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Turkish Version of the Junior Metacognitive Awareness Inventory: The Validation Study

Bilişüstü Yetiler Envanteri'nin Türkçe'ye Uyarlanması: Geçerlilik Çalışması

Utkun AYDIN*
Muğla Üniversitesi

Behiye UBUZ**
Orta Doğu Teknik Üniversitesi

Abstract

This article describes a study measuring metacognition by means of the Junior Metacognitive Awareness Inventory developed in the USA which was then adapted to be used in Turkey. The survey data from 314 middle school students and 589 tenth grade students were collected in two phases to facilitate both the exploratory factor analysis (EFA) and the confirmatory factor analysis (CFA). Furthermore, the reliability analysis of the scores and convergent, discriminant, and subgroup validity coefficients were examined. Findings suggested that the inventory measures two constructs, namely, the knowledge and regulation of cognition. These results demonstrated that the Turkish version of Jr. MAI is a valid and reliable instrument which may serve as useful in guiding future research aiming to understanding students' metacognitive awareness.

Keywords: Junior Metacognitive Awareness Inventory, parallel analysis, exploratory factor analysis, confirmatory factor analysis.

Öz

Bu çalışmanın iki amacı vardır. İlki, bilişüstü yeti boyutlarını belirlemek üzere Bilişüstü Yeti Envanteri'ni Türkçeye uyarlamak, ikincisi ise envanterin geçerlik ve güvenirliğini Türk kültüründe test etmektir. Bilişüstü yeti, bireylerin kendi öğrenme yapısını algılama ve kendi öğrenme özelliklerinin farkında olma gibi zihinsel güçlerini kapsamaktadır. Çalışma, farklı sınıf düzeylerinde 314 ilköğretim öğrencisinin bilişüstü yeti puanlarının yer aldığı açımlayıcı faktör analizi ve 589 onuncu sınıf öğrencisinin bilişüstü yeti puanlarının yer aldığı doğrulayıcı faktör analizi olmak üzere iki aşamadan oluşmaktadır. Öğrencilerin bilişüstü yeti puanlarının güvenirlik analizleri yapılmış ve uyuşum, ayırtedici ve altgrup geçerlikleri incelenmiştir. Bulgular, envanterin "Bilişin Bilgisi" ve "Bilişin Düzenlemesi" olmak üzere iki boyuttan oluştuğunu göstermektedir. Bu sonuçlar envanterin, öğrencilerin bilişüstü yetilerini ölçmede geçerli ve güvenilir bir araç olduğunu kanıtlamaktadır.

Anahtar Sözcükler: Bilişüstü Yeti Envanteri, Paralel Analiz, Açımlayıcı Faktör Analizi, Doğrulayıcı Faktör Analizi.

Introduction

The term 'metacognition' was primarily introduced by Flavell (1971) and generally described as 'thinking about thinking', 'knowing about knowing', or 'cognitions about cognitions'. All these characterizations signify the term metacognition as the knowledge about and regulation of one's cognitive activities in learning processes (Brown, 1978; Flavell, 1979; Schraw and Dennison, 1994; Schraw, 1998). Defining broadly, it is about "one's knowledge and control of own cognitive system" (Brown, 1987).

* Utkun AYDIN, Muğla Üniversitesi, Eğitim Fakültesi, Orta Öğretim Fen ve Matematik Alanları Eğitimi Bölümü, utkun@metu.edu.tr

** Doç. Dr. Behiye UBUZ, Orta Doğu Teknik Üniversitesi, Eğitim Fakültesi, Orta Öğretim Fen ve Matematik Alanları Eğitimi Bölümü,ubuz@metu.edu.tr

There is now a strong demand for more in-depth understanding about metacognition which is considered to be one of the most important factors affecting learning (Malmivuori, 2006). The interest in metacognition, using the term as a prompt for students to take the responsibility for their own learning, is also a development that is indicated in different curricular documents (NCTM, 1989; MEB, 2005) and appears in the affective objectives of Turkish curriculum that are devoted to becoming reflectively engaged in both awareness and control processes that offer students a malleable array of learning intentions (MEB, 2005). There seems to be a general consensus on the fact that the development of a sense of awareness constitutes an important objective of mathematics education, so that there seems to be a general trend towards including metacognition in the curriculum.

Students' repertoire of knowledge of cognition and regulation of cognition is suggested to have a substantial effect on their learning. Students' awareness of what information is given in the problem and what strategies to implement (declarative knowledge) trigger them to identify the basic facts and recall the critical attributes of these facts. The knowledge of why certain strategies are more efficient (conditional knowledge) leads them to explain the relational rules and judge the links between these rules. Aligned with the knowledge of how strategies can be integrated into the problem solution (procedural knowledge) students enrich the application of their procedures by the guidance of these strategies. While students make use of setting goals (planning) and allocating resources (selecting) to activate their recognition of the key facts, they direct their verifications (evaluating) of the algorithms and selection of the procedures. Throughout these processes, they make judgments (monitoring) about the strength of their selections. Accordingly, they reconstruct their thought processes (debugging) to explain why the condition in a certain procedure is satisfied or not.

Metacognitive perspectives typically employ one of two frameworks initiated by Brown (1978) and Flavell (1979). These frameworks have common distinction of basic dimensions as metacognitive knowledge and metacognitive regulation. Whereas metacognitive knowledge focuses on the acquired knowledge about cognitive processes, metacognitive regulation focuses on the coordination of cognitive processes. Flavell (1979) refers to metacognitive knowledge as person, task, and strategy; while Brown (1978) classifies it into subcomponents as declarative, conditional, and procedural knowledge. While there is consistent acknowledgement of the importance of awareness of task nature and progress, researchers mark the conceptualization of the knowledge of the personal learning characteristics. Flavell (1979) attains a unified description of metacognitive regulation referred to as conscious use of strategies that accompany planning, monitoring, and controlling processes. In the same vein, Brown (1978) postulates the general flow of these processes conveyed to planning, selecting, monitoring, evaluating, and debugging. Researchers commonly regarded regulatory processes as strategic decisions which individuals engage during the execution of the task.

A cursory glance of the research emanating from metacognition shows that emphasis has been placed on Flavell's framework in concert with the emergence of problem solving as a means of understanding the effect of regulatory processes (Artzt and Armour-Thomas, 1992; Garofalo and Lester, 1985) and Brown's framework remains central to current visions of the consensus that self-report inventories are the least problematic technique to measure metacognitive ability (Schraw and Dennison, 1994; Sperling et al, 2002). One of the important self-report inventories is the one developed by Sperling and her associates (e.g. Sperling, Howard, Miller, and Murphy, 2002). The framework initiated by Brown (1978) was employed to develop Jr. MAI (Sperling et al, 2002) in an effort to highlight research on self-report inventories of metacognition for use with students in grades 6 through 9 with regard to its appropriateness for academic settings. The convergent validity of Jr. MAI was provided by the administration of similar inventories such as Metacomprehension Strategies Index (Schmitt, 1990) and Index of Reading Awareness (Jacobs and Paris, 1987), while its concurrent validity was addressed by exploratory factor analyses that yielded two theoretical constructs initiated by Brown (1978). The internal consistency of the Jr.

MAI items indicated that it is a reliable measure with the correlation coefficient of .82. These significant results draw our attention to the importance of the adaptation of Jr.MAI.

Researchers have expressed interest in using Jr. MAI to investigate the effect of computer environments in promoting metacognitive awareness (Ke, 2008; Schwartz, Andersen, Hong, Howard, and McGee, 2004). Given that the Jr. MAI items were intended to measure students' metacognition in the United States, cross-cultural adaptation would highlight the interpretation of results from studies in other countries. Researchers suggest the need for multilanguage versions of educational and psychological tests (Ercikan, 2002; Hambleton, 2005; Hambleton and de Jong, 2003) as interest in cross-cultural psychology and international comparative studies of achievement grows. Yılmaz-Tüzün and Topçu (2007) roughly reported the validity and reliability of Jr. MAI in the study investigating the relationships among elementary students' epistemological beliefs, metacognition, and constructivist science learning environment with partial focus on conducting EFA to provide construct-related evidence of validity. Researchers, however, neither attempt to conduct CFA in terms of discriminant validity nor to investigate evidences for subgroup and convergent validity. These recognitions have raised the need to provide an in-depth study reporting exploratory and confirmatory factor analysis together with further validation techniques.

The purpose of the study was twofold. First, we took the Jr. MAI Version B originally developed by Sperling et al. (2002) and translated into Turkish. Second, we tested the validity and reliability of the Turkish version. The adaptation of the instrument would illuminate alternative ways to measure students' metacognition and highlight researchers draw upon parallel development processes in different languages and different national contexts for international comparisons.

Method

Samples

In the first phase, 314 tenth grade students (54.8% females, 45.2% males) from two public high schools and one private high school in Ankara-Turkey participated in the study. For the Phase 2, the sample involved 589 tenth grade students (51.5% females, 48.5% males) from three Anatolian high schools, three public high schools, and two private high schools in Ankara different from the previous sample. The participants of the both phases had an age range of 17 to 18. Students were accepted to Anatolian and private high schools according to their scores on the Orta Öğretim Kurumlarına Giriş Sınavı [Secondary School Entrance Examination] (OKS). This exam includes 100 multiple choice questions in four domains: Turkish Literature, Mathematics, Science, and Social Sciences. Students attending to private high schools have to pay a certain fee during the school year. To be accepted to public high schools students are required neither to take OKS nor to pay a fee to the school administration.

Instrument

Jr. MAI was administered by the mathematics or the classroom teachers of the students. The first researcher was also present at each school during the administrations in order to provide support to students in need of it.

Junior Metacognitive Awareness Inventory Version B (Jr. MAI). Jr. MAI developed by Sperling et al. (2002) with learners in grades six through nine was used to assess the students' metacognition in two major constructs: knowledge of cognition (KNOOFCOG) and regulation of cognition (REGOFCOG). It was translated into Turkish and then re-translated to English by two English language instructors. Turkish version of Jr. MAI was also checked by a Turkish language instructor in order to provide content-related evidence of validity. No changes were made to Jr. MAI items. For the purpose of content validation two experts in educational psychology and educational measurement were requested to assess the appropriateness of each item within idiomatic expressions, verify the matching of items to the corresponding subscales through semantic structures, and provide further suggestions with reference to heuristic approaches. Thus, the adaptation process was enriched in terms of both contextual and conceptual aspects. Regarding their feedbacks a brief explanation was provided about "learning strategies" as a footnote in the instrument.

The original version of Jr. MAI included eighteen items and students responded to each item on a 5-point Likert-scale which ranges from "1-never" to "5-always. The items were equally distributed on KNOOFCOG and REGOFCOG. There were no negative statements; hence, none of the items were recoded. The possible scores of this inventory ranged from 18 to 90 which were used to identify students' level of metacognitive awareness (e.g., 18= low metacognitive awareness; 90= high metacognitive awareness). The students were allowed 20 minutes to respond the inventory. They were also requested demographic data including gender, grade level, mathematics grade taken in the previous semester.

Procedure

A two-phase study was conducted during 2005-2006 academic year to adapt the Jr. MAI for Turkish secondary students. In the first phase, the dimensions of the inventory were determined. The data gathered from the first phase were evaluated by exploratory factor analyses. The second phase included the confirmatory factor analysis to evaluate whether the Turkish factor model specified in the first phase provides a good fit or not.

Phase 1. The exploratory factor analyses were performed to evaluate the factor structure of Jr. MAI with regard to the data obtained from Turkish secondary students. A principal component factor analysis with oblimin rotation was conducted to determine the factor structure underlying the data within the framework of SPSS 11.5 for Windows. The oblique method of rotation was chosen as a correlation between the subscales of Jr. MAI was expected (Ford, MacCallum, and Tait, 1986) and that the scores of the unrefined subscales were correlated at .43. In addition, the inter item correlations ranged from .11 to .52, sufficient to justify using an oblique rotation and analyzing both pattern and structure matrices (Henson and Roberts, 2006). The Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy and Bartlett's Test of Sphericity (BTS) were analyzed to ensure that the characteristics of the data were suitable for performing EFA. Since the results of KMO and BTS indicated satisfactory indexes, a further consideration was to determine the number of factors to be extracted in the subsequent analyses. Thompson and Daniel (1996) suggested three methods to select factors. Accordingly, the present study used: (a) eigenvalue-greater-than-one rule (Kaiser, 1960), (b) scree tests (Cattell, 1978), and (c) parallel analysis (Horn, 1965). To decide which items to retain in each factor the following rules were used: (a) item loadings have to exceed .30 on at least one factor (Hair, Black, Babin, Anderson, and Tatham, 2006) and (b) at least three significant loadings is required to identify a factor (Zwick and Velicer, 1986).

Phase 2. The confirmatory factor analysis was performed to provide supportive evidence to the factor structure by using LISREL 8 (Jöreskog and Sörbom, 1993). CFA is a theory-driven technique (Bollen, 1989) which is strongly recommended as a robust procedure for testing hypotheses about factor structures (Harris and Schaubroeck, 1990). The inventory which was modified with regard to the results of Phase 1 was administered to the new sample. Multiple criteria including the ratio of chi-square to the degrees of freedom (x^2/df), the root mean square residual (RMR), goodness-of-fit index (GFI), adjusted-goodness-of-fit index (AGFI), root mean square error of approximation (RMSEA), and comparative fit index (CFI) were used to test model-data-fit. It is suggested substantively interpretive models with chi-square ratios of three or less, a RMR below .05, a GFI above .90, an AGFI above .90, a RMSEA from .06 to .08, and a CFI above .95 as good fitting (Schreiber, Stage, King, Nora, and Barlow, 2006). The pairwise deletion was adopted to construct the covariance matrix among the variables for structural equation modeling.

Findings and Results

Phase 1: Exploratory Factor Analysis

The 18 items of the Jr. MAI were subjected to principal components analysis (PCA) and prior to the investigation we analyzed the KMO and BTS. The results yielded a statistically significant KMO index of .89 and a BTS 1317,08 which allowed us to conduct factor analysis. Subsequent investigations demonstrated the presence of four factors with eigenvalues exceeding 1, explaining 17.21 %, 15.71 %, 9.03 %, and 7.36 % of the variance, respectively. The total variance explained by these four factors was 49.3%. Eigenvalues, percentages of variances explained by factors, and factor loadings of the items of this version of Jr. MAI are demonstrated in Table 1.

Table 1.

Eigenvalues, % of Variances Explained by Factors, and Factor Loadings of the Items of the First Exploratory Factor Analysis

Components	1	2	3	4
Eigenvalues	5.34	1.34	1.14	1.04
% of variances	17.21	15.71	9.03	7.36
Items		Factor Loadings		
17	**.691**	.078	-.32	.138
7	**.658**	.328	-.042	-.009
10	**.618**	.003	.258	.233
8	**.551**	.422	-.062	-.151
6	**.546**	.013	.165	.015
9	**.515**	.229	.191	.267
14	**.508**	.403	.179	.070
18	**.414**	.131	.357	.407
2	.182	**.727**	.143	.162
1	-.092	**.709**	-.008	.171
4	.190	**.626**	.140	.055
3	.185	**.576**	.162	.017
13	.436	**.492**	.169	.128
12	-.014	.053	**.852**	.028
11	.279	.384	**.521**	.020
5	.170	.309	**.392**	-.082
16	.023	.080	-.168	**.793**
15	.319	.239	.234	**.524**

All items had factor loading of at least .30. The structure matrix revealed that seven items (items 6, 7, 8, 9, 10, 14, and 17) constituted the first factor, five items (items 1, 2, 3, 4, and 13) constituted the second factor, three items (items 5, 11, and 12) constituted the third factor, and the last factor gathered three items (items 15, 16, and 18). The screeplot was investigated to select the correct number of factors to be extracted. This inspection revealed a clear break between the second and third factors, and that first two factors explain the much more of the variance than the remaining factors. Hence, using Catell's (1966) scree test it was decided to retain two factors for subsequent analyses. The scree plot is presented in Figure 1. This was further supported by the results of parallel analysis. To compare the initial eigenvalues obtained in the first exploratory factor analysis with the corresponding values of the random eigenvalues, Monte Carlo PCA for Parallel Analysis (Watkins, 2000) was used. The results showed only two factors with eigenvalues of 1.44 and 1.34 exceeding the corresponding values of the random eigenvalues generated for 18 variables, 314 subjects and 100 replications. Therefore, a two-factor solution was selected.

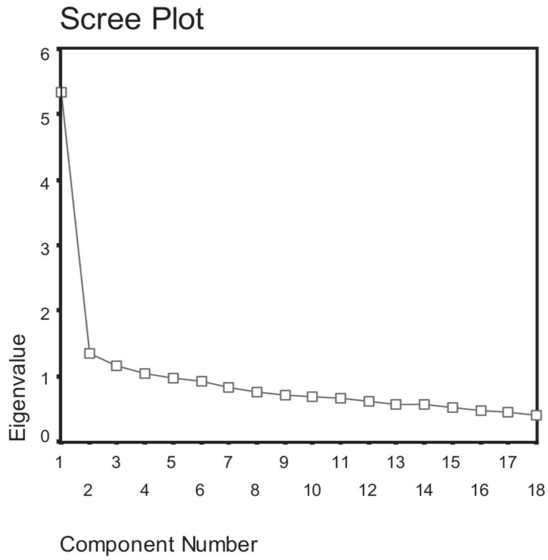

Figure 1. The Scree Plot

The second EFA was conducted by 18 items using an extraction to two factors. The two-factor structure explained 37.17% of the total variance, with Factor 1 contributing 18.72 % and Factor 2 contributing 18.45 %. Regarding the oblimin rotation, the two factors were interpreted in terms of the pattern and structure matrices. The careful examination of the factor loadings showed that item 16 in the first factor was problematic as its loading was under .30, and needs to be deleted. This was further supported by the inspection of its communality which revealed a low value of .074. It was suggested that communality values less than .30 indicate that the item does not fit well with the other items in its factor (Hair et al, 2006). Thus, within these considerations this item was dropped. Eigenvalues, percentages of variances explained by factors, and pattern and structure matrices along with communalities of the items for the second factor analysis with oblimin rotation of two-factor solution were presented in Table 2. In addition, item 14 which was a KNOOFCOG item loaded on the REGOFCOG and item 11 which was a REGOFCOG item loaded on the KNOOFCOG. The essence of item 14 was using different strategies that require the planning of appropriate ways to promote learning. In this sense, it nestles the characteristics of REGOFCOG. On the other hand, item 11 involving the knowledge of important information holds parallels with some KNOOFCOG items such as item 4 that includes the knowledge of what is expected to be learnt. The communalities of items 11 and 14 were .39 and .44, respectively. This provided further evidence that items 11 and 14 are not problematic in the sense of their communality values exceeding .30 and that they fit well with the other items on their factors. Therefore, items 11 and 14 were retained.

Consequently, the third EFA was conducted to determine the common factor structure of the remaining 17 items with oblimin rotation of two factor extraction. The KMO and BTS which yielded an index of .89 and 1297.85, respectively, ensured that the characteristics of the data set were suitable for EFA. The interpretation of the two factors with regard to the oblimin rotation in terms of the pattern and structure matrices demonstrated that all factor loadings and communality values were above .30, concurrent with the suggestions of Hair et al (2006). This analysis revealed that nine items (items 6, 7, 8, 9, 10, 14, 15, 17, and 18) constituted the first factor, and six items (items 1, 2, 3, 4, 5, 11, 12, and 13) constituted the second factor. Items in Factor 1 revolved around REGOFCOG and items in Factor 2 revolved around KNOOFCOG worked together. Minimum eigenvalues of these factors were 1.34 and together they explained 39.11 % of the common variance in item responses. In terms of variance explained by each factor KNOOFCOG accounted for 18.92

% and REGOFCOG accounted for 20.18 % of the variation on Jr. MAI. Along with the suggestions of Pett, Lackey, and Sullivan (2003) both the pattern and structure matrices were the focus of evaluation. The factor interpretability of the structure matrix drew parallels with the pattern matrix and revealed a simple factor structure with both KNOOFCOG and REGOFCOG showing strong loadings and all items loading substantially on only one factor. Table 3 demonstrates the eigenvalues, percentages of variances explained by factors, pattern and structure matrices along with the communalities of the items for the third factor analysis with oblimin rotation of two-factor solution.

Analysis of data from this EFA guided to form the final Turkish version of the Jr. MAI (see Appendix A) with 17 items on two subscales. These subscales along with the definitions are:

1. Knowledge of cognition (8 items): Individual's knowledge about her/his own capabilities, beliefs, cognitive abilities, and processes. Sample items from this subscale included: "I know when I understand something [Bir şeyi anladığımı bilirim]" and "I can make myself learn when I need to [Gerektiğinde, öğrenmek için kendimi motive edebilirim]".

2. Regulation of cognition (9 items): Individual's knowledge about her/his own control processes during the execution of the task. Sample items from this subscale included: "I really pay attention to important information [Önemli bilgiye gerçekten dikkat ederim]" and "I think of several ways to solve a problem and then choose the best one [Bir problem çözmek için çeşitli çözüm yollarını denerim ve daha sonra en uygun olanını seçerim]"

Table 2.

Eigenvalues, % of Variances Explained by Factors, and Pattern and Structure Matrix along with Communality Values of the Items for the Second Exploratory Factor Analysis

Components	1		2		
Eigenvalues	5.34		3.38		
% of variances	18.72		18.45		
Item	Pattern Matrix		Structure Matrix		Communalities
Components	1	2	1	2	
10	.71		.69		.47
17	.72		.67		.46
7	.56		.63		.43
9	.55		.63		.42
18	.54		.60		.37
14	.42		.58		.44
15	.45		.54		.33
6	.55		.53		.38
8	.37		.50		.32
16	.29		.26		.07
2		.74		.75	.57
4		.64		.66	.43
1		.72		.62	.43
3		.60		.61	.38
13		.45		.61	.47
11		.51		.60	.39
5		.42		.45	.31
12		.36		.37	.33

Table 3.

Eigenvalues, % of Variances Explained by Factors, and Pattern and Structure Matrix along with Communality Values of the Items for the Third Exploratory Factor Analysis

Components		1		2		
Eigenvalues		5.31		3.38		
% of variances		20.18		18.92		
		Pattern Matrix		Structure Matrix		Communalities
Components		1	2	1	2	
Item No						
Original Form	Final Form					
10	10	.74		.69		.49
17	16	.73		.67		.47
7	7	.57		.64		.43
9	9	.57		.63		.42
18	17	.55		.60		.37
14	14	.43		.59		.44
15	15	.43		.53		.32
6	6	.55		.53		.39
8	8	.39		.51		.32
2	2		.74		.76	.58
4	4		.63		.65	.43
1	1		.75		.64	.46
3	3		.60		.61	.38
13	13		.43		.60	.47
11	11		.48		.59	.39
5	5		.42		.44	.30
12	12		.32		.35	.32

Phase 2: Confirmatory Factor Analysis

The confirmatory factor analysis supported the two-factor solution that emerged from the exploratory factor analysis in the first phase. The maximum likelihood estimations appeared between .38 and .65 and all t values were significant at $p < .05$. Two subscales of the Jr. MAI (KNOOFCOG and REGOFCOG) were allowed to correlate to each other. Model specification and the parameter estimates are illustrated in Figure 2. This showed that the factor loadings of each item on the related dimension were at a reasonable size to define KNOOFCOG and REGOFCOG.

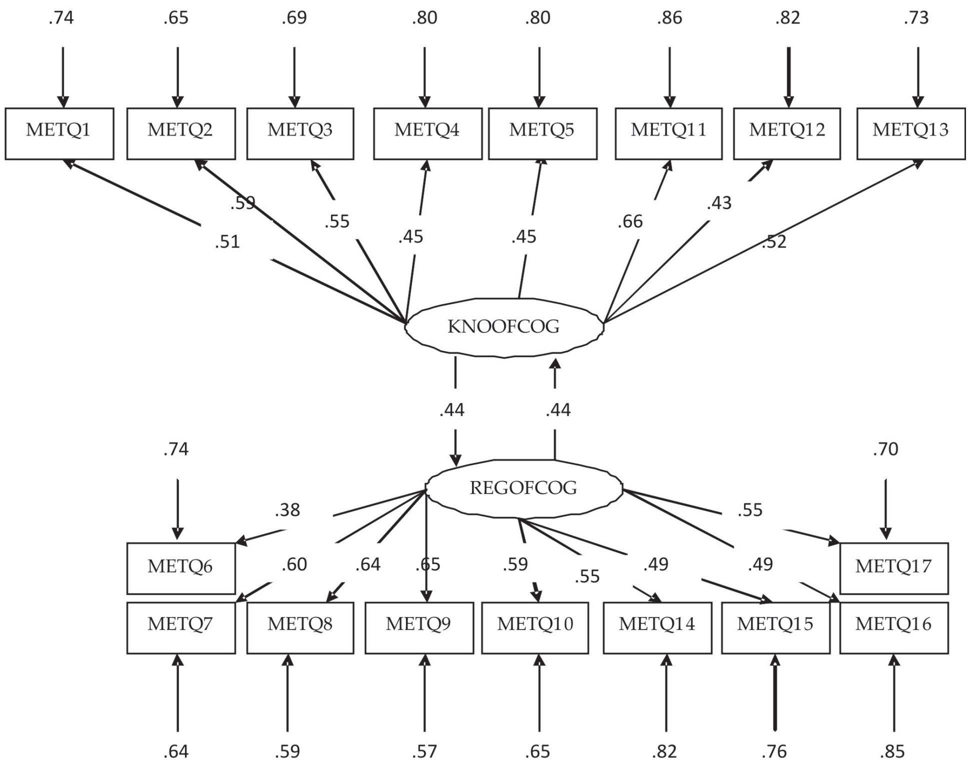

Figure 2. Standardized Coefficients for the Two-Factor Model of the Jr. MAI

Results of the two-factor model showed a fairly good fit relatively to the assessment criteria. The relation yielded a x^2= 285.71, df= 99, x^2/df= 2.88, RMR= .05, GFI = .94, AGFI = .92, RMSEA = .05, and CFI= .91. Results from the CFA suggested that the two-factor structure fit well to the sample data with all fit indices (RMR, GFI, CFI, AGFI, and RMSEA) indicating a good fit except for the ratio of the chi-square to the degrees of freedom which exhibited a reasonable fit. All parameters were found to be significant which indicated that each item contributes significantly to the corresponding subscale. We conducted an additional CFA to determine if a one-factor model was better suited to the data. Results of this CFA will be discussed below as evidence of discriminant validity.

Reliability Analysis

Reliability analysis with regard to the internal consistency yielded Cronbach alpha coefficients of .75 for the KNOOFCOG and .79 for the REGOFCOG, indicating satisfactory reliability. The further examination of item-total correlations revealed that all items in each subscale contributed to the consistency of scores with item-total correlations higher than .40.

Discriminant, Subgroup, and Convergent Validation

To demonstrate construct validity for the scores on the two subscales of the Jr. MAI, discriminant, subgroup, and convergent validity evidences were provided.

Discriminant Validity

Evidence for discriminant validity is provided when other theoretically plausible factor models are shown to fit worse to the data than the target model under investigation (Lance and Vandenberg, 2002). Hence, the superiority of the theoretical model as compared to two other theoretically plausible models was investigated. Two alternative confirmatory factor analytic models were tested, a common factor model and a null model. The model comparisons are presented in Table 4.

Table 4.
Goodness of Fit Statistics for Tests of Discriminant Validity

Model	χ^2	df	NC (χ^2/df)	RMSEA	RMR	GFI	AGFI	CFI	$\Delta\chi^2$	Δdf
Target	285.71	99	2.88	.05	.05	.94	.92	.91	-	-
Common Factor	724.06	119	6.08	.09	.06	.87	.84	.79	438.35	20
Null	436.44	100	4.36	.07	.15	.92	.88	.80	150.73	1

The more parsimonious, common factor model was specified such that all items loaded on a single factor proposing that the two a priori factors of the Jr. MAI are not conceptually or statistically distinct. This alternate model showed a poorer fit to the data than the target model (see Table 4). The comparison of the target model to the common factor model across goodness of fit indices revealed the target model fits the data better. In addition, the chi-square difference test indicated the superiority of the target model as compared to the common factor model ($\Delta\chi^2 = 438.35$, Δdf= 20 , p< .001). The significance of the chi-square supported that it is unlikely to take the common factor model as a correct alternate and provided additional support for the subscale dimensionality of the Jr. MAI measure.

It is widely acknowledged that a null model is expected to have a poorer fit to the data than a target model. However, a null model can establish discriminant validity if it is shown to fit significantly worse than the target model. The null model proposed that each item on the Jr. MAI is a single factor. As is demonstrated in Table 4, the target model again had a better fit to the data. The chi-square difference test indicated the superiority of the target model as compared to the null model ($\Delta\chi^2 = 150.73$, Δdf= 1,p< .001). These results offered supplementary evidence of the existence of the two a priori subscales of the Jr. MAI measure.

Consequently, this two-factor model of Jr. MAI was accepted as an appropriate version for Turkish students. Furthermore, the construct-related evidence of validity obtained by the correlation between KNOOFCOG and REGOFCOG yielded a significant positive relationship between two subscales with a value of .72.

Subgroup Validity

Hinkin (1995) suggested demonstrating subgroup validity when groups whose scores are expected to differ on a measure do so in the hypothesized direction. In the current study, gender and grade level were expected to differentiate students on the two subscales of the Jr. MAI. Thus, we generated multivariate analysis of variance to check these issues. The dependent variables were two subscales of the Jr. MAI. Gender was coded with 1= female (n= 506) and 2= male (n= 397), and grade level was coded as 1= sixth grade (n= 122), 2= seventh grade (n= 109), 3= eighth grade (n= 83), and 4= tenth grade (n= 589). Preliminary assumption testing on multivariate normality and homogeneity of variance-covariance matrices was conducted and no violations were detected.

The reports about gender-related differences in metacognition occur in parallel with either significant difference in favor of females (Ablard, Lipschultz, and Rachelle, 1998; Carr, Jessup, and Fuller, 1999; Carr and Jessup, 1997; Fennema and Peterson, 1985; Hyde, Fennema, and Lamon, 1990) or no significant difference (Fennema, Carpenter, Jacobs, Franke, and Levi, 1998; Lundeberg, Fox, and Punccohar, 1994; Sperling et al., 2002). Consistent with these diverse results and the findings documented in the original version of the inventory, results of multivariate analysis revealed no significant main effect for female/male difference (Wilks' Lambda= .99, F (2, 900)= 1.85, p= .15, η^2 = .004), suggesting that the female and male students did not differ on a linear combination of the two subscales of the Jr. MAI. The partial eta squared of .004 would be interpreted as a small effect (Cohen, 1988).

Researchers defended the view that differences in metacognition are caused in part by grade level differences (Schraw and Dennison, 1994; Sperling et al., 2002) in favor of students at higher grade. Specifically, it was predicted that eighth and tenth grade students would have higher scores toward metacognitive awareness on both subscales. Consistent with this prediction, results of multivariate analysis indicated a significant main effect for grade level difference (Wilks' Lambda= .97, F (6, 1796)= 3.96, p= .001, η^2 = .03), suggesting that students at different grades differed on a linear combination of the two subscales of the Jr. MAI. The partial eta squared of .03 would be interpreted as a medium effect (Cohen, 1988). The follow-up univariate analyses indicated that there was a significant mean difference among grade levels on the KNOOFCOG, F (3, 85)= 5.05, p= .002, η^2 = .04. Tenth grade students (M= 35, SD= 4.2) were more aware of what they know than seventh grade students (M= 33.4, SD= 3.8). On the other subscale, REGOFCOG, tenth grade students again had higher awareness of their regulatory processes, however, they did not appear significant. Thus, the findings of tenth grade students' higher scores on KNOOFCOG provided support for the prediction.

Convergent Validity

In addition to multivariate test, correlational analysis was employed between two subscales of the Jr. MAI and mathematics grades taken in the previous semester. It is widely acknowledged that students' awareness of their own learning and control over their regulatory processes are significantly related to their achievement with moderate (Artzt and Armour-Thomas, 1992; Garofalo and Lester, 1985) to small correlations (Schraw and Dennison, 1994; Sperling et al., 2002). Results revealed statistically significant, positive, and small relationship (Cohen, 1988) between previous mathematics grade and metacognitive awareness, r= .13, p< .01. Furthermore, analysis documented significant correlation of previous mathematics grade with KNOOFCOG (r= .13, p< .01) and with REGOFCOG (r= .11, p< .01) indicating a small effect (Cohen, 1988). As expected, significant and positive correlations provided further evidence for convergent validity.

Discussion

The central ideas that framed our research are the translation of Jr. MAI into Turkish and the evaluation of its validity and reliability. The results of this two-phase study support the validity and the reliability of scores on the two-factor model of Jr. MAI. A measure of metacognitive awareness in Turkish is noticeably absent, whereas similar self-report inventories assessing motivation or self-regulation become increasingly relevant. The presence of focus on regulation of cognition in such inventories does seem to be a central debilitation for the attempts to assess students' metacognition from a broadened perspective that captures the essence of both knowledge of cognition and regulation of cognition. Results from empirical research combined with the importance of students' knowledge of their own cognitive abilities and regulation of their own cognitive processes on their achievement served as the basis for the translation and adaptation of the Jr. MAI into Turkish.

The factor structure that emerged in the exploratory phase indicated the exclusion of some items from the original inventory. Low correlations might be expected due to this process; however, the construct validity of the inventory was supported by the correlation between the two subscales. This finding replicated the results of earlier studies on the relationship between KNOOFCOG and REGOFCOG (Schraw and Dennison, 1994; Sperling, Howard, Staley, and DuBois, 2004). Content validation of the items developed to capture the two subscales of metacognitive awareness confirmed the reliability of the scores on the KNOOFCOG and REGOFCOG.

The corroboration of the factor structure in the confirmatory phase of the study yielded a two-factor model of the Jr. MAI and thus provided support for the factorial validity of the inventory with a different sample. The relatively high correlations found between KNOOFCOG and REGOFCOG factors are plausible because knowledge about one's own capabilities, beliefs, cognitive abilities and processes contributes to knowledge about one's own control processes during the execution of the task, or vice versa. The interrelation that good learners effectively possess explicit descriptions of their own cognition, which improve their regulatory processes, supports the premise that metacognition provides students better use of their cognitive resources including attention, strategy selection, and awareness of comprehension. (Schraw and Moshman, 1995).

Construct validation of the scores on the two subscales was further assessed with convergent, discriminant, and subgroup validity evidence. The multivariate analyses results were marginally acceptable and the validity results were generally consistent with a priori predictions, providing initial support for two subscales of metacognitive awareness.

With respect to convergent validity, some support was found for our predictions regarding the relationship among KNOOFCOG, REGOFCOG, and math grades. As expected, results revealed a little significant correlation. This finding was consistent with previous research indicating small or nonsignificant correlations among metacognition, aptitude, and achievement (Allon, Gutkin, and Bruning, 1995; Sperling et al., 2002). One favorable view of this finding is that the Jr. MAI measures something other than achievement (Swanson, 1990).

The CFA provided substantive verification of the two-factor model. Values for several of the goodness-of-fit indices were at traditional cutoff criteria (Schreiber et al., 2006), and the two-factor model demonstrated superlative fit to the data. Evidence for discriminability of the KNOOFCOG and REGOFCOG subscales was established by the better fit of the two-factor model than either the one-factor or the null model. Support for the one-factor model would have indicated that students' metacognitive awareness was undifferentiated across two subscales. However, students' metacognitive awareness varied by knowledge of their own cognitive abilities and regulation of their own cognitive processes. Specifically, students who know when they understand something tend to ask themselves how well they are doing while they are learning something new or vice versa.

Some support was also found for our predictions regarding subgroup differences in metacognitive awareness. Results indicated that the Jr. MAI differentiated between grade levels, with higher knowledge of cognition scores for tenth grade students. This result seemed not to be surprising because older students are expected to be more aware of their own cognitive capabilities than younger students, which concurred with Schraw and Dennison's argument that as individuals gain more control over their cognitive processes, they become a good judge of themselves.

Conclusion

Conducting this study with two independent samples permitted the validation of the inventory. The Turkish version of Jr. MAI therefore appears to represent a valid and reliable measure of metacognition. A heightened consideration of metacognition in different curricular documents (MEB, 2005; NCTM, 1989) may devote research efforts to expand the contribution of metacognition on achievement. Hence, it would be useful as a tool in educational research on metacognition that enables the cross-cultural adaptation studies of self-report measures to be conducted with regard to the steadily growing interest in cross-cultural comparison studies such as Third International Mathematics and Science Study (TIMSS) and Programme for International Student Assessment (PISA). Through this lens, it might mark the beginning of research that provides support to reveal the relation between metacognition and achievement in different cultural settings.

This adaptation would help to replicate the previous research on investigating the effect of computer environments in promoting metacognitive awareness using Jr. MAI (Ke, 2008; Schwartz, Andersen, Hong, Howard, and McGee, 2004). A valid and reliable metacognitive scale might significantly contribute to the determination of students' level of KNOOFCOG and REGOFCOG, stressing the need to demonstrate the role of metacognitive levels in students' achievement in different subject areas (e.g., physics, chemistry, biology).

A concluding remark paves the way for future validation studies in which the focus should be oriented toward the relationship between these subscales of the Jr. MAI and other affective constructs such as motivation and self-confidence (Schraw and Dennison, 1994; Sperling et al., 2002).

Appendix A
Bilişüstü Yeti Anketi

Bu çalışmanın amacı, sizin nasıl öğrendiğiniz ve çalıştığınız hakkında bilgi edinmektir. Doğru veya yanlış cevap yoktur. Cevaplar kendi görüşlerinizi yansıtmalıdır. Her cümleyle ilgili görüş belirtirken önce cümleyi dikkatle okuyunuz, sonra cümlede belirtilen durumun size ne derecede uygun olduğuna karar veriniz. Lütfen size en uygun olan yuvarlağın içini doldurunuz. Teşekkürler!

	Hiçbir Zaman	**Nadiren**	**Bazen**	**Sık Sık**	**Her Zaman**
1. Bir şeyi anladığımı bilirim.	O	O	O	O	O
2. Gerektiğinde, öğrenmek için kendimi motive edebilirim.	O	O	O	O	O
3. Daha önce, benim için işe yaramış çalışma yollarını kullanmayı denerim.	O	O	O	O	O
4. Öğretmenin benden ne öğrenmemi beklediğini bilirim.	O	O	O	O	O
5. Konu hakkında daha önceden bilgim varsa daha iyi öğrenirim.	O	O	O	O	O
6. Öğrenirken anlamama yardımcı olacak resimler veya şemalar çizerim.	O	O	O	O	O
7. Çalışmamı bitirdiğimde kendime "Öğrenmek istediğim şeyi öğrendim mi?" diye sorarım.	O	O	O	O	O
8. Bir problemi çözmek için çeşitli çözüm yollarını denerim ve daha sonra en uygun olanını seçerim.	O	O	O	O	O
9. Çalışmaya başlamadan önce neyi öğrenmem gerektiğini düşünürüm.	O	O	O	O	O
10. Yeni bir şey öğrenirken kendime iyi gidip gitmediğime dair sorular sorarım.	O	O	O	O	O
11. Önemli bilgiye gerçekten dikkat ederim.	O	O	O	O	O
12. Konuya ilgim varsa daha çok öğrenirim.	O	O	O	O	O
13. Zihinsel açıdan güçlü olduğum noktaları, zayıf olan noktalarımı telafi etmede kullanırım.	O	O	O	O	O
14. Verilen işe bağlı olarak farklı öğrenme stratejileri* kullanırım.	O	O	O	O	O
15. Çalışmamı zamanında bitireceğimden emin olmak için ara sıra kontrol ederim.	O	O	O	O	O
16. Bir işi bitirdikten sonra kendime "Daha kolay bir yol var mıydı?" diye sorarım.	O	O	O	O	O
17. Bir işe başlamadan önce neyi tamamlamam gerektiğine karar veririm.	O	O	O	O	O

*Öğrenme stratejileri, bir işi başarıyla tamamlamak için kullandığımız yöntemlerdir. Bu stratejiler daha iyi öğrenmemize yardımcı olur. Örneğin:

- Bir problemi okuduktan sonra bilinenleri ve bilinmeyenleri belirlemek.
- Kafamız karıştığında verilen problemi tekrar okumak ve verilenler üzerinde düşünmek.
- Bir problemi çözmek için çeşitli yaklaşımlar kullanmak.
- Çalışırken küçük notlar almak.
- Eski bilgilerimizle yeni bilgilerimizi birleştirmek.
- Daha önce çözdüğümüz benzer örnekleri hatırlamaya çalışmak.

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