Translation and validation of a Chinese version of the Wayfinding Effectiveness Scale: A cross-sectional study

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Abstract

Background: Getting lost is a serious problem for elders with dementia. In North America, the Wayfinding Effectiveness Scale (WES) evaluates wayfinding effectiveness in persons with cognitive impairment. In Taiwan, such approach had not been implemented. As a consequence, this study translated the original scale into Chinese and tested its psychometric properties for family caregivers to evaluate persons with cognitive impairment in northern Taiwan.

Methods: It was a cross-sectional study design. Participants were 180 dyads (persons with cognitive impairment and their family caregivers, PWCIs and FCGs) from two memory disorder clinics at two teaching hospitals and from local community long-term care service programs.

Results: Forward/back translation was applied to develop the Chinese Wayfinding Effectiveness Scale (CWES). Factor analyses yielded a six-factor solution (explained variance = 66.77%): finding a destination and path in (1) familiar environments and (2) unfamiliar environments; sense of direction with (3) analytic strategies and (4) global strategies; (5) landmark and distance in familiar/unfamiliar environments; and (6) using a map in familiar/unfamiliar environments. One single-loaded factor item was deleted, yielding a 29-item scale. Construct validity using hypothesis testing was demonstrated by significant correlation coefficients between the total scale and its six subscales, among the total scale and the Chinese Mini-Mental Status Exam (CMMSE) and Chinese Neuropsychiatric Inventory (CNPI), and among five subscales and the CMMSE and CNPI. Only one subscale had subpar validity, suggesting future minor revision by a larger sample.

Conclusion: The Chinese Wayfinding Effectiveness Scale (CWES) is a valid instrument to measure wayfinding effectiveness in persons with cognitive impairment in Taiwan.

Introduction

In Taiwan, 33.3% of people with Alzheimer's disease experienced getting lost at least once over a 2.5-year period (Pai & Lee, 2016). Such events can lead to serious accidents, such as physical harm, falling, or even death, and greatly impact societies and their economies. For persons with cognitive impairment (PWCIs), spatial and environmental challenges increase the difficulties of impaired wayfinding and lead to getting lost (Algase et al., 2007; Kim & Kang, 2017). In fact, successful wayfinding by making sense of spatial surroundings (Kaplan & Kaplan, 1983) is required for survival. However, wayfinding can become challenged by both insufficient designs in contemporary architectural settings (Passini et al., 1995) and cognitive impairment (Chiu, 2003).

Wayfinding is spatial problem-solving (Passini et al., 1995) that involves several executive functions: (1) selecting a goal or destination (Chiu, 2003); (2) determining a path or route; (3) planning; (4) executing the plan; and (5) applying strategies to follow the route and reach the destination (Lezak, 1982). Accordingly, effective wayfinding requires cognitive maps to inform these executive functions (Chiu et al., 2004; Davis & Veltkamp, 2020). Cognitive maps assist individuals to orientate themselves by establishing their position, identifying shortcuts, and finding their way more efficiently (Casakin et al., 2000; Chiu et al., 2003). Building cognitive maps, or cognitive mapping, constitutes a process of acquiring knowledge about position and direction, including place and landmarks, route patterns, distances, and directions between places. During the cognitive mapping process, individuals must integrate environmental information to increase wayfinding effectiveness (Ishikawa et al., 2007; Chown et al., 1995).

Kaplan and Kaplan (1983) identified two possible wayfinding strategies: global and analytic wayfinding strategies. Global strategies, such as asking for directions, address the general problem of wayfinding without depending on personal knowledge of the environment. Analytic strategies are evident when knowledge of environmental elements, such as the relationships between areas and possible routes, can be used for wayfinding (Iaria et al., 2003). When given a wayfinding task, cognitively intact people adopt whatever strategy is most appropriate for completing the task (Logie, 1995). In contrast, PWCIs possess compromised cognitive mapping abilities, which makes imagining a space or environment more difficult, and this could explain wandering (Algase et al., 2004). Nonetheless, PWCIs can find their way in properly designed areas (Passini et al., 1995) or if they have been trained to apply certain strategies (Algase et al., 2004). Therefore, in terms of developing dementia-friendly communities (Wu et al., 2019), not only is environmental information essential for PWCIs (Vandenberg et al., 2015), but their wayfinding effectiveness is the key element to become socially integrated within the community (Simon et al., 1992).

Algase et al. (2007) developed the Wayfinding Effectiveness Scale (WES) for PWCIs. Hong and Lim (2009) then translated it into Korean. The psychometric properties of the original WES and its Korean translation were acceptable (Algase et al., 2007; Hong & Lim, 2009). However, no similar Chinese instrument is available in Taiwan. Given the prevalence of persons with Alzheimer's disease in Taiwan suffering from getting lost (Pai & Lee, 2016), the purpose of this study was to translate the WES (Algase et al., 2007) into Chinese (CWES), and test its psychometric properties in PWCIs in northern Taiwan. We assumed that the CWES would be reliable and valid for family caregivers to assess wayfinding effectiveness in PWCIs. We also expected the instrument to correlate significantly with measures of cognitive, behavioural, and psychological symptoms of dementia.

Methods

Design And Participants

Prior to conducting this research, we obtained approval from the institutional review board of the main participating hospital. In total, we contacted 189 dyads of PWCIs and their family caregivers (FCGs) through two memory disorder clinics at two teaching hospitals and from local community long-term care service programs in northern Taiwan. Nine dyads did not complete the test battery; therefore, we used the data of only 180 dyads for statistical analysis (Fig. 1).

(Insert Fig. 1 about here)

Once consent from the dyads was received, the PWCIs underwent a standard comprehensive evaluation at their respective clinics. To determine eligibility, a team of neurologists, clinical psychologists, and nurses assessed the type and severity of dementia and cognitive status. The main neurologists at the clinical sites diagnosed dementia through consensus agreement following the criteria in the *Diagnostic and Statistical Manual of Mental Disorders*, 4th edition (DSM-IV) (American Psychiatric Association, 1994), guidelines of the National Institute of Neurological and Communicative Disorders and Stroke, and the Alzheimer's Disease and Related Disorders Association (NINCDS-ADRDA) (McKhann et al., 1984). PWCIs were eligible for the study if they: (1) spoke Mandarin Chinese, Taiwanese, or Hakka dialect (all the recruited participants understood Mandarin which was the official language of Taiwan); and (2) had primary or secondary FCGs. PWCIs were excluded if: (1) their primary residence was a nursing home; (2) they had an acute illness, impaired sensory symptoms (hearing loss and/or severe visual problems), chronic alcohol abuse, or drug usage affecting the central nervous system; or (3) they had a Clinical Dementia Rating (CDR) greater than 3 (Morris et al., 2001).

To address the recall bias of PWCIs, FCGs were included if, for the past three months, they: (1) had provided most of the caregiving assistance to the family member with cognitive impairment; or (2) had provided secondary care by supervising hired care assistants or foreign helpers who were primary caregivers of the PWCI. Co-residency was not required for FCGs because, in Taiwan, it is common for married adult children who live nearby to regularly visit their parents' houses to assist with chores and/or medical needs. Family caregivers were excluded if they had: (1) been diagnosed with a cognitive or mental disorder, such as severe memory problems or major affective disorders; (2) untreated hearing or visual impairments; (3) been prescribed drugs known to impair or enhance attention, such as antidepressants, barbiturates, other depressants, or amphetamines; or (4) an insufficient command of Chinese, Taiwanese, or Hakka languages that would preclude them from testing.

Translation Of The Chinese Wayfinding Effectiveness Scale (Cwes)

The WES, developed by Algase et al. (2007), has a four-factor solution based on factor analysis results. The factors consist of: (1) complex wayfinding goals (CWG); (2) analytic strategies (AS); (3) global strategies (GS); and (4) simple wayfinding goals (SWG). The internal consistency reliability for the 30-item WES is high (.94 to .95). Cronbach's alpha values for the four subscales are stable (greater than .70) for these three versions: (1) FCGs reporting PWCIs' current wayfinding effectiveness; (2) FCGs reporting PWCIs' wayfinding effectiveness before disease onset; and (3) FCGs' current wayfinding effectiveness as a controlled condition. Test-retest reliability of the WES is acceptable for persons with dementia. Details of the scale's development are described in Algase et al. (2007).

Following the forward-and-back method (Brislin, 1970), the first author translated the WES into Chinese. Then, the second author, an English-fluent Taiwanese faculty member with a specialization in gerontology, back-translated the CWES to English. After comparing the 30 items on the back-translated version with the original English version, Dr. Donna Algase who was the original developer for the instrument, rated all 30 items as equivalent in meaning.

A six-member panel of experts in gerontological nursing, neurology, and clinical psychology evaluated the face and content validity of the CWES. The panel's comments guided revisions in the Chinese wording to clarify the starting point and endpoint of a travel path. We pilot-tested the updated translation with four FCGs to determine acceptability by asking them to rate whether any part of the translated scale was difficult to understand or confusing. Their feedback was positive, and no further modifications were made.

Measurements

We collected demographic data, such as age, gender, and education level, of the dyads. We also collected the PWCIs' disease data (such as type and severity of dementia and cognitive status), FCGs' relationship status with PWCIs, and if other helpers existed. The test battery for patients is described as follows.

Cognitive function

The Mini-Mental Status Exam (MMSE), a popular instrument developed by Folstein et al. (1975), was used to screen and monitor global cognitive impairment. The MMSE measures orientation, registration, recall, language, and spatial capacity for a total possible score of 30. A higher score indicates a higher level of cognitive functioning. A psychologist assessed cognitive function in PWCIs with the Chinese version of the MMSE (CMMSE), which has good validity and reliability (Guo et al., 1988; Shyu & Yip, 2001). The MMSE scores were copied from the patients' charts with their permission. Therefore, we did not calculate its Cronbach's alpha for this study.

Severity of dementia

The Clinical Dementia Rating (CDR) scale determines the stages of dementia for PWCIs using six domains: (1) memory; (2) orientation; (3) judgment and problem-solving; (4) community affairs; (5) home and hobbies; and (6) personal care. An overall score indicates the severity of dementia: 0 = none; 0.5 = very mild; 1 = mild; 2 = moderate; and 3 = severe. In this study, a psychologist evaluated dementia severity using the Chinese version of the CDR (CCDR). The global score for the Chinese version of the scale has an interrater reliability of kappa 0.63 (Lin & Liu, 2003). The CDR scores were copied from the patients' charts with their permission. Therefore, we did not calculate its Cronbach's alpha for this study.

Neuropsychological inventory

Behavioural and psychiatric symptoms of the PWCIs were assessed using the Chinese version of the Neuropsychiatric Inventory (CNPI) developed by Leung et al. (2001). Leung et al. evaluated the psychometric properties of the CNPI with a population of PWCIs in Hong Kong. Concurrent validity of all eight subscales of the CNPI correlated significantly ($p < .001$) with the corresponding domains of the

Behavioural Psychology of Alzheimer's Disease scale, which measures behavioural and psychological symptoms of dementia (Reisberg et al., 1997). The CNPI has a high level of internal stability, according to its internal consistency reliability of .84 for overall reliability, and both severity and frequency of .86. Kappa coefficients for interrater reliability are acceptable (range = .7 to 1.00), with intraclass correlation coefficients (ICC) for all subscales greater than .90 (Leung et al., 2001). Its overall Cronbach's alpha for this study was .88.

Chinese Wayfinding Effectiveness Scale

The 30 scale items were randomly ordered for the final CWES instrument. Items were scored on a 5-point Likert scale ranging from 1 (*never or unable*) to 5 (*always*); higher scores indicated better wayfinding effectiveness (Algase et al., 2007). We asked FCGs to complete the CWES and respond to each item as it applied to current behaviours of their care recipients.

Data analysis

To identify the conceptual constructs of the CWES, we conducted an exploratory factor analysis using principal component analysis with varimax rotation (Kim & Mueller, 1978). To determine internal consistency and reliability of the CWES, we calculated Cronbach's alpha for the total scale and each subscale. To find one-week test-retest and interrater reliability, we calculated intraclass correlations with a subset of FCGs ($n = 8$). To determine construct validity, we used correlation coefficients for the subscale and total CWES scores, CMMSE, and CNPI. Finally, to determine sensitivity and specificity, we used a Receiver Operating Characteristic (ROC) analysis of CDR scores to distinguish PWCIs with mild cognitive impairment from those in the early stages of dementia.

Ethical Considerations

This project was approved by the Institutional Review Board of the participating institution (IRB No. 97-0483B). Additional protection was provided to the vulnerable participants with cognitive impairment under the Declaration of Helsinki regulation. For example, we made sure that the PWCIs understood the purpose of this study by explaining this study in plain language and verifying their response at least three times. We also invited their family caregivers to help to explain this study to the PWCIs. If the PWCIs refused to participate in this study, we would ask them three times (30 minutes apart) and respected their final decision. Those who agreed to participate provided written informed consents and were assured of anonymity and confidentiality. All the informed consents of the dyads were obtained.

Results

Characteristics of persons with cognitive impairment and family caregivers

The mean age of the 180 PWCIs was 77.61 years ($SD = 8.18$); males and females were equally represented. Most PWCIs (73.3%) had received a diagnosis of Alzheimer's disease; 27.8% had a CDR score of .05, and 48.9% had a CDR score of 1. Details of the demographic and clinical characteristics of the PWCIs are shown in Table 1.

Table 1

Demographic and clinical characteristics of persons with cognitive impairment [a] (n = 180)

Characteristic	n	%	Mean	SD	Range
Age, years			77.61	8.18	52–98
Gender					
Female	91	50.6			
Male	89	49.4			
Education, years			8.16	5.20	0–19
Language					
Mandarin	101	56.1			
Taiwanese	74	41.1			
Hakka	4	2.2			
Other	1	0.6			
Marital status					
Married	122	67.8			
Divorced/separated	3	1.7			
Widowed	55	30.6			
Living arrangement					
Alone	2	1.1			
With spouse	48	26.7			
With family member(s)	55	30.6			
With spouse and family member(s)	67	37.2			
Others	8	4.4			
Diagnosis					
Alzheimer’s disease	132	73.3			
Vascular dementia	27	15.0			
Others	21	11.7			

Abbreviations: SD **= standard deviation;** CDR **= clinical dementia rating scale;** CMMSE **= Chinese version of the Mini-Mental State Exam;** CNPI **= Chinese version of the Neuropsychiatric Inventory.** [a] **Data obtained from family caregivers and chart review**

Characteristic	n	%	Mean	SD	Range
Mental status exam scores					
CDR					
0.5	50	27.8			
1	88	48.9			
≧ 2	42	22.4			
CMMSE			16.65	6.12	0–28
CNPI			16.37	19.84	0–96

Abbreviations: SD **= standard deviation;** CDR **= clinical dementia rating scale;** CMMSE **= Chinese version of the Mini-Mental State Exam;** CNPI **= Chinese version of the Neuropsychiatric Inventory.** [a] **Data obtained from family caregivers and chart review**

(Insert Table 1 about here)

The mean age of the FCGs was 56.01 years (SD = 13.83), the majority (65%) were female, and most (90.6%) were married. Nearly all FCGs (97.2%) had a familial relationship with the PWCIs, usually their spouse (40.5%) or child (55.6%). The mean duration of caregiving for FCGs was 39.02 months (SD = 40.60), and time devoted to caregiving was 66.15 hours/week (SD = 50.57). Of FCGs, 68% had additional help from family or friends. Table 2 lists the details of FCGs' characteristics.

Table 2
Demographic characteristics of family caregivers of persons with cognitive impairment (PWCI) (n = 180)

Characteristic	Missing data	n	%	Mean	SD	Range
Age, years		180		56.01	13.83	24–84
Gender						
Female		117	65			
Male		63	35			
Education, years				11.94	4.12	0–22
Language						
Mandarin		146	81.1			
Taiwanese		34	18.9			
Marital status						
Single		13	7.2			
Married		163	90.6			
Divorced/separated		4	2.2			
Occupation	27					
Unemployed		116	64.4			
Government employee		12	6.7			
Business		13	7.2			
Blue collar		4	2.2			
Agriculture		2	1.1			
Other		6	3.4			
Relationship to PWCI	1					
Spouse		73	40.5			
Child		100	55.6			
Grandchild		2	1.1			
Others		4	2.2			
Living with PWCI						

Abbreviations: SD **= standard deviation**

Characteristic	Missing data	n	%	Mean	SD	Range
Yes		139	77.2			
No		41	22.8			
Caregiving						
Duration, months				39.02	40.60	2–264
Total hours per week				66.15	50.57	4–168
Additional caregiving help						
Yes		122	67.8			
No		58	32.2			
Foreign helper						
Yes		40	22.2			
No		140	77.8			
Abbreviations: SD **= standard deviation**						

(Insert Table 2 about here)

Factor structure of the Chinese version of the Wayfinding Effectiveness Scale (CWES)

To determine whether the CWES was appropriate for analysis, we calculated the Kaiser-Meyer-Olkin index (Kaiser, 1974) and Bartlett's (1937) test of sphericity (Bartlett, 1937) for sampling adequacy. The Kaiser-Meyer-Olkin results for the data (n = 180) was .89, and the sphericity was $p < .000$, indicating that the sample was adequate for factor analysis. Therefore, exploratory factor analysis and principal component analysis with varimax rotation extracted six factors: (1) SWG = simple wayfinding goals (finding a destination and a route in familiar environments); (2) CWG = complex wayfinding goals (finding a destination and a route in unfamiliar environments); (3) SDAS = sense of direction and analytic strategies; (4) SDGS = sense of direction and global strategies; (5) LDE = landmarks and distance in familiar/unfamiliar environments; and (6) MAP = using a map in familiar/unfamiliar environments. This solution explained 66.77% of the variance of CWES scores (Table 3).

Table 3
Factor loading of the first order model of the CWES (n = 180 FCGs).

		Factor I	Factor II	Factor III	Factor IV	Factor V	Factor VI
Item		**SWG**	**CWG**	**SDAS**	**SDGS**	**LDE**	**MAP**
2	Can find the way around one's area of residence if the route and the destination are familiar	**.77**					
3	Can find way to near places if the route and the destination are familiar	**.76**					
12	Can locate any unfamiliar room in one's own home	**.76**					
11	Can locate any familiar room in one's own home	**.70**					
1	Can find way to distant places if the route and the destination are familiar	**.63**					
27	Can find the way through one's own home with one's eyes closed	**.56**					
6	Can find the way to near and unfamiliar places		**.83**				
4	Can find the way to distant and unfamiliar places		**.82**				
5	Can find the way to unfamiliar places around one's area of residence		**.80**				
24	Can generate alternate routes to common destinations with relative efficiency		**.64**				
28	Can locate lost items in one's own home by retracing one's steps			**.80**			
29	Can locate lost items in one's own home by systematically searching each room			**.73**			

Abbreviations: FCGs **= family caregivers;** SWG **= simple wayfinding goals (finding a destination and a route in familiar environments);** CWG **= complex wayfinding goals (finding a destination and a route in unfamiliar environments);** SDAS **= sense of direction and analytic strategies;** SDGS **= sense of direction and global strategies;** LDE **= landmarks and distances in familiar/unfamiliar environments;** MAP **= using a map in familiar/unfamiliar environments.**

		Factor I	Factor II	Factor III	Factor IV	Factor V	Factor VI
30	Overall, has a good sense of direction			**.48**			
22	Can compensate for a forced detour when traveling to a familiar location			**.48**			
18	Adheres to the saying: a place for everything and everything in its place			**.46**			
23	Can locate an unfamiliar location by circling in on it			**.43**			
26	Always puts small items, such as keys, in the same cabinet, in order to easily find them			**.42**			
17	Finds the way around a mall or museum by accessing a directory				**.76**		
14	Prefers a route in terms of left-right when obtaining directions to a new location				**.58**		
19	Can compensate without assistance once “off course” in an unfamiliar location				**.57**		
20	Can detect when one is “off course” in an unfamiliar location				**.56**		
21	Can detect when one is “off course” in a familiar location				**.53**		
10	Relies on landmarks when traveling to an unfamiliar location					**.68**	
16	Prefers distance estimates in terms of miles or blocks when traveling to a new location					**.67**	
9	Relies on landmarks when traveling to a familiar location					**.67**	

Abbreviations: FCGs **= family caregivers;** SWG **= simple wayfinding goals (finding a destination and a route in familiar environments);** CWG **= complex wayfinding goals (finding a destination and a route in unfamiliar environments);** SDAS **= sense of direction and analytic strategies;** SDGS **= sense of direction and global strategies;** LDE **= landmarks and distances in familiar/unfamiliar environments;** MAP **= using a map in familiar/unfamiliar environments.**

		Factor I	Factor II	Factor III	Factor IV	Factor V	Factor VI
15	Prefers a route in terms of landmarks when obtaining directions to a new location					**.67**	
13	Prefers a route in cardinal signs when getting directions to a new location					**.51**	
7	Relies on maps when heading for a familiar location						**.87**
8	Relies on maps when heading for an unfamiliar location						**.86**
	Eigenvalue	4.28	4.06	3.37	3.02	3.00	6.70
	R^2	14.29%	13.54%	11.25%	10.05%	10.01%	7.63%
	Overall R^2 = 66.77%						
	Number of items	6	4	7	5	5	2
	Mean	21.18	6.81	17.63	13.18	8.92	2.39
	Standard deviation	7.12	4.51	7.11	5.88	5.09	1.66
	Cronbach's alpha for subscales	.87	.91	.86	.83	.82	.92
	Overall Cronbach's alpha = .94						

Abbreviations: FCGs **= family caregivers;** SWG **= simple wayfinding goals (finding a destination and a route in familiar environments);** CWG **= complex wayfinding goals (finding a destination and a route in unfamiliar environments);** SDAS **= sense of direction and analytic strategies;** SDGS **= sense of direction and global strategies;** LDE **= landmarks and distances in familiar/unfamiliar environments;** MAP **= using a map in familiar/unfamiliar environments.**

(Insert Table 3 about here)

The Cronbach's alpha of the total CWES was .94 and ranged from .82 (LDE) to .92 (MAP) for subscales. All were higher than the 0.70 threshold (Nunnally, 1978), demonstrating excellent reliability and internal consistency (Table 3). Item 25 was single-loaded with a component value of less than .40, and was subsequently deleted. The final version of the CWES consisted of 29 items (CWES-29). The ICC values—one-week test-retest reliability of the CWES-29—were .81 for the total scale, and ranged from .51 (CWG) to 1.00 (MAP) for the subscales (Table 4). Interrater reliability was .99 for the total scale, and ranged from .94 (CWG) to 1.00 (MAP) for the subscales (Table 4).

Table 4
Reliability of the CWES-29: total scale and subscales.

		95% Confidence interval		
Test-retest Reliability	**ICC**	**Lower limit**	**Upper limit**	**Significance level**
Total scale	.81	.98	1.00	< .001
Subscales				
SWG	.81	.98	1.00	< .001
CWG	.51	.98	1.00	< .001
SDAS	.60	.94	.99	< .001
SDGS	.90	.86	.98	< .001
LDE	.82	.91	.99	< .001
MAP	1.00	–	–	< .001
	95% Confidence interval			
Interrater Reliability	**ICC**	**Lower limit**	**Upper limit**	**Significance level**
Total scale	.99	.98	1.00	< .001
Subscales				
SWG	.99	.98	1.00	< .001
CWG	.94	.98	1.00	< .001
SDAS	.98	.94	.99	< .001
SDGS	.95	.86	.98	< .001
LDE	.97	.91	.99	< .001
MAP	1.00	—	—	< .001

Abbreviations: ICC **= intraclass correlation coefficient;** SWG **= simple wayfinding goals (finding a destination and a route in familiar environments);** CWG **= complex wayfinding goals (finding a destination and a route in unfamiliar environments);** SDAS **= sense of direction and analytic strategies;** SDGS **= sense of direction and global strategies;** LDE **= landmarks and distances in familiar/unfamiliar environments;** MAP **= using a map in familiar/unfamiliar environments**

(Insert Table 4 about here)

Psychometric Properties Of The Of The 29-item Cwes (Cwes-29)

We evaluated the psychometric properties of the CWES-29 by examining its construct validity using hypothesis testing. Correlation coefficients between the six subscale scores and the total CWES-29 score were all significant (Table 5); the SDAS subscale and total score had the highest correlation ($r = .90$, $p < .01$). Hypothesis testing results showed that all correlation coefficients between the CWES-29 total score/subscales, the CMMSE, and CNPI were significant, except the MAP subscale (Table 5).

Table 5
Correlation coefficients for the CWES-29 and its subscales, the CMMSE, and the CNPI.

	SWG	CWG	SDAS	SDGS	LDE	MAP	CWES-29	C-MMSE	CNPI
SWG	1								
CWG	.53**	1							
SDAS	.70**	.65**	1						
SDGS	.68**	.56**	.73**	1					
LDE	.40**	.57**	.55**	.47**	1				
MAP	.16*	.35**	.19*	.16*	.50**	1			
CWES-29	.83**	.78**	.90**	.84**	.72**	.37**	1		
CMMSE	.58**	.36**	.51**	.59**	.26**	.09	.58**	1	
CNPI	− .27**	− .17*	− .24**	− .23**	− .13**	.02	− .25**	− .16*	1

Abbreviations: SWG **= simple wayfinding goals (finding a destination and a route in familiar environments);** CWG **= complex wayfinding goals (finding a destination and a route in unfamiliar environments);** SDAS **= sense of direction and analytic strategies;** SDGS **= sense of direction and global strategies;** LDE **= landmarks and distances in familiar/unfamiliar environments;** MAP **= using a map in familiar/unfamiliar environments;** CMMSE **= Chinese version of the Mini-Mental Status Exam; CNPI = Chinese version of the Neuropsychiatric Inventory; *** $p < .05$**; **** $p < .01$

(Insert Table 5 about here)

Sensitivity And Specificity Of The Cwes-29

The ROC analysis showed that the CWES-29's cut-off score for differentiating PWCIs with a CDR of .5 (mild cognitive impairment [MCI]) from those with a CDR = 1 (early stage of dementia) was 81.5 (rounded-up to 82) out of a total score of 145. Given this cut-off score, the CWES-29 was 70.0% sensitive and 78.4 specific (Fig. 2). The area under the curve (AUC) was .83 (SD = .04, $p < .000$, 95% confidence interval = .76 – .89), indicating good discrimination power.

(Insert Fig. 2 about here)

Discussion

The study demonstrated that the Chinese translation of the WES (CWES-29) had acceptable validity and reliability as an informative instrument for FCGs to assess the wayfinding abilities of PWCIs in northern Taiwan. Factor analysis with PCA showed that the 29-item scale had a six-factor solution, explaining 66.77% of the variance of CWES scores. The CWES factors (SWG, CWG, SDAS, SDGS, LDE, and MAP) reflected these by underlying constructs of wayfinding effectiveness from the original frameworks: destination and distance, sense of direction, route selection, familiarity, global and analytic wayfinding strategies, landmarks, and map use (Kaplan & Kaplan, 1983; Algase et al., 2007).

The CWES-29 differs somewhat from the WES. Given the psychometric properties of its items, the original WES (Algase et al., 2007) combines SWG and CWG into "complex wayfinding goals." We chose to separate their items into two groups by their distinction between familiar vs. unfamiliar environments. However, we integrated item 12 (*Can locate any* unfamiliar *room in one's own home*) into the SWG subscale because we considered one's residence to be a familiar environment. Similarly, we grouped item 24 (*Can generate alternate routes to common destinations with relative efficiency*) into the CWG subscale because we considered alternate routes to evoke the experience of being in unfamiliar territory that requires complex wayfinding strategies.

The underlying constructs comprising SWG and CWG were similar to Kwon and Lee's (2005) "sense of direction" factors for college students and two factors of the Everyday Spatial Questionnaire (Chiu et al., 2005) for PWCIs. Contrary to the WES, the CWES-29 showed that distance was unimportant for wayfinding in familiar and unfamiliar environments. The protective tendency of FCGs in Taiwan, who frequently accompany PWCIs when walking outdoors and limit or prevent PWCIs from being far away from home (Pai & Lee, 2016), may explain this discrepancy.

In the CWES-29, the underlying constructs of wayfinding were reflected by the items related to analytic (SDAS) and global (SDGS) sense-of-direction and problem-solving strategies. These subscales were similar to factors 3 and 4 of the wayfinding strategies in the Everyday Spatial Questionnaire for PWCIs (Chiu et al., 2005). Additionally, the five items assessing landmarks and distances in the LDE subscale were similar to "strategic ability" in the Korean version of the WES (Hong & Lim, 2009).

A major difference between the CWES-29 and the Korean version was the MAP subscale. In the CWES-29, the map usage (MAP) items were strongly loaded, and the MAP subscale had the greatest internal consistency of all subscales. Conversely, the Korean WES omitted any map usage factor (Kim & Kang, 2017). However, hypothesis testing results showed that the MAP subscores of the CWES-29 were not significantly correlated with the global cognitive measure (CMMSE) and behavioural problem measure (CNPI). Further refinement of MAP is needed.

Mild cognitive impairment is a transitional phase between normal aging and dementia. This transition is a critical window for screening and interventions (Petersen, 2016). Although we did not recruit older adults with intact cognition (CDR = 0) for further classification from persons with MCI, we were able to use CWES-29 in differentiating persons with mild dementia (CDR = 1) from MCI with 70.0% sensitivity and 78.4% specificity. Further refinement of CWES-29 is warranted to improve its psychometric properties.

Possible interventions can address interactions between technology and wayfinding effectiveness (Zhou et al., 2019) and educational programs for family caregivers to reduce their stress responses (Peng et al., 2017). Additionally, CWES-29 can be applied to identify PWCIs who are apt to get lost by using its cut-off point 82/145, and to develop training programs to support their independent living in their communities (Simon et al., 1992). All of the efforts of applying the CWES-29 in practice are focused on designing on-the-job training programs for nurses and related professionals by using the CWES-29 to assess PWCIs and to encourage PWCIs to increase social engagement. Regarding policy-making, the following issues are to be considered: building dementia-friendly communities to support families of PWCIs, and enabling stakeholders to work together (Sturge et al., 2021).

Certain limitations existed in this study. First, we recruited dyads from two memory disorder clinics at two teaching hospitals and from local community long-term care service programs in northern Taiwan, which could limit generalization of the findings to other regions. Second, the following items were not controlled: PWCIs' *past* wayfinding abilities (this study only used data of PWCIs' current abilities from family caregiver reports), the quality of the relationships between FCGs and PWCIs, and fatigue and depressive symptoms among FCGs. Such factors may have improved the reliability and accuracy of FCGs' observations of PWCIs. Third, the cross-sectional design prevents causal linking of cognitive decline with getting lost or other wayfinding problems. Finally, this study serves as a starting point to measure wayfinding in PWCIs, but additional research on declines in wayfinding effectiveness reported by PWCIs (Adekoya & Guse, 2019), its risk factors (Ali et al., 2016), its relationship with walking (Vandenberg er al., 2016), and its consequences, such as falls or accidents in PWCIs and impacts on family caregivers (Peng, Chiu, Liang, & Chang, 2017), is merited. Accumulating related data and results are critical to preventing and improving wayfinding problems, and can help to develop dementia-friendly communities (Wiener & Pazzaglia, 2021).

Conclusions

The CWES-29 is the first instrument for FCGs to assess wayfinding effectiveness in PWCIs in Taiwan. This study's results provide evidence that the CWES-29 is a reliable and valid instrument. The total CWES-29 scale and five of the six subscales were significantly correlated with the CNPI and the CMMSE. The correlation coefficients of the MAP subscale with the CMMSE and the CNPI were not significant, however, indicating that hypothesis testing was supported for only five subscales. Therefore, we suggest that additional studies with larger sample sizes and qualitative interviews with PWCIs evaluate the CWES-29 to elucidate when and how PWCIs use maps. In terms of the application of the CWES-29 in practice, we recommend designing on-the-job training programs that use the CWES-29 in assessing PWCIs and encouraging PWCIs to increase social engagement. Regarding policy-making, building dementia-friendly communities to support families of PWCIs and enabling stakeholders to work together are expected to substantially improve successful wayfinding in PWCIs.

Abbreviations

WES: Wayfinding Effectiveness Scale; CWES: Chinese Wayfinding Effectiveness Scale; PWCIs: persons with cognitive impairment; FCGs: family caregivers; CMMSE: CMMS; CNPI: Chinese Neuropsychiatric Inventory; DSM-IV: Diagnostic and Statistical Manual of Mental Disorders, 4th edition; CDR: Clinical Dementia Rating Scale; NPI: Neuropsychological inventory; ROC: Receiver Operating Characteristic analysis; SWG: simple wayfinding goals (finding a destination and a route in familiar environments); CWG: complex wayfinding goals (finding a destination and a route in unfamiliar environments); SDAS: sense of direction and analytic strategies; SDGS: sense of direction and global strategies; LDE: landmarks and distance in familiar/unfamiliar environments; MAP: using a map in familiar/unfamiliar environments

Declarations

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Authors' contributions

YC contributed to study design, obtain grant support, supervise data collection, write the main manuscript and conduct the statistical analyses. TC provided the statistical consultation. TK and WH provided professional comments of research procedures and manuscript preparations.

Disclosure statement

The authors report no conflict of interest.

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Availability of data and materials

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Ethics approval and consent to participation

This study was conducted in accordance with the Declaration of Helsinki and was approved by the Institutional Review Board of Chang Gung Memorial Hospital, Linkou, Taoyuan, Taiwan. The informed consents were obtained from all subjects and/or their legal guardian(s) before the data collection.

Consent for publication

Not applicable.

Competing interests

The authors declare that they have no competing interests.

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Figures

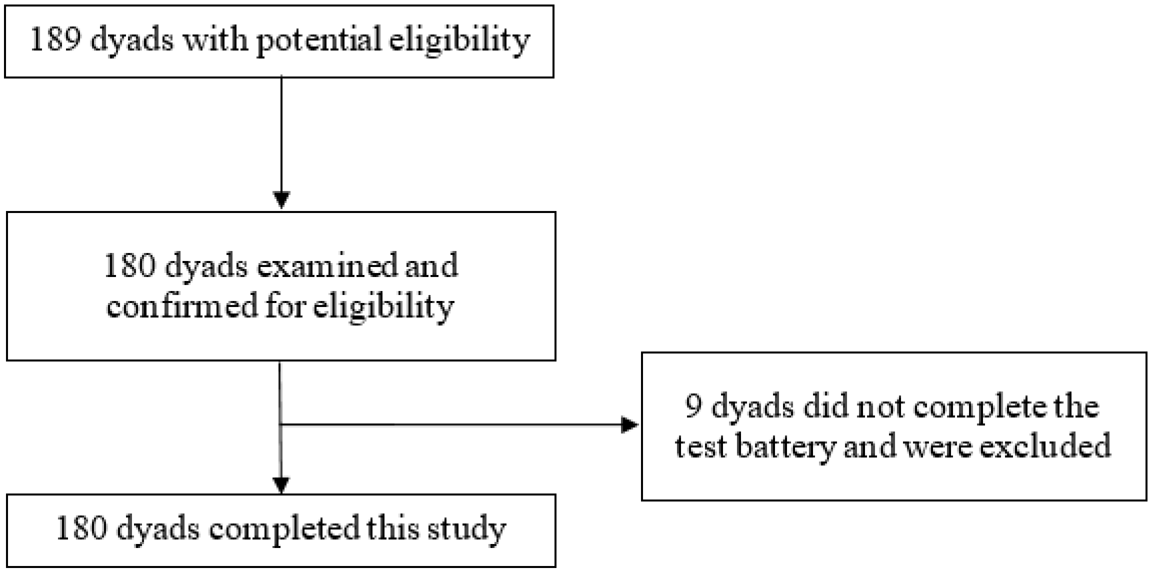

Figure 1

Participant recruitment flow chart

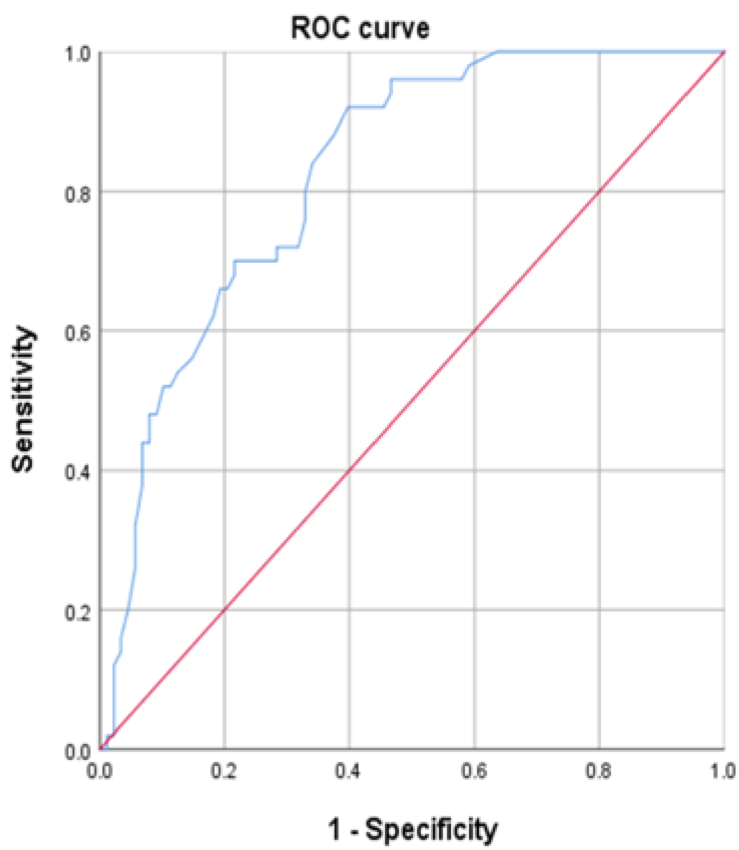

Figure 2

ROC curve of the CWES-29

Note: **diagonal segments are produced by ties**.