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Review

Metamemory among Adolescents: A Review

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ABSTRACT

Metamemory refers to the monitoring and control of memory processes. Theorists also include general knowledge and beliefs about memory processes under the purview of metamemory. Researchers have investigated various aspects of metamemory across various age groups and clinical groups over the last few decades. However, metamemory research among adolescent population seems to be relatively less, particularly in the past 10-15 years. The present review examines metamemory studies among the adolescent population (both general and clinical populations) in recent years. Book chapters and metamemory studies on adolescents(from 2000 to present) were reviewed. The studies included in this report were obtained from Google search and other specialized databases such as ScienceDirect and APAPsychNET with relevant keyword feeds. Review suggests that majority of metamemory studies have mostly been conducted on adults, old adults and children from both general and clinical population. The adolescent group has received little attention in recent years. Another observation is a differential pattern of correlation between metamemory and memory performance.

Keywords: *Metamemory, Memory, Adolescents.*

In the words of ancient philosophers like Descartes and William James, humans have been vested with a multitude of cognitive abilities. In addition to employing these abilities, researchers suggest that humans play an active role in monitoring and controlling these abilities. This is the essence of metacognition, which is a higher order cognitive ability. Simply put, it involves watching over one's own cognitive processes and thereby guiding it. This paper focuses on a specialized form of metacognition called 'metamemory', with special emphasis on this ability during adolescence- the life phase usually associated with rapid development of cognitive abilities.

In the following review, the concept of metamemory and the early theories and models will be briefly discussed, followed by review of recent research done on metamemory with special focus upon the adolescent population (both general and clinical population). The paper points

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out the potential gaps in the field of metamemory research and concludes with a discussion of the future research directions and implications of the same.

Metamemory

Since the advent of this concept, there has been a lack of consistency among researchers in defining the term 'metamemory'. The propounder of the concept, John Flavell (1971) defined metamemory as,"…(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". Years later, Dixon and Hultsch (1983) defined metamemory as "the knowledge one possess about the functioning, development, use and capacities of the human memory in general, and one's own memory in particular". More recently, Dunlosky and Bjork (2008) have defined metamemory as "people's knowledge of, monitoring of, and control of their own learning and memory processes." Even though these definitions speak of different aspects of metamemory, in essence, metamemory refers to the general knowledge one possesses about the functional aspects of memory, the self-referential judgements about one's own competence in monitoring and controlling learning and retrieval of information, and the use of this knowledge and experience to tailor one's memory performance.

Clearly enough, metamemory is a unified concept which comprises of concepts like memory monitoring, memory strategies and memory control. Memory monitoring refers to the assessment of one's own current state of, as well as, progress in learning and remembering that knowledge. For example, a student may evaluate the current state of knowledge while studying. Memory strategies are schemes or approaches through which one attains the desired level of memory performance by skillful effort. Well known memory strategies include using acronyms(abbreviated form of a string of words, e.g.., NASA for National Aeronautics and Space Administration), associations(identifying relationship between words or ideas), acrostics (a sentence made up of words, the first letters of which stand for some other words, for example, in the sentence 'My Very Educated Mother Just Showed Us Nine Planets', The first letter of each word gives the first letter of the planets, in order: Mercury, Venus, Earth, Mars, Jupiter, Saturn, Uranus, Neptune, Pluto.), etc, to learn and remember information. Memory control refers to processes that govern memory behaviour. For instance, a student who feels that his/her learning has not been adequate, he/ she may decide to re-learn a lesson to attain the desired level of learning and/or desired level of retention of the learnt materials.

Early models of metamemory

The earliest model of metamemory draws from the metacognitive model suggested by Nelson and Narens(1990) (see Fig. 1). This model suggests there are two cognitive levels- meta-level and object level that exchange information in a hierarchical way. The meta-level receives information from the object level by means of monitoring, and with the information thus obtained exercises control over the object level by providing information to and modification of the object level. In purview of metamemory, the metalevel signifies metamemory whereas the object level signifies memory itself. As the model suggests, metamemory monitors or

observes the status of one's learning and memory performance and the information thus obtained is then used to regulate memory behaviour and memory performance.

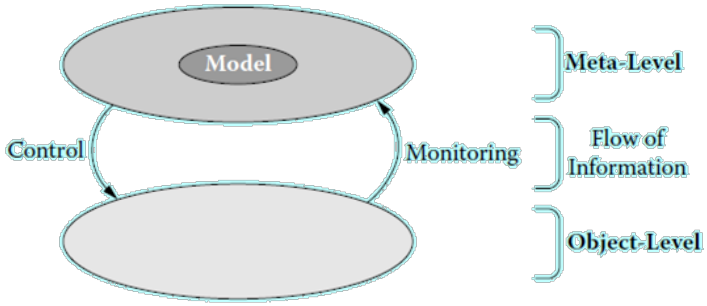

Figure 1. The integrated framework suggested by Nelson and Narens (1990) relating metacognition (meta-level) and cognition (object-level) that leads to monitoring and control processes. (Adapted by Dunlosky and Bjork in J. Dunlosky & R. A. Bjork (Eds.), A handbook of metamemory and memory (pp. 11-28). Hillsdale, NJ: Psychology Press.,2008b).

Following this simplified and direct model depicting metamemory in relation to memory, Nelson and Narens(1990) put forward yet another model of metamemory which was more elaborate in nature(see Fig. 2). This model portrays the various memory monitoring judgements and memory control processes in the order in which they occur at various stages of memory. The upper panel of the figure shows the different types of monitoring judgements and the control processes that take place during acquisition and retrieval phases of memory. These judgements or processes may not always occur consciously. A simple task like grocery shopping is a good example. While some people carry a list of the items to be bought, some do not. Such a difference in behaviour is dependent on whether one can remember all the correct items, the judgement of which is not always a conscious one.

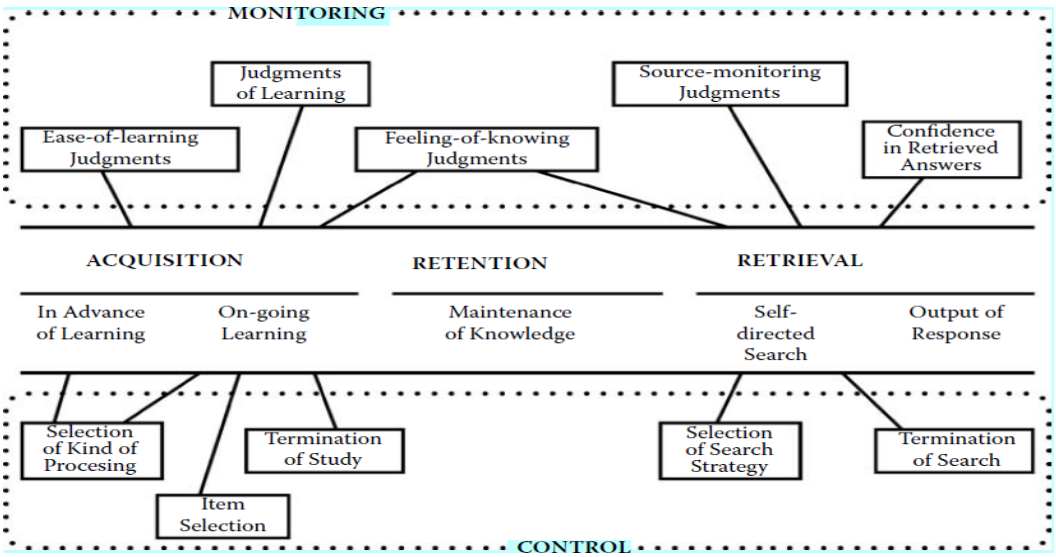

Figure 2. The Nelson and Narens (1990) framework. (Adapted by J. Dunlosky, M. Serra, and J. M. C. Baker, in F. T. Durso, R. S. Nickerson, S. T. Dumais, S. Lewandowsky, & T. J. Perfect (eds.), Handbook of Applied Cognition, 2nd ed., Wiley, New York, 2007.)

METAMEMORY IN ADOLESCENCE

The adolescent phase of life is characterised by rapid development of cognitive and metacognitive abilities together with the emergence of self concept and an improved ability to monitor behaviour. As Piaget (1936) suggested in his theory of cognitive development, higher order cognitive skills do not reach their peak of development until the adolescent phase. Theorists are of the view that such development requires the development of metacognitive skills, i.e., ability to monitor and control or regulate cognitive activities. Such a conceptualization refers to knowledge about one's own memory abilities, knowledge about how memory functions for different tasks and what strategies can be used to handle such tasks. These aspects closely correspond to the metamemory facets put forward by Flavell(1979)-metamemory knowledge, metamemory experience and metamemory skills.

Metamemory knowledge has been reported to develop as early as preschool years (e.g., Paulus, Proust and Sodian, 2013) and gradually improve over elementary years of school (e.g., Krebs and Roebers, 2012), finally reaching a peak point during adolescence and stabilizing during adulthood(e.g. Weil et al, 2013).

Early literature on metamemory has witnessed a differentiation between declarative and procedural metamemory (e.g., Flavell and Wellman, 1977; Schneider, 1999). Declarative metamemory involves statable knowledge and beliefs one holds about memory and factors and variables affecting memory, whereas procedural metamemory involves knowledge or judgements about memory monitoring and control processes. According to Cavanaugh and Perlmutter (1992), declarative metamemory is one where assessment is not followed by a subsequent memory performance whereas procedural metamemory is one whose assessment is followed by a concurrent memory performance. Even though declarative metamemory develops quite early in life, procedural metamemory rarely develops before early adolescence (Schneider, 1998). Research suggests that young children are well aware of how and what factors may affect learning and memory performance, but are not competent enough to apply that knowledge to regulate or improve their memory performance. Adolescents, on the other hand, develop sophisticated methods for efficient memorization and retrieval of information and tailor their memory behaviours accordingly (e.g., Ornstiein, Haden and Elischberger , 2006). A plausible reason, as researchers opine, for such a difference is that young children have comparatively less experience with moulding their learning behaviour in relation to their factual knowledge about memory strategies and factors that affect memory performance. Thus, the ability to monitor one's memory behaviour and to use this knowledge and other controlling techniques efficiently in mediating memory performance undergoes a gradual improvement with increase in age and experience.

Declarative metamemory has mostly been assessed using questionnaires, whereas procedural metamemory has been assessed following the 3 most common paradigms- ease of learning(EOL) judgements feeling of knowing(FOK) judgements, and judgement of learning (JOL).EOL judgements refer to judgements made prior to a learning task indicating how easy or difficult the task would be. JOL are judgements about how well a learning task has been

performed or how confident the learner is about his/ her performance in an upcoming memory test for the learned material. FOK judgements refer to judgments about how confident one is about correctly identifying currently unrecalled information in an upcoming recognition test.

Quantifying metamemory

The idea behind quantitative assessment of metamemory is to assess how accurately one can monitor or judge one's memory performance. This accuracy is basically a measure of the relation between the judgements and actual performance on memory tasks. One of the widely used method to calculate this relation is the Goodman- Kruskall gamma correlation (Goodman and Kruskall, 1959). It is employed as a measure of association between two ordinal variables. In case of metamemory or metacognition, it is a measure of relative accuracy of the monitoring judgements. Like all other correlation coefficients, its value ranges from -1 to +1. A value close to +1 indicates that the monitoring judgements are highly accurate, i.e., the individual can accurately distinguish between the items that s/he remembers well and those that s/he cannot remember well. Conversely, a value close to -1 indicates that the individual has given high metamemory judgements for items that s/he remembers poorly and vice-versa. Thus, even if a person performs poorly on a memory test, his/her metamemory would be high if he/she correctly identifies the poor performance.

Findings from metamemory studies among adolescents: general population

Adolescence period roughly corresponds to the teenage years of life. It is a period characterized not only by rapid physical development but also psychosocial development. It is considered to be a complex transition period where childhood dependencies give way to social independence of adult life (Greenfield, Keller, Fuligni, & Maynard, 2003; Steinberg, 2002). Even though there is no clear cut age range that defines adolescence, the age range that is generally considered to represent adolescent period is 10-18 years (American Psychological Association, 2002). However there have been inconsistencies in the literature where the chronologic definition of adolescence has incorporated ages from 9 to 26 years (Society for Adolescent Medicine, 1995). Going by the general notion, the present review incorporates studies that have considered participants within the age range of 10-18 years as adolescents.

One of the primary findings from metamemory research is that the ability to regulate and control memory shapes up during adolescence. Apart from this, metamemory research has provided many other information about the development of different monitoring and control processes based on the metamemory knowledge possessed by adolescents.

Research findings suggest that adolescents as young as 10 years old are competent enough to monitor their own memory. For example, in the study by Roebers,von der Linden, and Howie (2007) investigated whether adolescents could differentiate between information that was shown and that was not shown to them, based on their monitoring ability. 10 year olds were asked to rate the extent to which they could remember the contents of video clippings. They

were subsequently tested for the information shown. The test included some misleading questions and it was observed that they could differentiate between correct and misleading questions. This discriminating ability correlated with their judgements about their memorability (gamma correlation coefficients ranging from .53 to .70).

Tracking the developmental pattern for metamemory behaviour, i.e., use of memory strategies for controlling memory performance has also been an area of interest among metamemory researchers. A recent study by Daugherty and Ofen (2015) showed that adolescents show preference for deep level processing or encoding strategy in comparison to children who tend to prefer shallow level processing or encoding strategy. The participants in the study were given two recognition tasks- single word recognition and word pair recognition. These tasks were followed by the filling up of a metamemory questionnaire assessing their beliefs about the efficacy of different mnemonic strategies. Results indicated that even though both children and adolescents were aware of the effectiveness of deep encoding strategies, adolescents were more adept at implementing them in the memory tasks and hence performed better than children. The authors were of the view that the ability to use mnemonic strategies develops gradually with age and that young children have a tendency to underestimate the effectiveness of deep encoding strategies and hence go for the shallow encoding techniques.

However, reaching adolescence phase does not always guarantee optimal memory monitoring or control. Differences in memory performance may occur within this group based on other cognitive abilities. For instance, a study by Vidal-Abarca, Mana and Gil (2010) assessed a group of adolescents on their ability to regulate their learning in a comprehension task. Results showed that participants with better comprehending skills were more likely to give higher JOLs compared to those with poor comprehending skills. They were also more efficient in figuring out incongruities in the comprehension questions. Furthermore, they were more proficient in regulating their restudy behaviour in comparison to poor comprehenders.

In line with these findings, studies have also shown that even though children are considered to show overconfidence in metamemory judgements (e.g. Koriat and Shitzer-Riechert,2002; Vise and Schneider, 2000), adolescents too, can show such overconfidence under certain situations. A study by Lipko et al., (2009), showed that adolescents overrated their recall performance when there was no provision to compare their performance against a standard. They performed experiments where students from the 8^{th} standard were made to study standard definitions of different terms and were tested later on a recall test. The students were tested under three conditions- recall test (i) without provision to compare the response with standard definitions (ii) with provision to compare with exact standard definition (iii) with provision to compare with basic units of standard definition. Students showed overconfidence in judging the correctness of responses in the first condition but this overconfidence gradually decreased over the other two conditions where they could evaluate their responses against the

given standards. Such findings point towards the utility of providing experience to students about effectively monitoring their learning and memory.

Another interesting issue that has received much attention recently is the developmental differences in knowledge about others' learning and memory. Investigating such an issue has been opined to have implications for collaborative learning and social cogniton. In a recent study, Paulus, Tsalas, Proust and Sodian (2014), examined the developmental trend of developing knowledge about the learning and memory processes of others and speculated the underlying causes for the obtained findings. They carried out the study across four different age groups- 6-7 years old, 8-10 years old, 14-15 years old and adults. The participants were made to participate in a paired-associate learning task(termed 'self task') either before or after another task where they were made to see other people performing the same task in video clippings(termed 'other task'). The items used in the self task were either easy or difficult based on degree of semantic association. The video clippings were also manipulated based on the length for which they were shown. In the self task the participants were to provide JOLs for each of the items after studying them. Similarly, for the other task, they were to give JOLs for the person in the video clipping. The basic idea was to investigate whether participants use their experience cues to give judgement for other people's learning. Results revealed that individuals do use their own experience as a cue to base their judgements about others' learning and memory. However, there are developmental differences in the use of such cues. For instance, adolescents and adults use study time allocation (viz., length of the videos) as a cue to base their judgements which is not observed in case of children.

In summary, results of these metamemory studies suggest that adolescents possess a well developed knowledge about their memory. However, there may be instances where adolescents can display overconfidence in their metamemory judgements and hence engage in faulty memory monitoring, which in turn may affect their memory performance. Such faulty monitoring can, however be checked through proper guidance and feedback. Furthermore, metamemory is contingent on other cognitive abilities such as comprehension abilities. Lastly, adolescents judge the metamemory of others based on their own metamemory experience.

Findings from metamemory studies among adolescents: clinical population

Studying metamemory among the general population has provided important insight about what underlying processes check and supervise the various memory processes and how. Research has also helped understand the developmental trajectory of various metamemory processes. We now look at the studies that have focussed their investigation of this construct among the clinical population.

1. **Metamemory and autism.** Metamemory has been studied among adolescents with autism or autism spectrum disorder with the view to understand the cognitive difficulties and their underlying causes faced by this group. Wojcik, Moulin and Souchay (2013), conducted a study which probed the uniformity of metamemory

deficits among autistic adolescents across different forms of memory. Participants were made to take part in two types of feeling of knowing (FOK) tasks- semantic memory task and episodic memory task. Results showed that the metamemory deficits were only manifested during the episodic memory task and not in case of the semantic memory task. In fact, the austistic group was at par with the control group in giving accurate metamemory judgements in the semantic task, thus making it clear that the metamemory deficits observed among the autistic group does not extend to all forms of memory. The authors attributed this difference to an inability to recollect enough context related information which results in inaccurate FOK judgements in episodic memory.Yet another study by Souchay et al.(2012) portrayed a slightly different picture. They showed that even though adolescents with autism spectrum disorder were competent enough to recollect contextual information , they differed from normal controls in showing confidence in their recollection ability when perceptual aspects (in this case, colour and gender of the voice speaking the items) were involved . That is, when asked to give Remember-Know- Not seen judgements in a testing situation consisting of words shown previously together with distractor items, ASD group gave fewer remember judgements compared to the normal controls. Such an outcome was explained by the fact that making Remember-Know judgements are dependent on evaluating self-related information and people with ASD have difficulties in processing the self-related experiences in relation to the past.

2. **Metamemory and Mental retardation.** Another disability that has been studied in relation to metamemory is mental retardation. The literature on mental retardation suggests that the memory difficulties experienced by these individuals are partly due to their poor knowledge about memory, which in turn results in a reduced ability to use or generalize memory strategies efficiently (e.g. Valkil, Shelef-Reshef and Levy-Shiff, 1997). In view of these findings, Perez and Garcia (2002) studied whether adolescents with mental retardation could improve their metamemory following appropriate intervention. This intervention programme included (i) informing the adolescents about layout of the programme, (ii) familiarizing them with various concepts related to metacognition and metacognitive strategies, (iii) acquaint them with organizational strategies and (iv)providing opportunity to identify and solve problems independently. The post-intervention results reveal that there was significant improvement among the study group compared to the control group. Mentally retarded adolescents gained knowledge about the benefits of organizational strategies in learning new materials as well as the advantages of learning well associated information over poorly associated information.
3. **Metamemory among the brain injured.** Among the plethora of shortcomings faced by brain injured children and adolescents with regard to physical, social and emotional development, crucial among them is impaired cognitive development. In this context, research has suggested that it is memory that is of real concern among this group, as it is the pivotal cognitive ability required to function efficiently in day-to-day life. In addition, proper memory functioning is required by children and adolescents to learn and acquire knowledge and life skills. Brain injury has been documented to result in detriments in explicit memory; impaired delayed and immediate recall ability for both

verbal and non-verbal information (Allen et al., 2010). A recent study by Kizony, Tau, Bar and Yeger (2014) investigated how metamemory is affected among brain injured children and adolescents. Results showed that a majority of the study group (68.8%) reported having low memory abilities than normal peers. There were also differences in the use of memory strategies used by the two groups. While the normal group used context as a learning strategy, those in the brain injured group mostly used rehearsal as their learning strategy. Also, when made to estimate their performance on the memory tasks, the study group gave overconfident estimates than the control group, indicating a lack of ability to monitor their performance. Lack of meta-cognitive experiences was thought to be the reason for such an outcome.

POTENTIAL GAPS AND FUTURE DIRECTIONS IN METAMEMORY

Current status of metamemory research among adolescents

Even though the adolescence period is considered to be a crucial phase in development, the recent trends in metamemory research suggests that this group has been comparatively less represented and explored in metamemory research. 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 it was 347 and 499 results respectively. A similar search on APA PsychNet returned 8 results for adolescents and 9 for children, whereas 90 studies in case of adults. These figures provide an idea of the lack of metamemory studies on the adolescent group. There is also a scarcity of Indian studies on metamemory focusing on this age group. Therefore, more research involving this age group would help develop theories and thereby understand the underlying processes of memory development during adolescence.

Criticisms of metamemory tasks

Using lists of words, associated word-pairs, picture, etc. in metamemory experiments have no doubt helped in understanding the underlying mechanisms of how people monitor and supervise memory. However, findings from such tasks often show less generalizability, given the diverse nature of memory tasks people engage in their daily lives. In this context, researchers have also pointed out that school going children and adolescents engage in a number of cognitive activities which require memory (e.g. problem solving) and are far more challenging than learning word pairs. Metamemory for such challenging tasks have seldom been investigated. Research employing cognitively more challenging tasks would provide important insight into how metamemory is used to monitor and regulate memory behavior in the diverse cognitive activities people engage in daily. For example, de Bruin and van Gog(2012), pointed out that, with the rapidly evolving cybertechnology, the learning environment is also evolving. A practical example is accessing and learning information through hypertexts (e.g. hyperlinks on a webpage, such as Wikipedia). Investigating the monitoring and regulation of memory in such diverse learning environment could unravel how memory works in more complicated learning situations.

In this context, another interesting issue that warrants attention is how metamemory works in or influences situations that require other higher order cognitive processes such as problem solving and decision making. Problem solving and decision making tasks both require working memory along with other cognitive processes to traverse through the different stages of problem solving and decision making. Research incorporating metamemory theories and findings in understanding of other cognitive processes would explain the relationship among the higher order cognitive and metacognitive processes.

Link between Metamemory and Memory performance

Metamemory research with children has revealed that metamemory and memory are related to each other(e.g. Koriat, Goldsmith and Pansky, 2000). However, such relations have been observed to grow stronger with age and experience. The metamemory-memory link has been observed to be the strongest between knowledge of memory strategies and the use of it (Schneider, 2015). A meta-analysis by Schneider and Pressley (1997) evaluated more than 60 metamemory studies on children and adolescents which gave an average correlation of 0.41, indicating a moderate relationship between metamemory and memory performance. Some researchers have attributed this outcome to nature of tasks, lack of experience with metamemory tasks, age, etc (Schneider, 2015). Additional research is required to understand the cause behind obtaining poor to moderate correlation between metamemory and memory when a high correlation is theoretically expected. Moreover, with substantial number of researches on children and adults, exploring such relations across the adolescent phase would provide the developmental pattern of memory as well as metamemory.

IMPLICATIONS OF EXPLORING METAMEMORY AMONG ADOLESCENTS

With advances in the academic field, it has become a challenge for educators to guide students to gain maximum output in their academic endeavours. Students employ memory in almost all academic activities that they engage in. In this context, educational psychologists have started focussing on the effects of self-monitoring and metacognitive control on learning outcomes. Probing the relationship between memory and metamemory and the factors that influence this relationship, can make way for developing educational programmes that aim at improving memory monitoring and controlling abilities.

As research suggests, most children and adolescents have the knowledge of mnemonic strategies but are unable to employ them accurately or do not realize when to apply them. Metamemory research can help design training programmes to create awareness among students regarding the usefulness of various mnemonic strategies and train them to make appropriate use of them in situations that demand these strategies.

Lastly, metamemory research among clinical populations can assist in identifying the underlying causes of memory deficits and failures. A thorough understanding of the metamemory deficits across different psychiatric disorders can provide important inputs in designing disorder-specific corrective interventions.

CONCLUDING COMMENTS

Given the increasing importance of metamemory research, attempts are being made to transmit the insights from these studies to educational as well as clinical settings. For instance, self- regulated learning has been considered to be important for optimal academic performance in addition to proper classroom instruction. In the present report, the concept of metamemory was briefly elucidated along with the early models of metamemory which provided a more detailed understanding of the various components and facets of metamemory. The recent metamemory studies on the adolescent group was reviewed with a view to understand the operation of monitoring and control processes during this crucial life phase characterized by rapid cognitive development. The findings suggest that even though metamemory abilities are considered to be well developed among adolescents, there are evidences that it is not uniformly developed with respect to different metamemory components. Furthermore, research has suggested that various memory deficits among the different clinical groups can be attributed to deficits in metamemory abilities. However, given the comparatively less number of studies among adolescents group, additional research is warranted to fully understand the developmental pattern of the memory-metamemory relationship.

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