Comprehending memory beliefs and knowledge of adolescents: Development and Psychometric Properties of a Metamemory Scale for Adolescents

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Abstract-Metamemory (i.e. knowledge and beliefs about memory) of adolescents is assumed to influence performance of cognitive tasks requiring memory hence possibly impacting their classroom performance. This necessitates the availability of appropriate tools for assessing metamemory among adolescent population. Due to the dearth of appropriate self-report measures assessing metamemory among adolescents, the current study aimed at developing such a measure. This assessment tool would assess the level of knowledge about various aspects of memory as well as beliefs regarding memory competence, from a classroom learning perspective. A three-factor, 25-items metamemory scale was developed . Prior to pilot testing of the tool, content validity was evaluated. Based on the content validity and expert feedback and suggestions, scale items were revised. The revised version was pilot tested on a sample of 242 school-going adolescents (169 girls and 73 boys, 10 to18-year-olds). Based on the obtained data, psychometric properties of the measure were evaluated. Internal consistency estimates for the factors as well as for the full measure was indicative of the instrument's reliability. Confirmatory factor analysis revealed satisfactory fit to the data providing support for construct validity of the measure. Factor covariance reached statistical significance indicative of the scale's multidimensionality. Obtained results indicate that this scale can be a useful tool for assessing metamemory among adolescents, both in classroom setting as well as for research purpose.

Keywords:
Adolescents, metamemory, psychometric properties, scale development.

I. Introduction

Metamemory has often been defined either from the perspective of knowledge about memory or from that of monitoring of memory and utilization of memory skills. With respect to the former perspective, metamemory refers to an individual's knowledge about various facets of human memory system (such as capacities, limitations, functioning, influence of memory task characteristicson performance, etc) in general as well as self-referential beliefs about memory (e.g., Pierce and Lange, 2000; Flavell and Wellman, 1977). Whereas, the second perspective defines metamemory as the ability to monitor and control one's own learning and memory performance (e.g., Grainger, Williams and Lind, 2016; Flavell, 1971). These two perspectives have also been construed by many as defining two components of metamemory, commonly named declarative metamemory (DM) and procedural metamemory (PM), respectively, (e.g., Fritz, Howie and Kleitman, 2010; Dunlosky and Thiede, 2013).

Flavell's (1971) conceptualization of metamemory upheld both perspectives, i.e., knowledge about as well as monitoring and control of learning and memory processes as is evident from his definition of metamemory:
"… (the) intelligent "…(the) intelligent structuring and storage of input, of intelligent search and retrieval operations, and of intelligent monitoring and knowledge of these storage and retrieval operations" (p. 277).

A. Components of metamemory

Flavell and Wellman (1977) made a distinction between two components of metamemory, namely 'variables' and 'sensitivity' (referred to as declarative and procedural metamemory, respectively, in recent literature). The variables component comprises of knowledge about variables that are assumed to influence memory performance. Whereas, the sensitivity component constitutes of the application or use of the 'knowledge about variables' to monitor and control learning, memorization and retrieval of information. The variables component is further subdivided into three categories- Person variables, strategy variables and task variables. Knowledge and beliefs about one's own memory capacities and limitations constitutes person variables. Strategy variables refer to knowledge about memory strategies, mnemonics, their applicability, and relative pertinence and efficiency in situations demanding memory performance. Task variables refers to the knowledge about the various task characteristics that influence learning, storage and retrieval of information (e.g., Schneider, 1999; Tarricone, 2011). Another major point of distinction between the two broad metamemory components (i.e., declarative and procedural metamemory) comes from the assessment point of view. While assessment of DM is more of an 'offline' metacognitive assessment, where declaration of knowledge and beliefs about memory are not validated by memory task performance; that of PM is an 'online'

metacognitive assessment where jugdments about memory performance or memory tasks are often preceded or followed by performance on memory tasks (e.g., Sarac and Karakelle, 2017).

B. Existing metamemory assessment measures

In the four-decade long metamemory literature, DM has been assessed using a variety of assessment measures like interviews, tasks and scales. A majority of studies exploring the development of DM in children have done so using interviews, much of which was possible due to the seminal work done by Kruetzer, Leonard and Flavell (1975) in developing an interview instrument. Some studies used the measure in its original form (e.g., Cavanaugh & Borkowski, 1980); others used only portions of it (e.g., Lockl and Schneider, 2007); while another study reported a similar measure based on it (Belmont & Borkowski, 1988).

Several non-verbal measures of DM have been developed and used to study metamemory. Justice (1985, 1986) developed a technique for studying children's knowledge about the relative efficiency of different memory strategies, wherein they were to watch videos of various memory strategies and rank them in order of their degree of efficiency. DM –vignette task (Cornoldi & Orlando, 1988) and DM- story task (Cornoldi, Gobbo & Mazzoni, 1991) are two such measures that evaluate children's knowledge about various aspects of memory variables. DM-vignette task is used to assess children's knowledge about how memory is influenced by four factors- noise, number of to-be remembered-items, categorization of to-be-remembered items, and use of memory strategies, whereas DM- story task uses narrative passages to assess children's knowledge about forgetting and memory strategies (Leece, Demicheli, Zocchi & Palladino, 2015). Studies have also used various sort-recall tasks for assessing rehearsal as well as sorting strategies for effective recall among children (e.g., Kron-Sperl, Schneider & Hasselhorn, 2008).

Studies exploring declarative metamemory among the adults and older adults have done so using questionnaires (e.g., Parikh, Troyer, Maione & Murphy, 2015). Most of the metamemory scales and questionnaires reported in existing literature have been developed pertaining to various aspects of DM, more specifically, with items exclusively applicable for adults and older adults from both clinical and non-clinical population. Metamemory in Adulthood Questionnaire (Dixon, Hultsch and Hertzog, 1988) assesses metamemory on the following seven domains- achievement (i.e., perceived importance of performing well on memory tasks), anxiety (i.e., perceived impact of anxiety on memory task performance), capacity (i.e., perceived memory capacities), change (i.e., perceived stability of memory over time), Locus (i.e., perceived control over memory), strategy (i.e. reported use of memory strategies and aids), task (i.e. knowledge of basic memory processes). Memory Functioning Questionnaire (Gilewski, Zelinski & Schaie, 1990) assesses subjective appraisal of one's own memory capabilities across various everyday situations based on four domains- General frequency of forgetting (i.e. perceived frequency of forgetting in specific situations), Seriousness of Forgetting (i.e., perceived gravity of the consequences of forgetting in different situations), Retrospective Functioning (i.e. perceived change in current memory ability with respect to previous ability) and Mnemonics Usage (i.e., perceived frequency of using specific memory strategies). Another more recent questionnaire is Multifactorial Memory Questionnaire (Troyer and Rich, 2002). This questionnaire assesses three dimensions of self-reported memory-Contentment (i.e., emotions and perceptions about one's current memory ability), Ability (i.e., perceived frequency of everyday memory failures) and Strategy (i.e., reported frequency of employing memory aids). Other questionnaires include Memory Failures of Everyday Questionnaire (Sunderland, Harris & Baddeley, 1984), Memory Controllability Inventory (Lachman, Bandura, Weaver & Elliott, 1995), Everyday Memory Questionnaire (Royle anmd Lincoln, 2008), Cognitive Failures Questionnaire (Broadbent, Cooper, FitzGerald and Parkes, 1982) and the Subjective Memory Questionnaire(Bennett- Levy & Powell, 1980) to name a few. Literature on metamemory reveals that the number of studies on adults and older adults outnumbers that on adolescents by a large margin. In a review by Khatoon and Roy (2017), it was reported that a database search conducted through the ScienceDirect website using the terms 'metamemory' and 'adolescents' during the period '2000 to 2016' returned 134 studies, while in case of children and adults the numbers were 347 and 499 results respectively. A similar search on APA PsychNet returned eight studies for adolescents and nine for children, whereas 90 studies in case of adults.

Even though there are a considerable number of metamemory scales, none of them are suitable for adolescents. However, some can be made suitable with appropriate modification of items to suit their vocabulary and at the same time be of adequate relevance in capturing the various facets of their metamemory. Also, since most of these measures focus mainly on subjective beliefs that an individual holds about his or her memory capacities, limitations and strategies that one employs, they have been viewed as focusing only on the 'person' variable (e.g., Schnieder ,1999). Prior research examining DM of adolescents have mostly done so using metamemory tasks (see Schneider, 1999) and interviews(e.g., Kruetzer, Leonard, Flavell and Hagen, 1975) which focused on task specific metamemory knowledge (e.g., Justice, 1986), thus tapping only task specific DM components rather than providing a global or integrated assessment of DM.

C. Aim of the study

The present study reports the development of a scale that aims to assess DM of adolescents. The impetus for developing this tool was two-fold: first, was to introduce an assessment tool to alleviate the paucity of metamemory questionnaire for adolescents; second, to serve the purpose of another study exploring the development of DM across the adolescent years in relation to other cognitive and non-cognitive variables. Such a tool would serve the purpose of providing a holistic assessment of DM of adolescents, thereby opening new avenues for answering research questions pertaining to metamemory and performance of adolescents on memory tasks. This in turn, could have important implications in introducing modification in classroom instructions to assist students of this age group in reflecting upon and making intelligent use of their DM while performing in class.

II. Method

A. Participants

The sample for this study consisted of 242 students (169 girls, 73 boys) within the age range of 10-18 years (M = 13.64, SD = 1.98), from three middle and high schools in the city of Kolkata, situated in Eastern India.

B. Procedure

Conceptualization and Development. The present scale was based on the conceptualization of declarative metamemory which proposes that memory performance is influenced by three broad classes of variables, namely person variables, strategy variables and task variables. Initially, a three-factor, 30-items scale was constructed based on this conceptualization. Each of the factors had 10 items, the generation of which were conceptually driven and based on empirically established facts about human memory. The items were developed to capture metamemory of adolescents from the academic learning perspective.

Person variable The items for this subscale were framed to tap the beliefs and knowledge of participants regarding their memory capacities and limitations. For e.g., 'I find it hard to remember words that are difficult for me', 'I know exactly how much I will be able to remember after learning a lesson', etc.

Strategy variables This subscale comprised of items meant to assess participants' knowledge regarding the relative efficiency of various memory strategies in the learning situation. For e.g., 'Using acronyms (e.g. VIBGYOR for order of colors in a rainbow) can help us remember list of words'.

Task variables The items for this subscale were meant to assess the participants knowledge about the various learning related factors affecting encoding and retrieval of information. For e.g., 'In an exam, answering multiple choice questions is easier than answering subjective questions'.

C. Content validity

Prior to pilot testing of the scale, the initial draft of the measure was subjected to content validity analysis. Following the criteria for the minimum number of content experts proposed by Lynn (1986), three experts were recruited for the content validation of the scale. All the experts had a PhD degree in psychology; more than five years of research experience, and four or more publications in the area of metacognition or metamemory.

The raters were instructed to rate the relevance of each of the items on a four-point scale ranging from not relevant to highly relevant. They were also asked to classify each item into one of the three predetermined domains/factors of the scale, i.e., person variables, strategy variables and task variables. Additional instructions to the experts included asking them to provide suggestions for improving the relevance of an item (for example, by re-wording an item, suggesting an alternate item as a replacement, etc.) and to suggest domain-specific additional items.

D. Modifications in the scale

Following the content validity analysis, two items were dropped from the questionnaire while some items were reframed or replaced by other items as per the suggestions given by the experts. The modified scale consisted of 28 items (person variables=9 items; strategy variables= 11 items ; task variables=8 items).

E. Response and scoring

Response to each of the item was to be made by selecting one out of five response anchors which were based either on frequency or on degree of agreement. For the former, the five response anchors were 'never', 'rarely', 'sometimes', 'often' and 'always', whereas for the latter, the response anchors were 'strongly disagree', 'disagree', 'neither agree nor disagree', 'agree' and 'strongly agree', which were scored as 1 through 5 respectively. For both the response types, higher scores indicated high DM.

F. Pilot testing

Prior to the commencement of data collection for pilot testing of the tool, permission was sought from the school authorities. Participants completed the 28-items scale. The items for each of the three domains were grouped separately as three sections in the scale (Section A, B and C) with separate set of instructions for each of the sections. Participants were clearly instructed to select only one alternative from the five response anchors to indicate their response to each item. They were also explicitly instructed to respond to all the items and not to skip any of the items. Scores were calculated by summing up the respective weightage given to each response anchor, separately for each of the domain as well as for the full scale.

Scores of participants who did not respond to a substantial number of scale items (5 or more), were excluded from the obtained data set considered for statistical analysis.

G. Data analysis

Data thus obtained from the pilot administration of the tool, was subjected to confirmatory factor analysis to test the predetermined factor structure of the scale. Other statistical tests included examination of the internal consistency, descriptive statistics and domain inter-correlations. The analyses were done using MS-Excel, SPSS 16 and STATA 12.

III. Results

A. Content validity

The content validity index (CVI) for the items was calculated as the percentage of experts who agreed on the items being representative of the respective factors of DM. For strategy variables domain, there was 100% agreement among the raters for eight items, 33% agreement for one item and no agreement for one item. In case of person variable domain, the percentage of agreement was 100%, 66% and 33% and no agreement for two items, one item, five items and two items, respectively. Lastly for the task variable domain, the agreement was 100%, 66% and 33% for two items, three items and five items, respectively. The items with 33% agreement were either reworded or modified in accordance with the suggestions by the experts. Two items with no agreement and no modification suggested by any of the

experts were omitted. One item with no agreement was retained after modifying it in accordance to expert suggestion as it was considered by the authors to be of significant importance in tapping the construct.

B. Internal Consistency

Cronbach's Alpha was computed to examine the internal consistency of the measure. The estimates for the three factors, i.e., person variables, strategy variables, task variables and full measure were 0.58, 0.81, 0.57 and 0.82 respectively. The estimates for task variables factor and full measure were obtained after removing three items from the task variables factor based on the predicted improvement in the internal consistency estimates on deletion of those items. It is to be noted that the three deleted items were all reverse items probably indicating that these items may have created confusion among the young respondents thus contaminating the scores. The final scale thus consisted a total of 25 items (see Appendix).

C. Descriptive statistics

Table 1 shows the means, standard deviations, range and percentiles of the scores obtained by the participants. The mean scores on each of the factors as well as the full scale were more on the higher end of the observed range. To test the normality of the score distributions, Shapiro Wilk's test was performed. Results showed that neither the factor scores nor the full scale scores showed normal distribution.

Table 1
Descriptive statistics for scores on Metamemory in Adolescence Scale.

Measure	Person Variables (9 items)	Strategy Variables (11 items)	Task Variables (5 items)	Full Scale (25 items)
M	34.11	44.25	19.72	106.38
SD	4.75	6.51	3.20	10.87
Possible range	9-45	11-55	5-25	25-125
Observed Range	19-45	17-55	5-25	62-119
SK	-0.40	-1.17	-0.99	-0.66
Ku	0.61	2.71	2.49	0.69
Percentiles				
5	26.0	32.0	14.0	75.0
10	29.0	36.0	16.0	85.0
25	31.0	41.0	18.0	92.0
50	34.0	45.0	20.0	98.0
75	37.0	49.0	22.0	106.0
90	40.0	51.0	24.0	112.0
95	42.0	54.0	25.0	116.0
Shapiro-Wilk statistic	0.98**	0.93**	0.94**	0.97**

*Note: M=mean; SD=standard deviation; SK=skewness; Ku= kurtosis; n= 239; ** values are significant at 0.01 level.*

D. Factor structure

Confirmatory factor analysis (CFA) was conducted using STATA 12 to test the predetermined three- factor model against a single factor model with respect to goodness of fit indices, namely Chi Square/ degrees of freedom ratio, root mean square error of approximation (RMSEA), comparative fit index (CFI), Tucker Lewis index (TLI) and standardized root mean square residual (SRMR). The fit indices for each model are presented in Table 2. As is evident, the three-factor model showed a better fit in comparison to the one factor model. The standardized factor loadings for the three-factor model ranged from 0.2 to 0.67 (see Figure 1). All loadings were statistically significant at 0.001 level with the exception of one for which the loading was significant at 0.05 level.

Model	$\chi 2$ (df)	$\chi 2$ /df	RMSEA	CFI	TLI	SRMR
Three-factor model	520.3* (275)	1.892	0.061	0.769	0.748	0.069
One - factor model	442.168* (272)	1.626	0.051	0.084	0.082	0.064

Table 2
Goodness-of-fit indices for confirmatory factor models of Metamemory in Adolescence Scale (n=239).
Note: χ^2 (df), chi-square (degrees of freedom); χ^2 /df, chi-square/degrees of freedom; RMSEA, root mean square error of approximation; CFI, comparative fit index; TLI, Tucker-Lewis index; SRMR, standardized root mean square residual); *Significant at 0.001 level.

Table 3 shows the factor intercorrelations which were significant at 0.001 level with the exception of that between two factors, namely person variables and task variables. However, the covariances between the three factors were significant at 0.05 level which are presented in Table 4 .

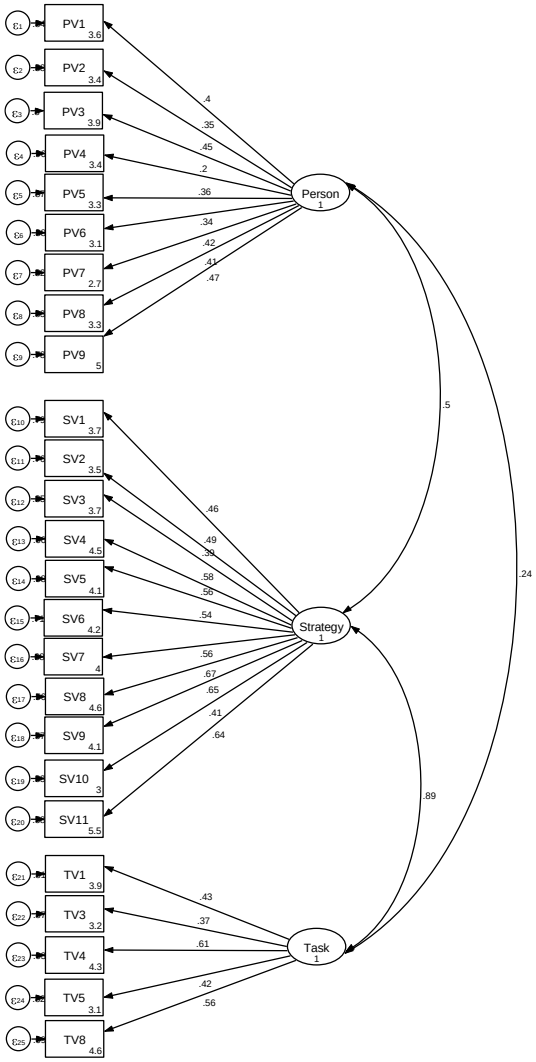

*Figure 1***.** The three-factor model with standardized factor loadings, error variances and covariance between the three factors of the 25- item Metamemory in Adolescence scale. *Note*: PV,person variable item; SV, strategy variable item; TV, task variable item; with the numbers beside them denoting the item number.

Table 3
Intercorrelation between the three factors of Metamemory in Adolescence scale.

Factors	Person variable	Strategy Variable	Task Variable
Person variable	1		
Strategy Variable	0.4*	1	
Task Variable	0.1	0.62*	1

** Significant at 0.001 level*

Table 4
Covariance between the three factors of Metamemory in Adolescence scale

Factors	Person variable	Strategy Variable	Task Variable
Person variable	1		
Strategy Variable	0.5*	1	
Task Variable	0.24*	0.89*	1

**Significant at 0.05 level*

IV. Discussion

The present study was conducted to develop a new self-report scale meant to assess declarative metamemory among adolescents and test its psychometric properties. A number of studies have reported scales on metamemory but to the best of our knowledge none of them address the metamemory of adolescents from academic learning perspective. The plethora of curricular and co-curricular activities that adolescents have to engage during school hours place great demands on their cognitive resources, memory being an inevitable one. The conceptualization that memory performance is influenced by three sets of factors, namely person variables, strategy variables and task variables, formed the basis of the present scale.

Initially, a 30- item scale was subjected to content validity analysis which revealed the degree to which the items developed for the tool were representative of DM as well as its three dimensions or factors. Modification of items were undertaken based on the content validity indices and expert suggestions. Also, the comprehensibility, ambiguity and clarity of the items were taken into consideration while making changes.

The internal consistency of the resultant 28-items scale was examined. Following the omission of three reverse items revealed the scale as being highly reliable. Thereafter, psychometric properties were examined with the scale finally comprising of 25-items (see Appendix).

Results of CFA revealed that a 25-item three factor model adequately fit the data. The superiority of a three factor solution over a single factor solution in terms of estimates of fit indices is indicative of the multidimensional nature of the scale. As suggested by previous studies, the construct of metamemory is multidimensional in nature (Troyer and Rich, 2002; Gilewski, Zelinski and Schaie, 1990). This could justify the use of the subscales separately for the assessment of the separate dimensions of declarative metamemory.

The inclination of the mean scores towards the higher end of the possible range suggests that declarative metamemory was high in the present sample. Schneider and Lockl (2002) demonstrated that by the time individuals reach adolescence, they develop impressive knowledge about memory strategies and factual knowledge about memory. So, the present finding is in line with previous research. Mean scores on the higher end in case of person variable factor might be suggesting that adolescence not only develop impressive factual knowledge

about memory but are also self aware of their memory capacity and limitations.

There was no a-priori hypothesis about the relationship between the scale domains. It was observed that the domains were intercorrelated with the exception of correlation between person variable and task variable. The observed relationship between the person variables domain and strategy variables domain suggests an association between self-awareness about memory competencies and general knowledge about relative effectiveness of memory strategies. Ideally, it is expected that individuals who can make appropriate metacognitive judgement about their memory make use of efficient memory strategies that suit their needs. This warrants them to have the knowledge about the various memory strategies even though they might not necessarily make use of those strategies. A significant relationship between strategy variables and task variables domains is an indicator of the possibility that the knowledge about various memory strategies develops in the context of knowledge about memory task characteristics and demands. Finally, an individual's general perception of his or her memory competence may develop as a result of various social factors such as judgements and remarks made by significant others and does not solely take shape as a result of exposure to memory demanding situations. This could be a possible reason for a non-significant and low correlation between person variables and task variables domain.

Overall, the 25-item scale showed promising psychometric properties which makes it a sound tool that can be used for assessing declarative metamemory among adolescents, both in classroom setting as well as for research purpose.

V. Limitations and Future Directions

Since the tool is at its infancy stage, there are a number of issues that still need to be addressed. A limitation of the study is that the convergent validity could not be established due to lack of similar metacognitive tools for adolescents. However, the validity of the scale could be established by examining the association of the subscales with measures of constructs such as memory self-efficacy, locus of control, academic achievement, etc. It might be reasonable to expect that an individual's knowledge and beliefs about his or her memory will have some reflection on the aforementioned constructs and vice versa.

Another limitation of the study was that we did not examine the item characteristics in terms of item difficulty and discrimination. Further research examining item characteristics will assist in refining the items which in turn can be expected to bring about improvement in model fit with respect to the existing factor structure.

Additional research can be undertaken to use the tool to explore the developmental trend of declarative metamemory across the substages of adolescence, viz., early middle and late adolescence. It is a well established fact that cognitive skills exhibit an accelerated growth during the adolescent phase of life. Finding out whether this applies to metacognitive knowledge as well, would further upgrade our understanding of the related mechanisms underlying the development of cognitive functions (memory, in this case).

VI. Conclusion

The present study was an attempt to introduce a scale for assessing declarative metamemory of adolescents from a holistic standpoint. Extant literature witnesses a lack of such a self-report measure which gauges declarative metamemory for the adolescent age group, especially from an academic learning perspective. In this study, we attempted to address this issue by developing the Metamemory in Adolescence scale. The robustness of the measure was examined through (i) content validity analysis; (ii) internal consistency analysis; (iii) confirmatory factor analysis; and (iv) factor intercorrelations.

The findings thus obtained provide evidence for the scale being a reliable and valid measure of self-referential beliefs and factual knowledge about different aspects of memory. However, additional research is required for the further refinement and improvement of the scale in terms of item characteristics.

Appendix

The items included in the final version of the scale are listed as follows. The values in parentheses represent the respective factor loadings for each item.

Person variable

1. I find it hard to remember words that are difficult for me. (.40)
2. I feel I can improve my memory. (.35)
3. I feel confident of remembering what I learn in school. (.45)
4. I give up easily when I cannot remember an answer. (.20)
5. I know exactly how much I will be able to remember after learning a lesson. (.36)
6. I forget important points of a lesson I learnt. (.34)
7. I remember lessons better than my friends. (.42)
8. I think my memory will improve when I grow older. (.41)
9. I remember my lessons because I pay attention in class. (.47)

Strategy variables

1. Rhyming a new word with a known word helps us remember it.(.46)
2. Using acronyms (e.g. VIBGYOR for order of colors in a rainbow) can help us remember list of words. (.49)
3. Writing down the steps of a process (e.g., steps in math problems) is a good way to remember the process. (.39)
4. Asking ourselves questions about the learnt lesson can help us remember the lesson. (.58)
5. Creating a picture in our mind of what has been read is a good way to remember the lesson. (.56)
6. Learning a chapter, again and again, can help us remember the lesson. (.54)
7. Relating new concepts with known concepts helps us remember them better. (.56)
8. Underlining/marking important points in the textbook help us to memorize them. (.67)
9. Asking a friend to quiz us on a lesson that we learnt can improve our memory for the lesson.(.65)
10. Going through the alphabets one by one can help remember a word that we have forgotten. (.41)

11. Understanding the meaning of words helps us remember them better. (.64)

Task variable

1. In an exam, answering multiple choice questions is easier than answering subjective questions. (.43)
2. A recently learnt lesson (say 1 or 2 hours ago) is easy to recall compared to the one learnt a week ago. (.37)
3. Diagrams in a chapter help us remember details better. (.61)
4. A story is easier to remember than an informative chapter (e.g. geography chapter). (.42)
5. Pictures in a chapter help us remember the information better. (.56)

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