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Psychometric Properties of the Persian Word Pairs Task to Evaluate Declarative Memory

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ABSTRACT

Introduction: According to the declarative/procedural (DP) model, the semantic aspect of language depends on the brain structures responsible for declarative memory. The word pairs task is a common tool to evaluate declarative memory. The current study aimed to design a valid and reliable task to evaluate declarative memory in Persian-speaking children at the learning and retention stages and investigate its relationship with the semantic aspect of language.

Methods: A panel of experts agreed on the content validity of the proposed task. The reliability of the task was determined using internal consistency and test-retest reliability. A total of 31 typically developing children aged 7-9 years participated in this study.

Results: The content validity of all the 42-word pairs was calculated as one. The test-retest reliability showed a correlation coefficient of 0.825 (P<0.001). The task showed acceptable internal consistency (Cronbach's alpha 0.880). The results of correlation analysis showed no significant relationship between declarative memory and semantic aspect. However, the regression analysis showed that the retention stage can explain 24.2% of the variations in the semantic aspect.

Conclusion: It seems that the word pairs task has good validity and reliability to evaluate declarative memory. The task applied to evaluate the semantic aspect can be one of the potential causes of the lack of a relationship between the semantic aspect and declarative memory. The participants' scores in the retention stage can be predicted concerning their performance at the semantic aspect.

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Highlights

- The proposed task has several advantages as follows:

- Good validity and reliability to evaluate different stages of declarative memory, including learning, immediate recall, delayed recall, delayed recognition, and retention.

- Children's performance improves with age at different stages of the task.

- Subjects' performance in the retention stage of declarative memory was the only component predicting the score of the semantic aspect.

Plain Language Summary

One of the components of long-term memory is declarative memory. This memory includes the semantic memory in which information about vocabulary is stored. In this research, the word pairs task was designed to evaluate declarative memory in children aged 7 to 9 years and its validity and reliability were investigated. The final task consists of 42 unrelated word pairs that are presented to children in several stages, and it examines the ability of children to communicate between pairs of unrelated words in terms of meaning (e.g., book-teeth). The better the children's performance in this task is, it indicates the better performance of these children's declarative memory. The task has good validity and reliability and can be used to evaluate children's declarative memory and to determine changes after introducing declarative memory improvement techniques.

1. Introduction

One of the main types of long-term memory is declarative memory consisting of episodic memory and semantic memory. Episodic memory is responsible for learning, storing, and recalling knowledge related to personal events. On the other hand, the semantic aspect involves facts and concepts (Desmottes, Meulemans, & Maillart, 2016). The combination of these two memories forms declarative knowledge subjected to the person's conscious awareness (Ullman, 2015).

The declarative/procedural (DP) model proposed by Ullman and Pierpont argues that language depends on several structures in the brain, which are responsible for other functions. For instance, the mental lexicon, a fundamental component of any given language responsible for storing lexical knowledge, is mainly dependent on the intact function of the temporal lobe which is the brain area involved in declarative memory (Ullman, 2004, 2015). Learning the phonological form and meaning and sound-meaning mapping for each lexical item takes place in the declarative memory system. Therefore, it is expected to find a significant relationship between declarative memory and the person's performance in the lexical tasks. Moreover, the grammar of any given language, which is related to combining lexical items into more complex representations, is controlled by brain structures involved in procedural memory (Ullman, 2001, 2004; Ullman & Pierpont, 2005).

Learning in declarative memory can be evaluated by verbal and non-verbal tasks (Ullman & Pullman, 2015). The word pairs (WP) task is commonly used to evaluate declarative memory in the verbal area (Lum, Conti-Ramsden, Page, & Ullman, 2012). The WP task requires learning the phonemes and meaning of each word, sound-meaning mapping, and creating semantic associations between the word pairs. Although all these components depend on the mental lexicon of a language, they occur in the medial temporal lobe and hippocampus, which are the same areas for learning and recall in a declarative memory system (Lum, Gelgic, & Conti-Ramsden, 2010; Squire & Wixted, 2011). The WP task usually has a predefined procedure involving the learning, immediate recall, delayed recall, and delayed recognition stages (Cohen, 1997).

During the learning stage, the children are presented with an oral list of word pairs. After each presentation, children are asked to recall the second word from the list of the word pairs. The learning stage usually includes three to five repetitions of the before-mentioned tasks. Each of these repetitions is called a "trial". In the next stage, the children are asked to recall both words in each pair (immediate recall). After a 30-minute interval, the participants are asked to recall the entire list of word

pairs again (delayed recall). Next, the previous list of word pairs is presented along with other word pairs as a distractor to determine whether the child can identify the target items from all items (delayed recognition). In the WP task, the level of verbal information learning is determined by the average total number of words recalled accurately during the three to five initial trials, and during the immediate recall, delayed recall, and delayed recognition stages (Lum et al., 2012).

These stages focused on the initial stages of learning, where acquired knowledge is generally reviewed after a few minutes. However, since the main goal of learning is to retain information for more than a few minutes, some tests also account for the retention stage. The retention stage is generally examined 24h after the initial learning. (Lum et al., 2010). In this stage, the participants are presented with a list of distractor items along with a list of initial stimulants and are asked to determine which stimulus was previously presented and which is new (Lukács, Kemény, Lum, & Ullman, 2017).

Evaluating declarative memory is one of the subscales of any memory test. In 1990, Sheslow and Adams proposed the wide range assessment of memory and learning (WRAML) scale for children aged 5-16 years. This scale also includes a verbal learning subscale to evaluate the learning, delayed recall, and recognition stages of declarative memory. They computed the internal consistency of this scale ranging from 0.81 to 0.92 in different stages and test-retest reliability ranging from 0.59 to 0.77 (Adams, 2010).

In 1994, Delis et al. proposed the California verbal learning test-children's version (CVLT-C) scale for children aged 5-16 years with an average reliability of 0.72 for all age groups. The scale includes five trials in the learning stage, a delayed recall stage, and a recognition stage to assess declarative memory (Delis, Kramer, Kaplan, & Ober, 1994).

In 1997, Cohen proposed the children's memory scale (CMS) to evaluate memory and learning ability in children aged 5-16 years. The WP task used in this scale includes learning, immediate recall, delayed recall, and recognition stages. The internal consistency coefficients for this WP task in different age groups were reported between 0.71 and 0.91 for the verbal and non-verbal subtests, between 0.72 and 0.84 for the delayed recall task, and between 0.75 and 0.79 for the delayed recognition task (Cohen, 1997).

In Iran, the only test containing a task similar to the WP task to evaluate declarative memory is the Wechsler memory scale-revised (WMS-R) evaluating the memory of people aged 16-90 years. This scale has been standardized in Iran and its reliability for the subtests ranges from 0.28 to 0.92. One of the subtests of this test involves recalling verbal pairs, including eight-word pairs, four semantically related and four unrelated (Orangi, Atefvahid, & Ashayeri, 2002). This scale evaluates two stages of initial learning and delayed learning and does not include other learning stages, i.e. immediate recall, recognition, and retention. Also, it is not appropriate for individuals under 16 years of age.

Despite the importance assumed for the relationship between accurate performance in declarative memory and mental lexicon in the DP model, no Persian task exists to evaluate the children's declarative memory performance in different stages of learning. The main goal of the current study was to propose a task to evaluate declarative memory in different stages of learning along with determining the validity and reliability of the proposed task. The second goal was to explore the trend of changes in different stages of the task in different age groups. And finally, based on the assumed relationship between declarative memory and the semantic aspect of language, the study utilized regression analysis to explore the role of declarative memory in explaining the semantic aspect of language.

2. Materials and Methods

The current study consists of two main stages. First, developing the word pairs (WP) task and then, evaluating its psychometric properties.

Task development

The word pairs were extracted from the book "Basic Persian Words" (Nematzadeh S, Dadras M, Dastjerdi Kazemi M, & Mansoorizadeh.M, 2012). The book provides words classified in four levels based on their frequency, for each grade in elementary school. The words in the first level have the highest frequency, and children are familiar with all words in each level. In this study, 82 high-frequency word pairs with unrelated meanings were selected for the learning, recognizing, and retention stages. In the word selection stage, initially, the words in the first level, and several words from the second level were selected. The phonologically dissimilar words were selected based on onset and rhyme. Also, the distractors used in the recognition and retention stages had no semantic relationship with the words

in the learning, recall, and recognition stages. Word selection was carried out based on the network model proposed by Collins and Quillian in a way that none of the semantic relationships in a class existed between the word pairs (Collins & Loftus, 1975). The task was developed similar to the children's memory scale (CMS) proposed by Cohen based on four stages of learning and each learning stage included three trials. Following Lukacs et al. (Lukács et al., 2017), in the retention stage, the children had to recognize whether they had already heard a specific word pair after 24h.

Evaluating the task

Eight speech-language pathologists (SLP) with master's degrees or higher participated in calculating the content validity index (CVI) and content validity ratio (CVR) of the WP task. The agreement value of 0.75 was considered acceptable for including a word in the list of pairs. Finally, a total of 42-word pairs were selected, i.e., 14-word pairs for each stage of initial learning, immediate recall, delayed recall, recognition stage, and retention stage.

The face validity of the initial version of the task was examined by administering it to 10 seven-year-old normal children (five girls and five boys). The children's behavior during the test administration showed that the test procedure was vague for them, which led to the modification of the test administration (Ebadi et al., 2014).

Similar to other studies (Lum et al., 2012), a total of 31 students aged 7-9 years from primary schools located in three different areas of Isfahan City, Iran, were recruited using non-probability convenience sampling to examine the internal consistency of the WP task. The inclusion criteria included being monolingual (Persian), aged 7-9 years, not suffering from visual, auditory, neurological, neurodevelopmental disorders, emotional-mental disorders, attention deficit hyperactivity disorder (ADHD), delayed psychomotor and speech-language developments.

To determine the test-retest reliability, it was administered to the same participants after a one-week interval. The Cronbach's alpha and Pearson's correlation coefficients were used to determine internal consistency and test-retest reliability of the task, respectively (Ebadi et al., 2014).

Measures used for inclusion criteria evaluation

The participants included 31 students (14 girls [45.2%] and 17 boys [54.8%] with Mean±SD age of 95.09±7.95 months. The sample included 19 children in the age group of 7-8 years and 12 children in the age group of 8-9 years. The inclusion criteria were confirmed using the parents' answers to the medical history questionnaire. The auditory processing domains questionnaire (APDQ) (Ahmadi, Jarollahi, Ahadi, & Hosseini, 2017) was used to confirm the lack of auditory processing disorders in children. The lexical knowledge was evaluated in two dimensions of perception and expression using three subtests (picture vocabulary, relational vocabulary, and oral vocabulary) of the test of language development-primary, third edition (TOLD-P: 3). The picture vocabulary subtest was used to evaluate understanding, based on which the children were asked to point at one of the four images corresponding to the presented auditory stimulus. Relational and oral vocabulary subtests were performed to evaluate the expression. In the relational and oral vocabulary subtests, the children were asked to express the similarity between the two words and define the words, respectively. Afterward, the developed WP task was administered to all children.

The study was approved by the Ethical Committee of the University of Social Welfare and Rehabilitation Sciences with the approval code IR.USWR.REC.164.1397. All the parents signed the informed consent before the experiment.

3. Results

The results of the content validity ratio were computed as 1.00 indicating that all experts agreed on the necessity of the word pairs. On the other hand, 65-word pairs had a CVI of 1.00, indicating that all experts considered the word pairs to be entirely relevant. The final set of word pairs consisted of 42 pairs, including 34 pairs with a CVR and CVI of 1.00, and 8 pairs with a CVR of 0.75 and a CVI of 1.00.

The test-retest reliability was examined by calculating the Pearson correlation coefficient between two tests, i.e. 0.835, which was statistically significant ($P<0.001$). The internal consistency of items was computed as 0.88 of Cronbach's alpha coefficient.

Table 1 represents the mean scores of participants in different stages of the WP task and the scores of the semantic section of TOLD-P: 3. In each stage of the WP task,

Table 1. Children's Mean±SD scores in tasks used for evaluation

Variables	Age (y)	Mean±SD	Ranges
Learning score (trial 1)	7-8	1.73±1.36	0-5
	8-9	2±2.04	0-8
Learning score (trial 2)	7-8	3.84±2.40	0-9
	8-9	5.08±3.26	1-10
Learning score (trial 3)	7-8	5.63±2.65	1-10
	8-9	7.16±3.58	2-13
Learning score	7-8	11.21±5.53	2-30
	8-9	14.25±7.54	4-26
Immediate recall	7-8	4.89±2.02	1-9
	8-9	6.58±1.88	4-10
Delayed recall	7-8	4.52±1.80	2-8
	8-9	5.50±2.43	2-10
Delayed recognition	7-8	13.10±1.52	8-14
	8-9	13.50±0.90	11-14
Retention	7-8	13.05±1.35	10-14
	8-9	13.50±0.67	12-14
Semantic	7-8	64.2±7.89	43-75
	8-9	72.58±3.87	67-79

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the maximum possible score was 14, calculated based on the number of words accurately recalled or recognized.

Using the parametric t-test with two independent samples and the non-parametric Mann–Whitney U test, the changes in the variables presented in Table 1 were investigated in two age groups of 7-8 years and 8-9 years. The results showed that although changes increase with age, the only statistically significant increases are in the immediate recall stage of declarative memory ($P<0.05$) and the semantic aspect of TOLD-P:3 ($P=0.001$). Using the repeated measures of analysis of variance (ANOVA), the significance of changes was evaluated for all participants in all three trials of the learning stage. The results indicated that the increase in the number of recalled words in the three trials of the learning stage is statistically significant ($P<0.001$).

The significance of the difference between the last trial of the learning stage and the recognition stage was evaluated using a paired sample t-test. The results indicated a significant difference between the recognition stage and the last trial of the learning stage ($t=14.627$, $P=0.000$), i.e., children's performance in the recognition stage was significantly better than in the learning stage. Also, the results showed no significant difference between the performance of the subjects in the recognition and retention stages ($t=0.162$, $P=0.837$), and no significant relationship between the semantic aspect of language and learning stage ($r=0.15$, $P=0.402$), immediate recall stage ($r=0.31$, $P=0.083$), delayed recall stage ($r=0.036$, $P=0.849$), delayed recognition stage ($r=-0.183$, $P=0.325$), and retention stage ($r=0.23$, $P=0.203$) of declarative memory task.

Regression analysis

Considering the proposed relationship between declarative memory and the semantic aspect of language (Lum et al., 2012 for a review), and following the presumptions of the regression analysis, the scores of the semantic aspect of language (dependent variable) were predicted by different stages of declarative memory (independent variables). The results of the multivariate regression analysis indicated that the variable of the retention stage affects the semantic aspect of language (P=0.001) and predicts 50.9% of variations in the semantic aspect of language. In other words, one unit increasing the standard deviation in the score of the retention stage increases the score for the semantic aspect of language by about 0.550 units.

4. Discussion

The main objective of the current study was to design a valid and reliable task to evaluate declarative memory among Persian-speaking children and explore the relationship between declarative memory and semantic aspect based on the DP model. The current study showed that the developed WP task has acceptable levels of test-retest reliability (Pearson coefficient=0.825) and internal consistency (Cronbach's alpha=0.880) (Cohen, 1997; Delis, et al., 1994) and can be used as a valid and reliable task to assess declarative memory in children with speech and or language disorders.

According to the DP model, it is believed that declarative memory is relatively intact in developmental language disorder (DLD) and plays a compensatory role for the syntactic deficit and other deficits in DLD (Lukács et al., 2017; Lum et al., 2012). Therefore, the WP task has great importance in assessing declarative memory due to its compensatory role in DLD.

Consistent with previous studies, as children get older, their performance in different stages of the task improves (Lum, Kidd, Davis, & Conti-Ramsden, 2010). In addition, the number of words recalled in three learning trials gradually and significantly increased, which is consistent with the results reported by Lum et al. This increase indicates that as children are repeatedly exposed to the same words, they can better associate words in a pair (Lum, Ullman, & Conti-Ramsden, 2015).

Consolidation refers to the internalization of information after the initial learning. Considering the consolidation effects, subjects were expected to perform significantly better in the retention stage compared to the recognition stage. However, the results showed no significant difference between recognition and retention, while a significant difference was observed between the last trial of the learning stage and the recognition stage. These results are consistent with the results reported by Lukacs et al., and it seems that normal children show their best performance at the recognition stage, therefore no room exists for improvement following the consolidation (Lukács et al., 2017).

According to the DP model and similar studies (Lum et al., 2012), it was expected to observe a correlation between the semantic aspect of language and the person's performance in WP task, while the performance in declarative memory task can predict the score for semantic aspect. Unlike previous studies, the current study showed no correlation between the semantic aspect and the WP task. One of the probable reasons can be attributed to the smaller sample size, and the other can be related to the task used to evaluate the semantic aspect of language. Lum et al. evaluated the children's lexical abilities using the expressive one-word picture vocabulary test (EOWPVT) and the receptive one-word picture vocabulary test (ROWPVT) addressing the reception and expression of words in different classes of objects, verbs, adjectives (Lum et al., 2010; Michalec & Henninger, 2011). However, the current study used three subtests of picture vocabulary, relational vocabulary, and oral vocabulary. Just picture vocabulary of TOLD-P: 3 that explores the comprehension of lexical items similar to Lum et al includes nouns and adjectives.

The regression analysis showed that the subjects' performance in the retention stage of declarative memory was the only component predicting the score of the semantic aspect. According to the similarity observed between children's performance in the recognition and retention stages, we expected that the recognition stage predicts the score of the semantic aspect. However, it was not approved. The difference in similar tasks in these two stages can be a potential cause for this result. It seems that in the retention stage, the presented words become a part of the children's lexical reserve due to a 24-hour interval, and therefore, the individuals' performance in this stage and their ability to consolidate the information in the mental lexicon can predict semantic aspect.

5. Conclusion

In sum, the results demonstrated satisfactory validity and reliability of the developed WP task. With an easy scoring system and requiring an administration time-

frame of only 15 min, this task can be used to evaluate declarative memory in cognitive, speech, and linguistic disorders, particularly for developmental language disorders. Moreover, the results confirmed the predictions of the DP model concerning the relationship between the semantic aspect of language and declarative memory in the retention stage.

The current study had limitations. The age range of our study limited the findings to children between 7-9 years.

Ethical Considerations

Compliance with ethical guidelines

All ethical principles are considered in this article. The participants were informed of the purpose of the research and its implementation stages. They were also assured about the confidentiality of their information and were free to leave the study whenever they wished, and if desired, the research results would be available to them. A written consent has been obtained from their parents. This study was approved by the Ethics Committee of the University of Social Welfare and Rehabilitation Sciences (Code: IR.USWR.REC.164.1397).

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Authors' contributions

All authors equally contributed to preparing this article.

Conflict of interest

The authors declared no conflict of interest.

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