularly when using the 33-item FACT-Cog3.

Results from psychometric properties analyses confirmed the reliability and validity of the FACT-Cog3 among the clinical sample (RQ1). The results from reliability measures indicated very high internal consistency for the 33-item version and even higher internal consistency for the 37-item FACT-Cog3. For both versions, the pattern of correlations showed the highest correlation with another self-reported cognitive scale to demonstrate concurrent validity, moderate correlations with fatigue and psychological distress to demonstrate convergent validity, and the lowest or no correlation with nausea and pain to demonstrate discriminant validity; the non-clinical sample showed a similar pattern of results (RQ2b). Inclusion of the multitasking items was associated with similar or higher reliability and validity coefficients for the relevant FACT-Cog3 subscales. This is unsurprising as the multitasking items are indicative of real-life situations that require multiple tasks to be completed simultaneously and by including these items, the FACT-Cog3 becomes a more comprehensive measure of the deficits experienced by cancer survivors (Tannock et al., 2004).

When comparing subscale scores between clinical and non-clinical samples, results showed that the FACT-Cog3 displayed known-groups validity for the PCI, PCA, and QOL subscales, however, it was unable to discriminate between groups on the CFO subscale. This might reflect the subtle nature of some perceived changes to cognitive functioning experienced by cancer survivors that might not be apparent or obvious to those around them. Inability to distinguish between clinical and non-clinical samples was also found in a study conducted by Cheung et al. (2013) using the Chinese adaptation of the CFO; these authors reported elsewhere that family members providing psychosocial support during treatment were generally "forgiving" and "patient" when cancer survivors displayed cognitive lapses (Cheung et al., 2012).

Furthermore, family members might be reserved in voicing opinions about changes to loved ones' cognitive functioning as these comments might not be received well (Cheung et al., 2013). These findings suggest the CFO subscale might not accurately represent what others have noticed about changes to someone's cognitive functioning.

The present study was strengthened by similarities between clinical and non-clinical samples. The two samples were matched on variables likely to influence cognitive functioning, such as age, years of education, and psychological distress. However, the clinical sample was predominantly recruited from Breast Cancer Network Australia and sampling purposes for related studies required the participants to be females mostly aged between 35 to 64 years, which limits the generalisability of the study in other cancer populations, due to influences such as age and gender differences in reporting (Bray et al., 2018). Future research should consider evaluating the FACT-Cog3 with a more diverse cancer sample that includes both men and women. The heterogeneity of the clinical samples due to combining samples from different recruitment was a further limitation of the current study.

Choice of cognitive comparison scale might be considered a limitation of the present study as the EORTC-QLQ-C30 cognitive subscale consists of two items assessing perceived memory and concentration and does not consider other cognitive domains known to be affected by cancer and associated treatments (Bray et al., 2018). However, this subscale was chosen because it is the only other measure developed and validated for the purpose of assessing patient-reported cognitive functioning in an adult cancer sample.

Until now there has been uncertainty regarding the factor structure, reliability, validity, and scoring of the FACT-Cog3 for use in clinical and non-clinical samples. Previously, those wishing to use the FACT-Cog3 were encouraged to run analyses based on their own samples to determine whether to include the additional multitasking items, resulting in many inconsistencies within the literature. However, based on the results of the present study, it is recommended that researchers and clinicians include the additional multitasking items and score each subscale individually when using the FACT-Cog3. This is consistent with previously published recommendations (Lai et al., 2014). It is further recommended that subscale labels are adjusted to distinguish between 33-item and 37-item scoring. Labels are suggested to reference the number of items for PCI and PCA, labelling them as "PCI18", "PCI20", "PCA7", and "PCA9" respectively. This distinction is particularly important for clinicians who might consider using the PCI subscale as an outcome measure, as suggested by the scale authors (Wagner et al., 2009). In doing so, clinicians might consider use of cut-scores, such as 54 for PCI18 (i.e., less than 54 indicates impairment) or score of 60 for PCI20 as established through recent research conducted with breast cancer survivors (Van Dyk et al., 2020).

In conclusion, the FACT-Cog3 has shown validity and reliability for assessing patient-reported cognitive impairment following cancer. Researchers should be cautious when administering FACT-Cog3 to non-clinical participants as the factor structure can vary from that in cancer survivors, particularly with 33-item scoring. To more comprehensively encompass cognitive difficulties that cancer survivors report, it is recommended that practitioners include multitasking items when scoring the scale. More importantly, it is essential that practitioners disclose which scoring method they have used and label subscales accordingly, to avoid under- or overestimation of perceived cognitive ability and impairment for future meta-analyses and reviews.

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Code Availability Not applicable.

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Data Availability Data are available from the corresponding author upon reasonable request.

Declarations

Ethics Approval All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional research committee (Griffith University Human Research Ethics Committee 2018/380) and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Consent to Participate Informed consent was obtained from all individual participants included in the study.

Consent for Publication Not applicable.

Conflict of Interest On behalf of all authors, the corresponding author states that there is no conflict of interest.

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