

TESTING INVARIANCES OF WORKING MEMORY BATTERY ACROSS ORDINARY AND SCHIZOPHRENIC GROUPS

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ABSTRACT_ *In the present study, I created a new valid Working Memory Battery (WMB) to test the invariance of working memory structure across ordinary and schizophrenic groups. I conducted two consecutive studies (Study 1 and 2). In Study 1, the sample comprised 59 ordinary adults. The ages of the sample participants ranged between 27 and 51 years. The purpose of that study was to validate a new WMB. In Study 2, the sample consisted of two groups (Group 1 and 2). Group 1 comprised 59 ordinary adults whose ages ranged from 27 to 51 years. Group 2 comprised 57 schizophrenic patients whose ages ranged from 27 to 51 years. I used the new WMB to test the invariance across groups. The first study showed that the new WMB is valid. The second study showed that the construct of working memory is invariant across the study groups.*

KEYWORDS: *Working Memory, schizophrenic, Saudi Arabia.*

TESTING INVARIANCE OF WORKING MEMORY BATTERY ACROSS ORDINARY AND SCHIZOPHRENIC GROUPS

Working memory refers to a process of storing and maintaining recent information by holding and manipulating it as on-line cognition to perform other tasks [1].

According to Baddeley and Hitch's (1974) model, working memory consists of three components (central executive, visuospatial sketchpad, and phonological loop); the central executive component coordinates between long-term memory on one side, and other two systems of working memory on the other side. The slave systems contain both visuospatial component, which is responsible for storing and maintaining visual and spatial information, and the phonological loop component, which holds the verbal information [2,3]. Baddeley and Hitch added a new component (Episodic Buffer) to their model in 2000 to serve as a link among working memory, long-term memory, and consciousness [4].

Working memory has become a significant construct in the clinical setting Cramon, Hoppe, & Werheid [5], and the evaluation of working memory impairments in psychiatric problems such as schizophrenia has become a valuable aim [6].

Numerous studies investigated working memory in schizophrenia. Spindler et al [7] investigated the central executive component in schizophrenia. Sharma, Hughes et al [8] investigated the effect of typical antipsychotics in reducing positive symptoms of schizophrenia as reflected on the performance of working memory tasks. Lee and Park [9] investigated working memory in schizophrenia using a meta-analysis method. Brahmabhatt et al [10], Meda et al [11], Scheuerecker et al [12] and Karch et al [13] investigated an MRWE scanning of schizophrenic patients compared to healthy controls during performing working memory tasks. Pflueger et al [14]. and Simon et al [15]. explored the relationship between the level of insight and performance of working memory tasks in schizophrenic patients. Pachou et al [16]. examined the regional cortical activations in schizophrenic patients compared to healthy controls while performing working memory tasks using EEG. Zanello et al [17]. examined the illness duration of schizophrenia and its effects on working memory. Zilles et al [18]. investigated both visuospatial and phonological loop components of working memory in schizophrenia. Cosman et al [19]. and Quee et al [20]. investigated visuospatial component in schizophrenia.

Many studies have utilized the working memory as a marker of schizophrenia disorder, and there was no clear investigation of working memory construct in schizophrenia. As a result, the main purpose of the present study is to test the invariance of Baddeley and Hitch's (1974) working memory model across ordinary and schizophrenic groups. In order to carry out the present study, I conducted two consecutive studies. The first study aimed to validate a new Working Memory Battery (WMB) on ordinary participants, and then I conducted the second study to test the factorial equivalence of scores resulted from the new WMB across ordinary and schizophrenic groups.

Study 1: Validation of a Working Memory Battery Based on

Baddeley and Hitch's Model (1974) in Normal Sample.

The main purpose of this study is to validate a new working memory battery.

Method

Participants:

Fifty-nine healthy individuals (30 males, 29 females) selected from the general population. The ages ranged between 27 and 51 years. The participants' education years ranged between 8 and 26 years. Inclusion criteria were ordinary adults with no history or present existence of neurological or psychiatric disorders. Exclusion criteria were history or present existence of neuropsychological and psychiatric disorders, or inability to complete working memory tasks. All the selected participants completed the new Working Memory Battery (WMB).

Measurements:

The present study included the following measurements: (a) Mini International Neuropsychiatric Interview (MINI) Sheehan et al [21] and (b) a new WMB. Every two tasks of WMB designed to estimate one of the working memory components. The WMB comprised the following tasks:

Phonological loop tasks

Digit Span task (DS)

I used DS to assess the phonological loop. In this task, I asked the participant to repeat in the same order a string of numbers spoken by a computer [22,23].

Reading Comprehension task (RC)

I used RC to assess a phonological loop. In this task, I asked the participant to decide whether the sentence spoken by the computer was reasonable or not and to remember the last word of it [24,25].

Visuospatial tasks

I designed the tasks using Microsoft PowerPoint and presented them on 14.2-inch screen. The presentation time for a single dot is 2.5 seconds, and the delay time among dots is 0.5 seconds.

Dot colors and Locations task (administration condition 1) (DL1:)

I used DL1 to assess the visuospatial component. The first administration condition included two subtasks: the visou-task, and the spatial task. In the visou-task, there were colored dots, which had a fixed location (center of the screen). A single dot was presented in the first attempt. For every following trial, the dots increased gradually by one. In this task, I asked the participant to remember the colors of dots in the same order. I applied a condition to stop the test when a participant failed to remember the colors of dots in two consecutive trials. The total score of DL1 is the mean of the scores for both subtasks.

In the spatial task, there were dots in varied eight locations (in circle design around the center of the screen) that had a fixed color (Black). A single dot was presented in the first attempt. For every following trial, the dots increased gradually by one. In this task, I asked the participant to remember the locations of dots in the same presented order. I applied a condition to stop the test when the participant failed

to remember the locations of dots in two consecutive trials. Dot colors and Locations task (administration condition 2)). In the visuospatial task (DL2), there were six varied-colored dots in eight varied locations. A single dot was presented in the first attempt. For every following trial, the dots increased gradually by one. In this task, I asked the participant to remember the colors and locations of dots in the same presented order. I applied a condition to stop the test when the participant failed to remember the colors and the locations of dots in two equivalent trails [7].

Central executive tasks

The Word and its Location task (WL)

I used WL as a coordinating task for assessing a central executive component of working memory. I designed WL task as a box divided equally into four parts. In the first trial a single word appears randomly in one part of the box. For every next trial, the words increase gradually by one. In this task, I ask the participant to remember the words and their locations in the same presented order. The test was stopped when the participant failed to remember in two subsequent trials [26].

Digit Backward task (DB) as a processing task

This task was used to assess the central executive component of working memory. In this task, I followed the same procedures as in the DS task. Conversely, I asked the participant to repeat the digits in the reverse order [22].

Procedures:

I interviewed 87 participants using MINI for screening the presence of any common psychiatric problems. The final number I accepted to include in the present experiment was 70 participants who met the inclusion criteria and had no psychiatric problems. Next, I administered the WMB on the

included participants in the following order: DS, DL1, WL, RC, DL2, and DB. The final number of participants who accomplished the WMB was 59 healthy individuals .

Results and Discussion

Reliability analysis:

Internal consistency:

I analyzed the six tasks of the WMB as six items using Cronbach's alpha (n= 59; $\alpha = .846$). This result revealed that the WMB has excellent internal consistency.

Test-retests reliability:

I conducted the test-retest reliability analysis after a one-week interval between the first and the second administration of WMB. Results revealed that there is a very high significant correlation between the two administrations scores ($r(59) = .913, p = .001$)

Validity analysis:

Construct validity :

The three-factor model (phonological loop, Visuospatial, and central executive; n= 59) was tested with Confirmatory Factor Analysis (CFA). I used Maximum Likelihood (ML) as a discrepancy of the estimation. The results revealed that there was no significant difference between the observed data and the model ($\chi^2(6, n = 59) = 5.006, p = 0.543$). The model fit indices showed the following values: Goodness of Fit Index (GFI) = 0.973, the Normed Fit Index (NFI) = 0.971, the Incremental Fit Index (IFI) = 1.00, the Comparative Fit Index (CFI) = 1.00, and the Root Mean Square Error of Approximation (RMSEA) = 0.000. The CFA statistics indicated that the working memory battery reflected the three-factor model of working memory construct (see figure 1).

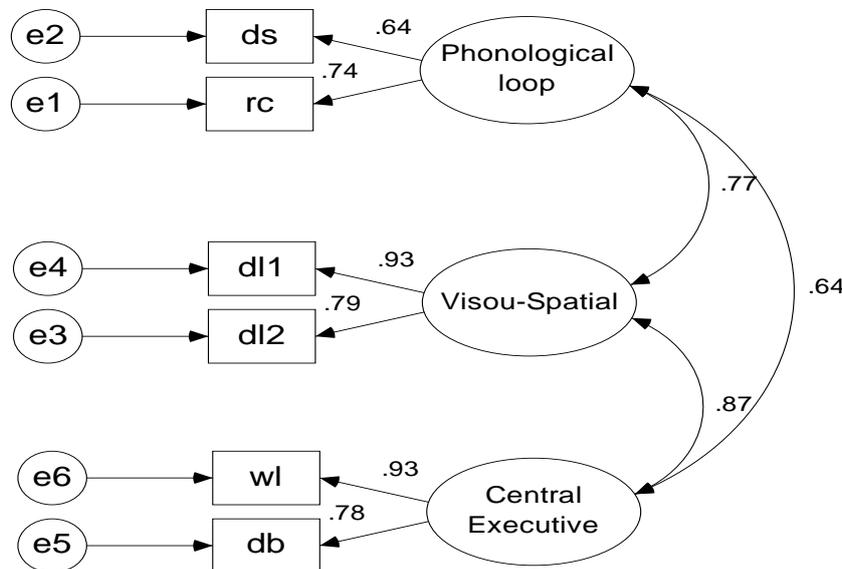


Figure 1

The CFA standardized regression weights of 6 tasks and the correlation among the three-factorr of the new WMB

Study 2: Testing the Invariance of Working Memory Model Construct across Ordinary and Schizophrenic Groups

The main purpose of the present study is to test the factorial equivalence of scores from WMB across ordinary and schizophrenic groups .

Method:

Participants:

The present study included two groups. The first one was the ordinary group, which comprised 59 participants (30 males, 29 females) who were selected from general population. The ages ranged between 27 and 51 years (M=34.95, SD=7.09). The years of education ranged between

8 and 26 years. The second group was the schizophrenic one, which comprised 57 schizophrenic patients (30 male, 27 female) who were selected from both inpatients and outpatients schizophrenic patients from Al Amal & Psychiatric Hospital in Jazan and Mental health hospital in Jeddah (Saudi Arabia). The ages ranged between 27 and 51 years (M=35.28, SD=7.09). The number of years of education ranged between 8 and 26 years.

The inclusion criteria of the ordinary group were the absence of the mental disorders and major health problems. The exclusion criteria of the ordinary group were existence of current or past psychiatric, neuropsychiatric disorders, or any

substances dependency. The inclusion criteria of the schizophrenic group were the existence of schizophrenia according to the diagnostic criteria of DSM-5, and the existence of active phase with duration of illness ranged between 2 and 10 years of illness. The exclusion criteria of schizophrenic group were the presence of comorbidity in addition to schizophrenia, and major disabilities in general medical condition. To explore whether there were significant differences between the two groups in terms of demographic characteristics, I used t-test statistics. There was no difference between the two groups in terms of ages ($t(114) = -.252, p = .802$). Moreover, there was no difference between the two groups in terms of years of education ($t(114) = -.46, p = .963$).

Measurements:

The present study included the following measurements: (a) MINI; (b) Structured Clinical Interview based on the Schizophrenia Diagnostic Criteria of DSM-5 (SCI-DSM-5); and (c) WMB.

Procedures:

I diagnosed the schizophrenic patients using a SCI-DSM-5. As a result, I selected 65 patients out of 77 whose symptoms met the SCI-DSM-5. I excluded the other eight patients because of comorbidity and general medical condition disabilities. The final number of the schizophrenic patients

was 57. Next, I selected the ordinary group from the general population in consideration of matched ages, years of education, males: females' ratio, and the sample size to the schizophrenic group. I screened the healthy individuals using MINWE to insure there is no existence of any psychiatric problems.

The procedures of WMB administration were applied to both groups in single individual administration condition, and in a closed quiet room using Microsoft Windows OS laptop. The administration order of WMB tasks was DS, DL1, WL, RC, DL2, and DB .

Results and discussion

All statistical analyses conducted using SPSS (version 18) and Amos (version 16).

Configural model analysis:

The result of the configural model testing for configural invariance revealed χ^2 value to be 10.568 with 15 degrees of freedom. The CFI was 1.000, and RMSEA was .000. These results concluded that the hypothesized multigroup model of WMB structure was well-fitting across the ordinary and schizophrenic group. The limitation of this first statistical analysis was that the number of factors and the pattern of their structure were similar but not identical across ordinary and schizophrenic groups (see figure 2, and 3).

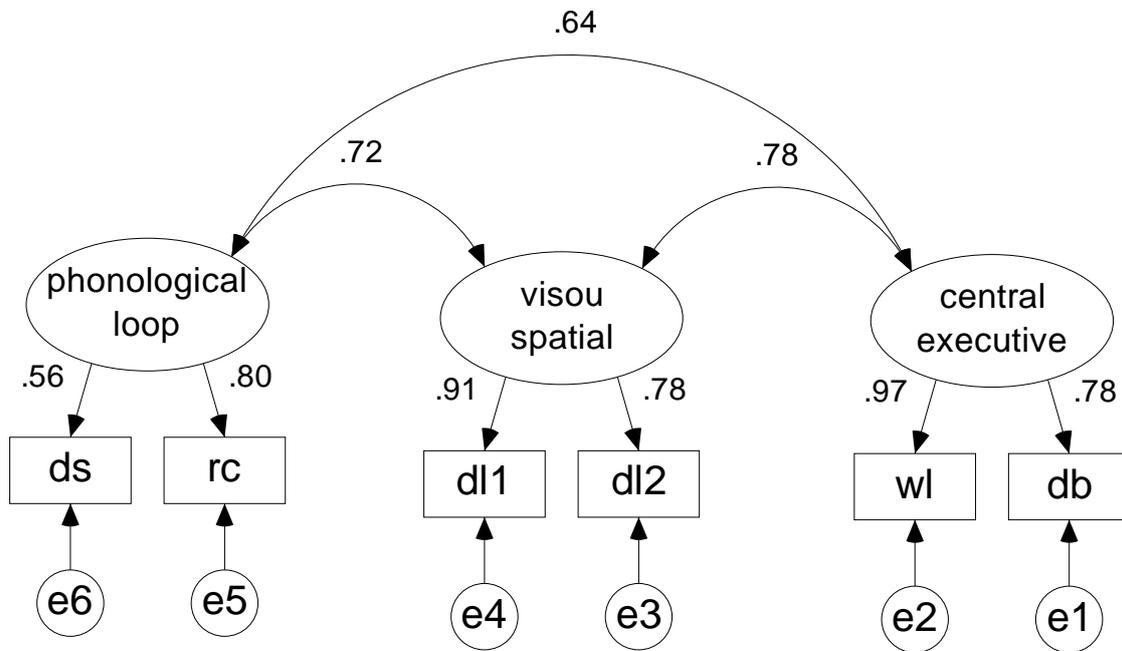


Figure 2
Configural model for ordinary

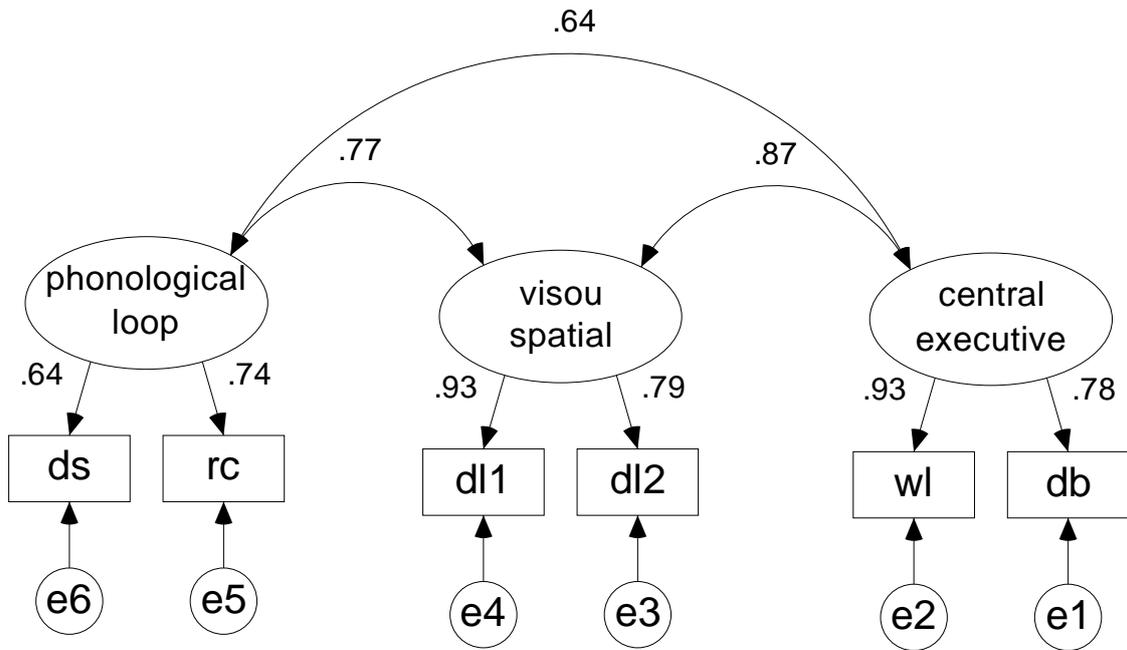


Figure 3
Configural model for schizophrenia

Measurement model (full metric) analysis

In order to test for the factorial measurement across groups, I conducted a full metric model (Model A; see Figures 4 and 5) across groups by assigning equality constraints manually using Amos program on all factor loadings only Byrne [27].

The results revealed that the measurement model was invariant across ordinary and schizophrenic groups, χ^2 to be 10.568 with 15 degrees of freedom. The CFI was 1.000 and RMSEA was .000.

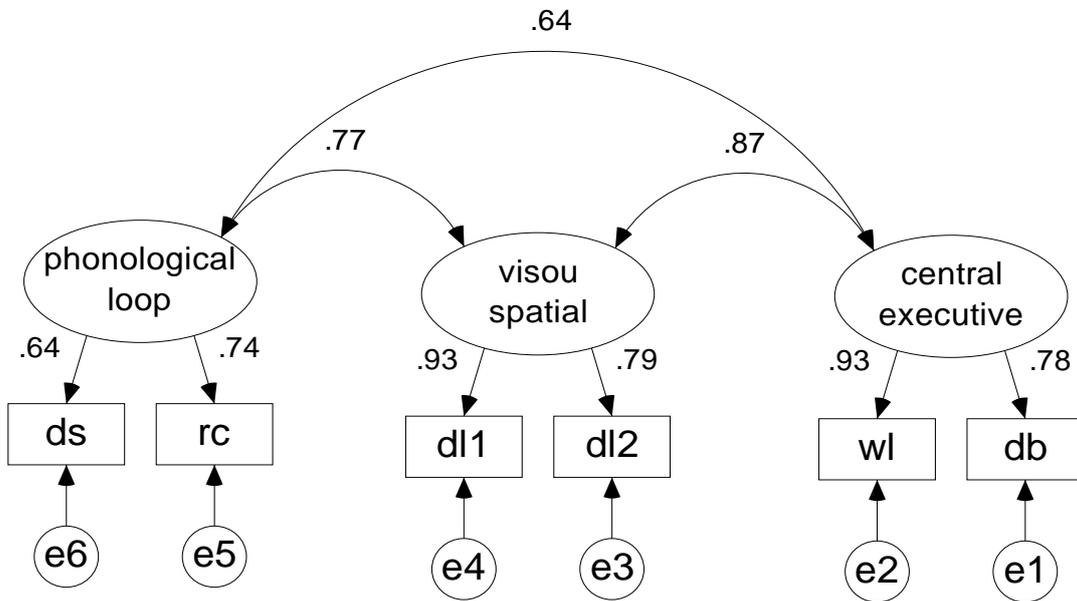


Figure 4
Full metric model for ordinary

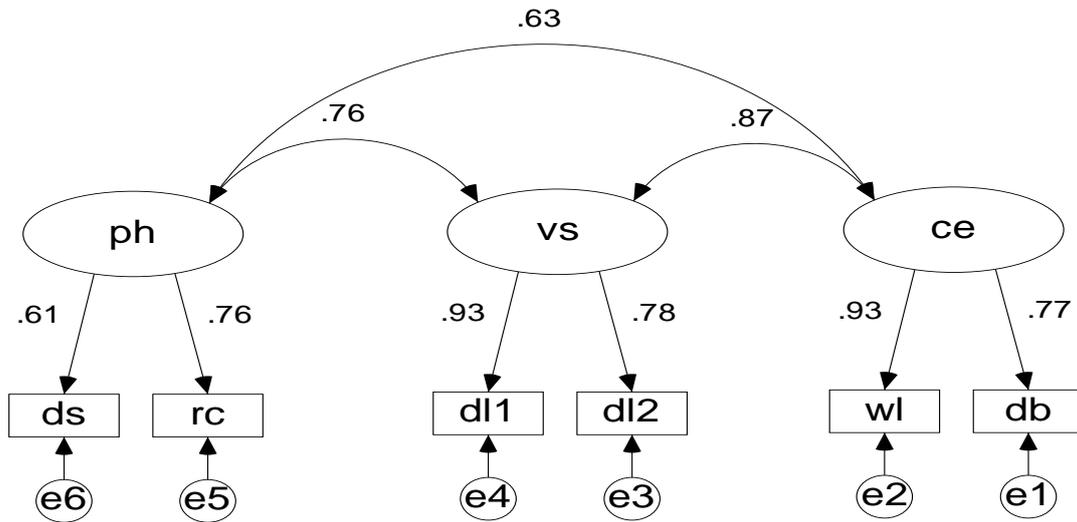


Figure 5
Full metric model for Schizophrenia

Measurement model (partial metric) analysis:

In the next step of testing for the measurement model, I imposed constraints on some of the factor loadings while letting other factor loadings be tested freely. Three models tested in three patterns of imposing equal constraints across the study groups. In the first partial model (Model B), I assigned equal constraints for the phonological loop factor only. In the second partial model (Model C), I assigned equal constraints for the visuospatial factor only. In the third partial model (Model D), I assigned equal constraints for the central executive factor only. The results of Model B were $\chi^2 = 10.429$ with 13 degrees of freedom, and probability level = .659. The CFI was 1.000, and RMSEA was .000. In Model C, the χ^2 was 10.282 with 13 degrees of freedom. The CFI was

1.000, and RMSEA was .000. The results of Model D were χ^2 to be 10.152 with 13 degrees of freedom. The CFI was 1.000, and RMSEA was .000. These results concluded that the measurement models (partial metric models) were invariant across ordinary and schizophrenic groups.

Structural model analysis:

I tested for invariance related to the structural portion of the main model. In this part of the testing process, the model specified all factor loadings, and the three-factor covariance constrained equally across ordinary and schizophrenic groups (See figure 6, and 7). Results revealed that the structural model was invariant across the study groups, χ^2 was 10.785 with 18 degrees of freedom. The CFI was 1.000, and RMSEA was .000.

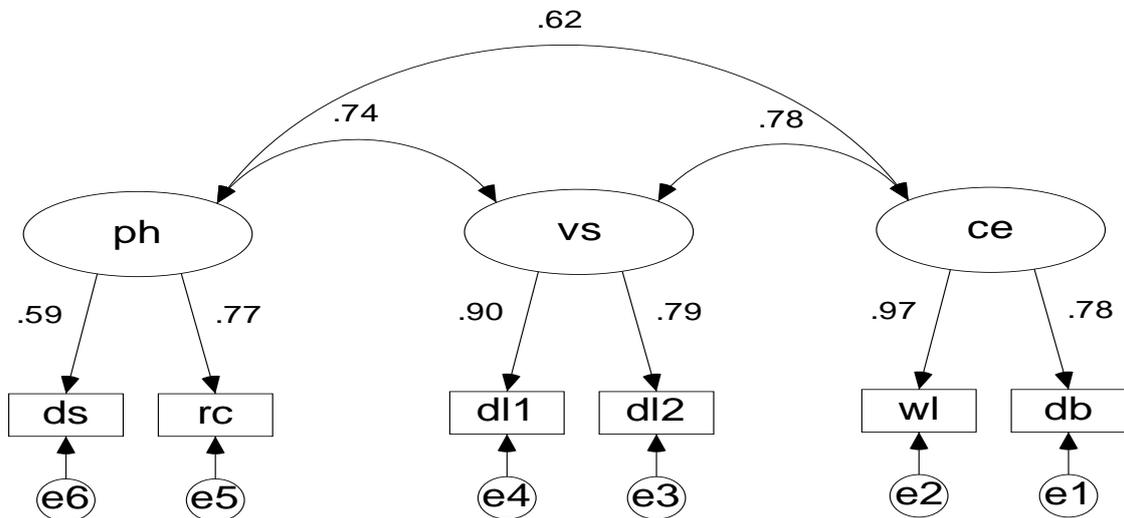


Figure 6
Structural Model for ordinary

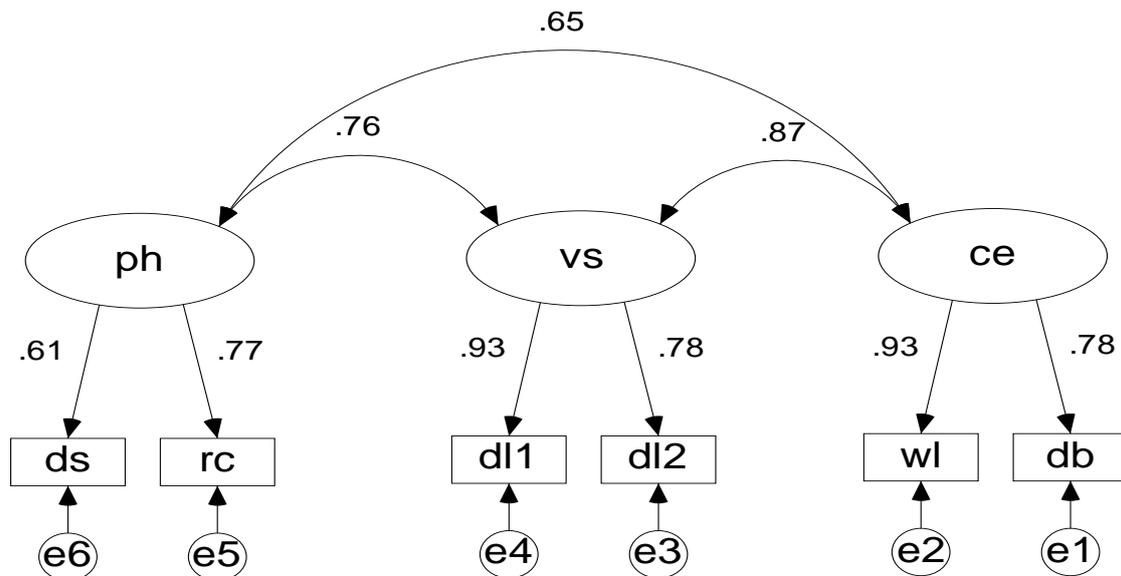


Figure 7
The structural model for Schizophrenia

Models comparison:

In comparing both measurement models (A, B, C, and D models) and structural model to configural model (see table 1), the results revealed that all the measurement models were completely invariant as Δ CFI value was = .000 in overall

measurement models, and according to Cheung and Rensvold [28] which proposed the cutoff point of Δ CFWE < .001. Furthermore, the structural model was completely invariant as Δ CFWE value was = .000.

Table 1
Goodness-of-fit Statistics for Tests of Multi-group Invariance

Model description	χ^2	df	$\Delta \chi^2$	Δ df	CFI	Δ CFI
Configural Model	10.150	12	-	-	1	-
Model A	10.568	15	.418	3	1	.000
Model B	10.429	13	.279	1	1	.000
Model C	10.282	13	.132	1	1	.000
Model D	10.152	13	.002	1	1	.000
Structural Model	10.785	18	.635	6	1	.000

Note. Δ = the difference

General Discussion

In the present study, I aimed to test the invariance of working memory structure across schizophrenic and ordinary groups. In order to achieve this purpose, I conducted two consecutive studies. Studies, which examined the working memory in schizophrenia, may have biases in their results because there is no evidence of the similarity for working memory structure across ordinary individuals and schizophrenic patients groups. Consequently, I tried to test invariance for working memory construct across ordinary and schizophrenic groups.

I conducted two consecutive studies (Study 1 and 2). In Study 1, in terms of reliability and validity, the new WMB has a good reliability as showed in the results section. The new WMB has excellent internal consistency in working memory tasks, and a very high correlation in test-retest administrations. Therefore, I found that the selected tasks of working memory well-known tasks reflected perfectly the structure of working memory in ordinary individuals sample according to Baddeley and Hitch's (1974) model of working memory. These findings proved that the WMB was structured well using the CFA single group analysis.

In Study 2, I used the new valid WMB to estimate invariance across ordinary and schizophrenic groups. As predicted, in the first step of testing invariance across the study groups, the configural model indicated that there is a similarity among study groups in the structure and numbers of factors. In more

specific testing for invariance across the study groups, I tested for the factorial measurement model. The measurement model in full metric terms indicated that the construct of working memory is invariant across the study groups. Next, I tested the measurement model in terms of partial metric analysis to make sure of the invariant across the study groups for every factor separately. The partial metric analysis indicated that every factor is invariant across the study groups.

Finally, I tested for structural invariance across the study groups. The structural model result indicated that the structure of working memory is invariant across groups. The comparisons among all models were estimated, and the result showed that the working memory structure is fully invariant across ordinary individuals and schizophrenic patients. As a result, all studies that compared the schizophrenic patients to ordinary individuals were valid.

CONCLUSION

I developed a new working memory battery based on Baddeley and Hitch's (1974) model of working memory. The results showed that the working memory battery reflected well the three-factor model for working memory construct in an ordinary sample. Next, I tested the invariance for working memory structure across ordinary and schizophrenic groups. The results indicated that the structure of the working memory was fully invariant across ordinary and schizophrenia groups.

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