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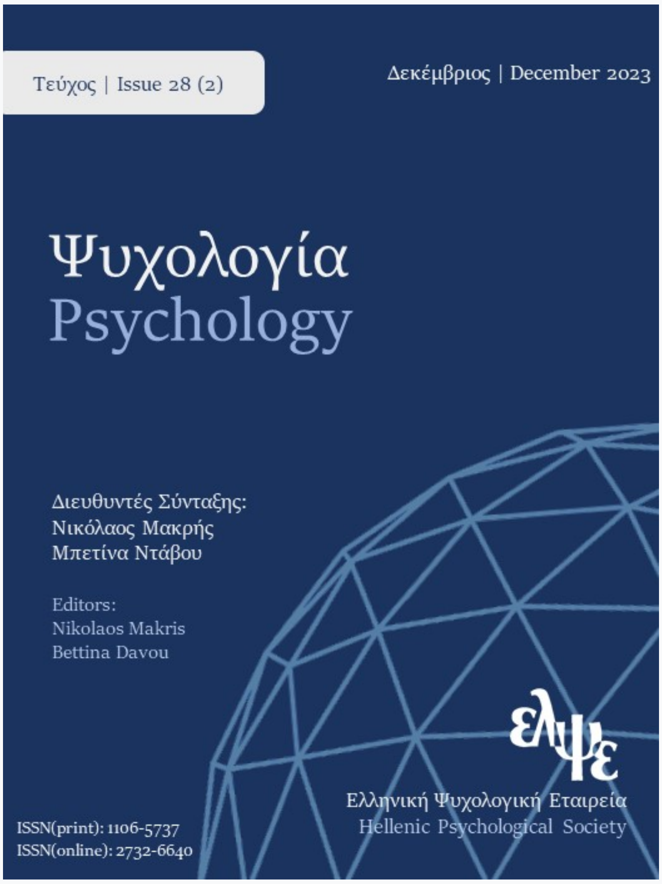

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Executive functions, listening comprehension, and metacognitive processes in childhood: Developmental profiles

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ABSTRACT

Despite the established interplay between executive functioning and metacognition, evidence remains limited regarding children's metacognitive monitoring in the form of offline performance estimates of their executive efficiency. Moreover, we know little about the relations among listening comprehension, executive functions, and metalinguistic awareness in childhood. The present study constitutes a first exploration of developmental profiles related to executive functioning, listening comprehension, and corresponding metacognitive-metacomprehension monitoring in periods marking their emergence and interplay. Participants were 95 preschoolers (Mage 5.5), and 109 second graders (Mage = 7.5). Executive function (i.e., working memory, inhibition, and cognitive flexibility) and a listening comprehension task were administered, along with offline performance estimates following completion of each task. Fluid and crystallized intelligence tests were also administered. Cluster analyses were applied. Across ages, one cluster was characterized by lower cognitive performance, but overestimated metacognitive judgements, while a second cluster demonstrated the exact opposite pattern. Older children performed at a higher cognitive level. Yet, metacognitive monitoring did not improve as a function of age, in the sense that a third, metacognitively accurate cluster did not emerge among second graders. Working memory and listening comprehension, along with their metacognitive-metacomprehension estimates, demonstrated the greatest contribution to the cluster solution in both age groups. The inhibition-metainhibition measures proved stronger profile determinants in the older group. The fluid intelligence measure showed a reduced contribution with age and vocabulary proved to be a weak and insignificant distinctive characteristic of the profiles emerging among preschoolers and second graders, respectively. Findings are discussed in relation to relevant research data and theoretical suggestions regarding cognitive and metacognitive development.

Introduction

Over the last decades, a significant number of studies have focused on the development of cognitive and metacognitive operations in childhood. We have learned a lot regarding children's executive functioning (EF), its interplay with language development and its contributions to academic achievement. Parallel lines of research have focused on children's metacognitive monitoring, as applied to EF (e.g., to working memory-WM, inhibition, or cognitive flexibility) or linguistic processing (e.g., metacomprehension capacity). Yet, we still know little about the interplay of the above in shaping and differentiating profiles of cognitive-metacognitive capacity, despite the importance of the latter for learning and academic performance. To our knowledge, this is the first study concurrently examining the accuracy of young children's offline estimates about their EF and comprehension capacities as a means to discuss related metacognitive monitoring during childhood. Moreover, this is a first attempt to capture inter-individual differences in the accuracy of EF and comprehension estimates via a cluster approach that aims to identify profiles of related capacities and study their differentiation as a function of children's age. The following sections present key theoretical suggestions and recent findings on EF, metacognitive-metacomprehension, and comprehension development, along with evidence regarding their under-researched so far interplay as a function of age and accumulated educational experience.

Executive functions and their development

Despite deviations and heterogeneity in theoretical and empirical approaches, EF may best be defined as "self-regulatory and complex cognitive processes, including adaptive and flexible mental operations that are activated in new and demanding situations to improve performance on tasks" (Roebers & Feuer, 2016, p. 40). The above generic definition connotates that the term EF serves as an umbrella, under which various higher-order processes are accommodated, all at service of purposefully maintaining and achieving the cognitive task at hand. Miyake and colleagues (Miyake et al., 2000; Miyake & Friedman, 2012) identified three distinct functions: (i) *inhibition* (i.e., resisting distractor or proactive interference and suppressing prepotent responses, to focus on the cognitive task at hand; see also Friedman & Miyake, 2004), (ii) *shifting* (i.e., switching flexibly between mental sets or changing task demands – also approached as cognitive flexibility), and (iii) *updating* (information updating and monitoring). Besides, a bulk of evidence has been gathered regarding the capacity to concurrently maintain and process or manipulate information in WM (see Baddeley, 2000), with several studies focusing on the early years of development (e.g., Gathercole & Baddeley, 2014).

There is still an ongoing debate about the origins of EF, their developmental course, as well as the role of genetic and environmental effects on their development (Best & Miller, 2010; Roebers & Feuer, 2016). Although the three functions identified by Miyake et al. (2000) might not be that clearly differentiated before middle childhood (Karr et al., 2018; Nelson et al., 2017, 2022; Wiebe et al., 2008), it seems that expressions of inhibition, WM and shifting are present early on in development (for an overview, see Diamond, 2013; Zelazo & Carlson, 2012). Despite the individual differences observed, the following are rather well established: (a) infants exhibit basic EF; for example, attentional control which permits them to focus on relevant stimuli and ignore distractions, (b) in early childhood (2-5 years) EF continues to develop, as children's WM span expands, and more elaborate inhibitory control emerges, with children being more able to suppress automated or impulsive reactions, and (c) in middle childhood (6-12 years) EF becomes more refined and complex, and an increase in cognitive flexibility is observed, resulting in efficient switching between tasks.

Executive functions, their development and differentiation have drawn much scientific attention due to their significance in the overall adaptation of individuals. Indicatively, early-in-life EF efficiency has been identified as a powerful predictive factor of academic success (Gunzenhauser & Nückles, 2021; Nelson et al., 2017) and of social adaptation in early adulthood (see Diamond, 2013). As it will be argued in the sections that follow, despite a significant number of studies focusing on EF development, its links to metacognitive development and to domains of linguistic processing, such as comprehension and particularly listening comprehension among preschool-aged children, remain relatively understudied.

Metacognitive development

The term *metacognition*, as introduced by Flavell (1979), was defined as the knowledge we have of our own cognitive processes, involving two key components: *metacognitive knowledge* and *metacognitive regulation*. Metacognitive knowledge, also known as declarative metacognitive knowledge (of people, tasks, and strategies), refers to one's accumulated *knowledge about their knowledge and learning*. Metacognitive regulation, alternatively termed as procedural metacognitive skills, refers to the *monitoring* and *control* of one's cognitive processes, including planning and evaluating one's own thinking and learning.

The notion of metacognition immediately attracted scientific interest, since, as Nelson and Narens (1990, p. 1) put it, «Metacognition is simultaneously a topic of interest in its own right and a bridge between areas, e.g., between decision making and memory, between learning and motivation, and between learning and cognitive development". Following the pivotal Flavell's (1979) theory of metacognition, various alternative theoretical frameworks have been proposed (see Efklides, 2011; Kuhn, 2000; Nelson & Narens, 1994; Zimmerman, 2000), all stressing the contribution of this higher-order process that guides, evaluates, and monitors cognition in academic success, even after controlling for cognitive abilities (e.g., as those involved in solving puzzles) and/or other self-regulated learning factors, such as motivation (Marulis, & Nelson, 2021).

As far as metacognitive development is concerned, the following milestones have been identified: (a) between the ages of 2 to 3, children begin to display rudimentary signs of recognizing their cognitive abilities

(Flavell, 1979), (b) as an effect of developing their *Theory of Mind* (Wellman, 2014, 2018; Wellman & Woolley, 1990), between the ages of 4 and 5 children can consider different perspectives and understand that others may possess diverse knowledge and thoughts. This capacity for perspective-taking and their primary understanding of "how the mind works" enhances children's metacognitive abilities, (c) when entering typical educational settings (at least in developing and developed countries), around ages 6 to 8 children start applying basic metacognitive strategies (Schneider & Pressley, 1989), such as using memory aids and planning. In parallel, children at that age become more able to regulate their cognitive processes, and (d) in preadolescence (between 9 to 12 years of age), a noticeable improvement in metacognitive monitoring is observed. Assessment of comprehension and performance, as well as recognition of evaluating their own understanding, identification of errors, and adjustment of strategies, is now in order.

Numerous studies have approached the metacognitive abilities of young children in monitoring and controlling their cognitive performance. A rather common finding is that preschoolers and early school-aged children, although they roughly exhibit the ability to metacognitively monitor, control and evaluate their performance, they tend to overestimate its actual correctness (Kälin & Roebers, 2022; Lipko et al., 2009; O'Leary & Sloutsky, 2017; Roebers & Spiess, 2017). This early overconfidence is replaced by more accurate performance self-evaluations later in school life, where social or effort-based feedbacks are gradually replaced by more objective, formal instructions and ratings of children's performance in the school setting (Destan et al., 2017).

The developmental interplay between metacognition and executive functions

As fundamental components of human cognition, metacognition and EF have a role in self-control, goal-directed behavior, and adaptive learning. On one hand, EFs are a group of cognitive processes that enable cognitive control. On the other hand, broadly speaking metacognition is the process of "thinking about one's own thinking" as well as controlling and self-regulating knowledge acquisition and learning.

In an interesting theoretical approach, Roebers presented a unified framework for EF and metacognition, arguing that these notions have a great deal in common. Her main idea is "... that a core feature for an overarching framework of these two concepts concerns an individual's ability to form and use metarepresentations of cognitive and learning processes. This includes the ability to look at one's actions at a remove, ideally objectively, and to act on the information that stems from this meta-perspective" (Roebers, 2017, p. 15). In other words, in this overarching model, EF and metacognition are viewed as first-order domain-specific processes, both serving a common, domain-general second-order system of self-regulative processes.

According to Roebers's model (2017), although EF and metacognition are both considered expressions of cognitive self-regulation, their interrelation is susceptible to changes along development. Specifically, in very young ages the newly emerged, underlying ability to form metarepresentations may result in a reciprocal relation between the two. Later, between 4 and 6 years, given that meta-representational ability is mastered, EF may be a precondition of metacognition: inhibition, updating, and shifting may be prerequisites to metacognitively stop and check progress in a task, monitor and control it, and shift between strategies during problem solving, respectively. From early elementary school years onwards, when basic metacognitive skills are typically mastered and domain-specific knowledge is accumulated, children no longer fully depend on EFs, although they are facilitated by them. The final phase could explain the observed intra-individual differences, where EF efficiency does not presuppose implementation of appropriate metacognitive skills and vice versa.

Extending Roebers's (2017) model, Marulis et al. (2020) emphasize a different aspect of the relation between EF and metacognition. In their approach, the end goal when integrating metacognition and EF (either theoretically or empirically) is supporting children's ability to be agents of their own learning. The key-point to advance this agency is "...the way metacognition can help children to build agency over their own learning is by making it clear when, how and why to use EF" (p. 50).

Despite the above described prominent and conjoint contribution of EF and metacognitive monitoring in self-regulated adaptive behavior, there aren't many studies that have looked at their relationship. The limited research conducted so far in children aged from 4 to 8 years (see Kälin & Roebers, 2022) has demonstrated that a connection between inhibition and monitoring is exhibited only in younger kids (4 to 6 years). The results also refute a strong correlation between WM and shifting with monitoring. In accordance, Marulis and her collaborators (2020), citing relevant research that co-examined metacognitive processes and EFs in preschool and school-aged children, argue that although metacognition and EF share parallel developmental trajectories their emergence does not necessarily guarantee their concurrent activation when a child is engaged in a goal-directed behavior.

Given the above research and findings, one could argue that the expected relationship between metacognition and EF, although theoretically robust, has not been yet empirically established. The moderate correlations between various EF and metacognitive components could be attributed to a variety of methodological faults (e.g., inappropriate task selection) or theoretical diversities, since both concepts have been differentially approached.

The dynamics of early comprehension capacities

Comprehension involves the extraction of meaning from written or orally presented linguistic material, via one's active engagement in a linguistic interaction context (Oakhill et al., 2019; RAND Reading Study Group, 2002). During listening comprehension in particular, the individual derives meaning based on the processing of the linguistic information presented orally and perceived contextual cues in relation to semantic and strategic knowledge and episodic memory entries. Specifically, linguistic processing involves decoding of sounds or letters, retrieval of lexicon entries or inference generation regarding unknown words within a given context, as well as grammatical processing, and understanding pragmatics (Kim & Phillips, 2014). Comprehension also involves effortful, higher-order processing, aiming at the formation of hypotheses or predictions, the generation of necessary or elaborative inferences, as well as the metacognitive monitoring of the meaning extraction process and the evaluation of its outcomes (Butterfuss & Kendeou, 2018; Kim, 2016).

Over the last decades, a significant number of studies have focused on typical comprehension trajectories and related difficulties, yet, mostly within written language settings. However, listening comprehension, along with word recognition, has long been regarded an antecedent of reading comprehension capacity and a key determinant of individual variation and difficulties faced in comprehension contexts from the early years (see *Simple View of Reading*, Gough & Tunmer, 1986; see also Hogan et al, 2014; Oakhill et al., 2019). We still know little about the cognitive and the metacognitive underpinnings of this early indicator of not only literacy development but academic achievement more generally (see Altemeier et al., 2008; Cain & Oakhill, 2006; Kim, 2016; Language and Reading Research Consortium et al., 2018; Monette et al., 2011; Oakhill et al., 2005; St Clair-Thompson & Gathercole, 2006). The sections that follow attempt to critically approach and synthesize evidence stemming from lines of research relating the development of certain EFs or metacognitive capacities to the growth and variation of comprehension over childhood. As it will be made evident, we still have limited knowledge of their developmental interplay, especially when listening comprehension constitutes the focus of discussion.

The developmental interplay between executive functions and comprehension

Although we have learned a lot lately about the contributions of EFs to language processing, and several studies have focused on their associations with reading comprehension (moderate and positive; see Follmer, 2018), the role of EF in listening comprehension development has received scant attention. Comprehension in general necessitates various language (vocabulary, grammar) and metalinguistic skills (comprehension monitoring), as well as a cognitive reservoir (e.g., WM, sustaining or shifting the locus of attention, suppressing interference) to support encoding and processing of information in a given text, also in relation to long-term memory entries (see Kim, 2016). Yet, EFs might hold a more important role in supporting listening comprehension, as oral, rather than visual, presentation of linguistic material does not allow offline review and processing of its content. This might set additional demands on both the attentional system and WM in order to focus and sustain attention, minimize distractibility, and increase encoding and online processing efficiency, as the linguistic material is presented (Language and Reading Research Consortium et al., 2018; see also Aaron et al., 2002). Such demands might regard encoding and processing at both the word- or phrase-level (i.e., phonological, grammatical, or lexical, with the latter often involving inferential processing to derive meanings for unknown words) and the text-level (e.g., integration of information across sentences, automatic or strategic retrieval of information from long-term memory to generate inferences or comprehend similes based on text cues, etc.), of course under metacognitive influence.

Specifically, the scarce existing evidence confirms significant contributions of WM capacity measures (complex span tasks) to the prediction of listening comprehension in the preschool phase (Florit et al., 2009) or the first grade of elementary school (Kim, 2016). A study by Chrysochoou (2006; see also Chrysochoou & Bablekou, 2011) involving 5.5-, 7.5- and 9.5-year-olds, showed stronger WM, rather than short-term memory, contributions to the accuracy of listening comprehension. The predictive capacity of WM was actually found to decrease as a function of age and school experience, and it was stronger in the case of higher-order comprehension skills, such as necessary or elaborative inference generation and simile comprehension, which necessitate exploitation of long-term memory resources (i.e., general knowledge) for semantic processing purposes, relative to literal comprehension capacity (memory for the text).

The contributing role of the inhibitory control aspect of EF has also been studied, but with studies again focusing mostly on reading comprehension (e.g., Cain, 2006). Prepotent response inhibition, resistance to distractor interference, as well as resistance to proactive interference aspects of inhibition (see Friedman & Miyake, 2004), seem to constitute correlates of early reading comprehension efficiency (e.g., Blair & Razza, 2007; see also Butterfuss & Kendeou, 2018; Christopher et al. 2012). Moreover, evidence suggests that difficulties in inhibitory processes influence the performance of poor comprehenders (e.g., Borella et al., 2010; De Beni & Palladino, 2000; De Beni et al., 1998, exp. 2; Gernsbacher, 1997).

In particular, evidence has highlighted the role of suppression in word- and sentence-level comprehension (Gernsbacher, 1991). The ability to resist interference from distracting information, that is, either relatively encoded information (e.g. phonological codes for letters or letter units) or semantically relevant information (e.g., semantic entries in the mental lexicon), is thought to affect memory at both the encoding and retrieval stages (de Ribaupierre, 2002; see also Altemeier et al., 2008). Prepotent response inhibition contributions to reading comprehension have also been reported (see overview in Butterfuss & Kendeou, 2018). In the Kieffer et al. (2013) study, for example, performance on a stroop task predicted 9–10-year-old children's ability to employ top-down processes that are necessary for comprehension, including suppressing irrelevant information, synthesizing key information, and generating inferences. Christopher et al. (2012) actually showed that less skilled comprehenders require more time to ignore irrelevant information and restrain dominant responses.

Similarly, the role of the ability to consider or flexibly shift between multiple tasks or cues (see Miyake & Friedman, 2012; see also Zelazo et al., 2003) in comprehension development has not received great attention so far. Text comprehension, however, requires the active coordination of multiple activated elements and quite often young children, as well as poor comprehenders more generally, are inflexible in their processing (Cartwright, 2015; see also Cartwright, 2008, 2009). Moreover, comprehension relies on the coordination of general world knowledge with bottom-up (vocabulary, grammar) and top-down (pragmatic) information processing (see Kendeou et al., 2016). Both oral and reading comprehension would necessitate flexible allocation of attention to multiple semantic or grammatical cues concurrently (see also Cartwright, 2015). As Butterfuss and Kendeou (2018) suggest, shifting might facilitate comprehenders in effectively engaging from lower-level reading to appropriately considering phonological and semantic information in the text, alternating comprehension strategies, as well as monitoring comprehension and engaging in metacognitive processing. Moreover, the ability to suppress perseveration in the face of syntactic or semantic ambiguities during online language processing might be a key determinant of comprehension capacity (see Kieffer et al., 2013).

Existing evidence remains scarce, however, and, to our knowledge, it mostly regards cognitive flexibility with reading comprehension contexts. Altemeier and colleagues (2008) found that longitudinal change in rapid automatic switching and a combined inhibition/shifting measure from Grade 1 onwards was related to reading comprehension in Grade 4. In a series of studies focusing on reading comprehension in children as well as in adults, on the other hand, Cartwright and colleagues (see overview in Cartwright, 2015) indicated the important role of graphophonological – semantic flexibility in reading comprehension efficiency, beyond that of general intelligence and phonological or semantic processing capacities. In the Johann et al. (2020) study with 9-year-old children, cognitive flexibility and fluid intelligence were positively related to reading comprehension. In addition, interestingly, Kieffer et al. (2013) showed that shifting capacity (as tapped by perseverative errors in sorting) contributed both directly to reading comprehension, as well as indirectly via language comprehension (see also Spencer et al., 2020 for the significant mediating role of receptive language capacity more generally). Regarding age, Altemeier and colleagues (2008; see also Altemeier et al., 2006) found that the predictive ability of key EFs - including inhibition and shifting - for reading comprehension was more greatly evident in the early elementary years and declined with age and school experience. To our knowledge, there is no developmental evidence for inhibition and cognitive flexibility contributions to listening comprehension capacity.

Metacognition in comprehension contexts

As mentioned in the relevant section, metacognition refers to one's ability to monitor, control, and accurately evaluate their learning process and make necessary cognitive adjustments to improve performance. Metacognition in comprehension is the process during which comprehenders derive meaning from linguistic material, by creating a mental representation that contains all the salient information needed to adequately understand what was said or read. Of course, this demands cognitive skills such as decoding at the word and sentence level, grasping links between sentences, and using prior knowledge to holistically make sense of the text, to name but a few (Baker, 2017). Metacognitive knowledge in comprehension refers to comprehenders' capacity to accurately estimate their knowledge of the linguistic material, in order to derive in depth meaning and effectively monitor and regulate comprehension. Thus, *metacomprehension* "involves metacognitive processes that support comprehension, allowing readers *(*or oral comprehenders*, authors' note)* to evaluate the understanding in progress, and tentatively implement the necessary adjustments to improve the level of coherence of the mental representations generated in the reading (or listening*, authors' note*) process" (Soto et al, 2019, p. 3). Good comprehenders realize whether they have gaps understanding what was said/read and take suitable steps to achieve a higher comprehension level, by controlling and regulating their comprehension; they possess high metacomprehension accuracy.

Development of metacomprehension

In general, research on metacognition within listening comprehension contexts is very limited. A reason may be that oral and written comprehension have several metacognitive components in common, for example metacognitive knowledge, monitoring, and regulation. However, in research and practice the focus has started to shift towards the investigation of listening comprehension capacities particularly among preschoolers, thinking that effective listening comprehension constitutes an antecedent of reading comprehension capacity later in school (DeBruin-Parecki et al., 2015). Literature shows that metacognition and comprehension are interwoven with cognitive and linguistic operations (Baker, 2017).

As Baker (2017) notes, limited research examines children's metacognitive development using a long age range. Eme and colleagues (2006) found that third and fifth grade French schoolchildren differed in their metacognition; younger children mentioned fast and errorless reading as a key feature of good readers, while older ones reported that context comprehension is a key of good readers. In an interesting study, Annevirta and Vauras (2001) followed Finnish children from kindergarten to grade 3, examining metamemory, metalearning and metacomprehension knowledge using qualitative methods. Elements of metamemory were observed in preschool, of metalearning in grade 1, whereas metacomprehension monitoring and evaluation developed last, appearing in grade 3. Similarly, Annevirta et al. (2007) showed quantitative increases in metacognition. They again followed children from kindergarten through to grade 3 and observed a greater increase in metacognitive knowledge from grade 1 to grade 2 than from kindergarten to grade 1. This finding may implicate the role of formal education in the development of metacognition (see also Annevirta & Vauras, 2010). An Italian study (Lecce et al., 2010) found that fourth grade children performed better than second graders on metacognitive knowledge and basic strategies, though fourth graders' performance didn't improve further in an 11-month period.

Nevertheless, it is generally agreed upon that metacognition develops late in children (see Pintrich & Zusho, 2002). The investigation of the difficulties children face in metacognitive monitoring and regulation of comprehension dates back several decades (e.g., Brown & Day, 1983; Brown et al., 1979; Garner, 1981; Markman, 1979). Overall, this literature shows that children are not aware of the steps involved in successful comprehension. Their metacomprehension skills and accuracy are not efficient, rather they are quite low (Dunlosky & Lipko, 2007; Hacker et al., 2008; Rawson & Dunlosky, 2007; Thiede et al., 2009). Related to that is the finding that individuals often appear overconfident while their performance is poor and vice versa; they appear underconfident while their performance is high (Yang et al., 2023). According to Baker (2017), metacognition and comprehension develop following a cycle. As metacognition develops, it affects comprehension. In turn, developed comprehension has a positive effect on metacognition and the cycle goes on. Yet, interestingly, individuals in general, and not just children, perform very poorly on metacomprehension accuracy and they monitor their comprehension capacity very ineffectively (see Prinz et al., 2020, and Yang et al, 2023, for meta-analyses).

Some research, though, has found existence of basic metacomprehension skills in the preschool years (Annevirta et al., 2007; Baker, 2006; Whitebread et al., 2009). In a study with orally presented stories, Baker (1984) found that kindergarten children pointed out information given in the story that conflicted with their prior knowledge but failed to identify story inconsistencies. In the three ages examined, third graders were more successful than first graders, who in turn were more successful than kindegarteners, the worst performance being the inconsistencies identification task even for third graders. Evidence of some comprehension monitoring abilities was also obtained with children 30 months-4 years (Skarakis-Doyle, 2002; Skarakis-Doyle & Dempsey, 2008).

Finally, although some correlational studies have observed that metacognitive knowledge is a predictor of reading comprehension, among other factors (e.g., van Kraayenoord et al., 2012; see also van Kraayenoord, 2010), some others have only found weak connections (e.g., Sperling et al., 2002). For instance, it appears that, for children to achieve comprehension monitoring, metacognitive knowledge is a prerequisite; such monitoring doesn't come before grade 2 for effective comprehenders (Annevirta & Vauras, 2006). Let us note here that metacomprehension judgments are a form of monitoring, and they refer to a person's capacity to globally evaluate their comprehension performance and the extent of their understanding of the text (Thiede et al., 2009).

Metacognitive contributions to comprehension

As noted above, there has been an interest in exploring preschoolers' comprehension skills lately and this interest has led to a small number of studies investigating metacognition in relation to listening comprehension. Strasser and del Río (2014) worked with Chilean preschoolers and investigated inference-making skills, inhibition, WM, and comprehension monitoring, among other variables. They found that when the task demanded more complex skills, monitoring, inference-making, inhibition, and WM contributed to listening comprehension.

Kim and Phillips (2014) showed contributions of inhibitory control, theory of mind, and comprehension monitoring in preschoolers' and first graders' listening comprehension capacity, even after controlling for vocabulary and age. Kim (2015) also found that cognitive skills such as WM, comprehension monitoring and theory of mind are connected to listening comprehension in an interesting pattern: Working memory, among others, contributed to comprehension monitoring and theory of mind, whereas monitoring and theory of mind contributed in turn to listening comprehension.

In the case of older children, in a longitudinal study with 8-, 9-, and 11-year-olds, Cain and colleagues (2004) investigated relations between WM and reading comprehension. In all ages examined, WM, inference generation capacity, and comprehension monitoring predicted reading comprehension, after controlling for word reading, vocabulary, and verbal ability. In harmony with Kim (2015), the comprehension measures (inferences, monitoring) had a distinct contribution to reading comprehension, beyond WM mediation.

Finally, a study carried out with Chinese ESL (English as a Second Language) learners revealed that both effective and ineffective oral comprehenders employed their existing knowledge, as well as text and context information. However, the effective listeners created more inferences, monitored their comprehension, and evaluated comprehension more than ineffective comprehenders (Goh, 2002). In a similar line, Vandergrift et al. (2006) argued that guiding ESL students during listening tasks, by helping them predict, monitor, evaluate, and solve problems, can have a positive effect on learners' comprehension regarding development of their metacognitive knowledge, which in turn is a prerequisite for the development of self-regulated listening.

Aims of the study

Considering the above, in the present study we aim to empirically approach children's metacognitive offline monitoring as applied to EF components (i.e., WM, inhibition, and cognitive flexibility) and listening comprehension, by asking pre-school and school-aged children to provide metacognitive judgments of their actual EF and comprehension performance (i.e., we tapped an aspect of metacognitive monitoring, see Roebers, 2017; Schraw, 2009). To our knowledge, this is the first study that attempts to shed light into the following issue: How accurate are children about their performance on EF and comprehension tasks as a function of age? The theoretical contribution is important since the results will highlight and give answers to a derivative question we also investigated: How metacognitively transparent are EF components and listening comprehension during childhood?

Preschoolers and second graders were chosen as participants, considering that (a) literature has shown (Wellman & Woolley, 1990) that children as young as 4-5 can think about different perspectives and comprehend that others may have different views, and (b) upon entrance to formal education, around ages 6-8 children start using basic metacognitive strategies (Schneider & Pressley, 1989) and become more able to regulate their cognitive processes, in response to the training received and the problem solving demands set in the school setting. Besides, using an oral, rather than reading, comprehension measure allowed us to study both preschoolers and second graders in terms of their metacognitive/metacomprehension monitoring. It is noted that listening comprehension has scarcely been investigated in relation to EF, despite the strong relation expected between the latter and higher-order linguistic processing (e.g., Butterfuss & Kendeou, 2018; Cain, 2006).

Given that literature examining metacognitive monitoring of EFs, particularly in the form of metacognitive judgments after executive task completion, doesn't appear to exist, two alternative hypotheses could be formed:

1. Since second graders have received metacognitive practice in the educational setting, we might expect them to perform better than preschoolers if they manage to transfer their metacognitive practice to the EF and comprehension processes.

2. Since children receive domain-specific metacognitive training neither in relation to EF operations nor in listening comprehension in Greek schools, we might expect them not to show a metacognitive benefit, due to the general metacognitive exposure, as compared to preschoolers.

3. A third hypothesis derives from Hypothesis 2; if children turn out to be inaccurate as far as metacognitive monitoring is concerned, we should expect them to be either overestimating or underestimating their performance, in accordance with the literature (see Prinz et al., 2020; Yang et al., 2023).

To examine the above, a cluster approach was adopted to capture individual differences as shaped by the developmental interplay between cognitive and metacognitive operations. It allowed us to investigate, for the first time to our knowledge, whether distinct profiles are formed regarding children's metacognitive and metacomprehension monitoring in EF and comprehension as a function of age. It is suggested that this is an important field of research since metacognitive-metacomprehension operations exert a prominent effect on children's cognitive development and educational attainment.

Method

Participants

The study involved 95 preschoolers (61-73 months of age, M_{age} = 67.13, *SD* = 2.32; 50 female), and 109 grade 2 students (80-97 months of age, M_{age} = 89.31, *SD* = 3.56; 49 female), attending various state schools in Thessaloniki (about one million inhabitants). No participants were diagnosed with speech or learning difficulties, as confirmed by parents and teachers.

Design

The present study adopted a cross-sectional design to explore profiles of metacognitive and metacomprehension offline monitoring in EF and listening comprehension in the preschool versus the early elementary school years. The EFs assessed were WM, inhibition, and cognitive flexibility. The listening comprehension assessment tapped participants' ability to respond to comprehension questions regarding information either explicitly stated or implied in the stories that were orally presented to them. Participants' metacognitive and metacomprehension capacity was reflected in the deviation between their performance estimates following task completion and actual task performance. It is finally noted that measures of fluid (non-verbal reasoning) and crystallized (receptive vocabulary) intelligence were also entered in the cluster analyses conducted to derive profiles per age group so that possible covariance with the cognitive, comprehension, and metacognitive-metacomprehension measures is taken into account.

Procedure

Participants were individually tested in the school setting. The EF and listening comprehension tasks were administered in pseudorandom order, each followed by the relevant metacognitive-metacomprehension assessment. Total assessment lasted approximately 75 minutes (split into three sessions). Informed consent was given by parents. Parents and children were informed that children could discontinue at any stage if they so wished. The study was approved by the Board of Directors of the School of Early Childhood Education at the Aristotle University of Thessaloniki.

Measures

General intelligence indices. Children were administered the *Colored Progressive Matrices* (CPM-Raven, 2008), a test of non-verbal reasoning. In this task, participants see matrices involving a figure in each cell but one, and they have to choose a figure among the options provided to fill in the empty cell. The test includes three sets (A, AB, B) of 12 items each. Items within a set become increasingly difficult, requiring greater capacity to encode and analyze information at a non-verbal level. A child's overall score is the sum of correct responses given in the three sets administered.

Moreover, participants' receptive vocabulary was assessed with the *Peabody Picture Vocabulary Test-Revised* (PPVT-R; Dunn & Dunn, 1981). The task requires children to listen to each word the experimenter presents orally and select the picture more accurately representing the word's meaning out of a set of four. The test consists of a maximum of 150 trials and a child's overall score is the sum of correct responses given by the time he/she had made six errors in eight consecutive trials.

Working memory. The capacity to concurrently maintain and process information in WM (Baddeley & Hitch, 1974; see also Baddeley, 2000) was assessed with the *Listening recall* task of the *Working Memory Test Battery for Children* (Pickering & Gathercole, 2001; as adapted for use with Greek children in Chrysochoou, 2006; see also Chrysochoou & Bablekou, 2011; Chrysochoou et al., 2011, 2013, 2018). In the context of the task, participants were presented with blocks, each including six sets of short sentences. The number of sentences in each set ranged from one to six and corresponded to an equivalent span (demand) level. Children listened to the sentences of each set, and they were asked to judge the veracity of each sentence presented (e.g. *scissors cut paper* is true; *balls are square* is false), before recalling the last word of each sentence in the set in the right order (e.g., *paper, square*). Testing ceased when children failed in any three sets in a particular block. A child's score on the test was the sum of his/her correct responses.

Inhibition. Children were administered a child *Attentional Network Task* version (see Rueda et al., 2004a, 2004b), in which yellow fish were presented instead of the arrows used as target and flanker stimuli in the adult version (see Fan et al., 2002; as adopted by Callejas et al., 2004). Participants were told to keep their eyes on the fixation cross (+) throughout the experiment. In each trial, the fixation cross was presented for 400 ms, followed by a warning cue that lasted 150 ms. The no cue and central cue warning conditions were control conditions for the alerting cue (double asterisk) and the spatial cue (an asterisk was presented at the location of the upcoming target array - above or below fixation), respectively. After an interval of 450 ms, the target array was presented above or below the fixation point (for 1700 ms or until response). The target was a fish, looking left or right. It was either presented alone (neutral condition trials) or centrally, flanked by four identical fish that were looking towards the same direction as the target fish (congruent condition trials) or in the opposite direction (incongruent condition trials). Children were told that they should "feed" only the fish at the center of the row, by appropriately responding with the mouse (i.e., right-clicking for a fish pointing to the right, and vice versa). Auditory feedback was provided in each trial (*yoo-hoo* sound for correct and beep sound for incorrect responses). There were 12 conditions overall, created by fully combined congruency and warning type. Children were given 24 practice trials, and three experimental blocks, each including 48 trials presented in random order. A mean overall accuracy inhibition (interference resolution) index was calculated for each participant for the purposes of the present study.

Cognitive flexibility. The *Lexical Stroop Sort picture-word Task* (LSST) (Wilbourn et al., 2012; see Kazi et al., 2019 for a Greek version) was used to assess participants' cognitive flexibility. Children were concurrently presented with the picture of a colored object (e.g., a "white bed") and an acoustic label, naming a color or an object. Labels corresponded either to the actual object shown (e.g., "bed") or its color, (e.g., "white"), or to an irrelevant object (e.g., "table") or color (e.g., "black). Children were asked to decide as fast as possible if the label named the identity of the object (choosing a face icon on the screen, which held an empty box), its color (choosing a face icon on the screen, which held a color palette), or none (choosing a "cheating" face icon). The task included a set of training trials and 20 main assessment trials. A mean overall accuracy index was calculated for each participant for the purposes of the present study, indicating how flexibly children paired labels with picture properties.

Listening comprehension. In the listening comprehension task (Chrysochoou, 2006; see also Chrysochoou & Bablekou, 2011; Chrysochoou et al., 2011, 2018) participants were presented with five stories (one practice and four main assessment stories), accompanied by questions tapping the following capacities (two questions per capacity in each story): literal comprehension, namely the ability to recall information that was explicitly stated in the story, and three questions tapping comprehension of information implied in the stories; specifically, the generation of necessary and elaborative inferences, and simile comprehension. A mean score of the four comprehension measures was calculated for each participant.

Metacognitive and metacomprehension assessments. Participants were asked to estimate performance on each of the aforementioned tasks right after task completion. Specifically, they were asked to estimate the number of final words of sentences they correctly recalled in the WM task and to report via a 5-point Likert scale (1-*not at all well,* depicted by a sad face, to 5-*very well,* depicted by a happy face) how well they did in the inhibition and cognitive flexibility tasks; similarly, they were asked how well they had responded to questions regarding information explicitly stated or implied in the stories they had heard in the context of the comprehension task. The deviation of each metacognitive-metacomprehension estimate from children's actual performance on the respective task was then calculated (estimated performance minus actual performance per task, based on z-scores).

Results

To examine differences in cognitive-comprehension performance as a function of age, a series of analyses of variance were conducted. It is noted that several cases of low in strength bivariate correlations among measures did not constitute the execution of a multivariate analysis of variance appropriate (range of Pearson r coefficient = .26 to .56). Significant Age Group effects were obtained in the analyses conducted for all cognitive measures: $F(1, 202) = 77.65$, $p \leq .001$, $\eta_p^2 = .278$ ($M_{Preschoolers} = 17.43$, $M_{Second\ graders} = 22.51$) for non-verbal reasoning (CPM-Raven); $F(1, 202) = 54.31$, $p \leq .001$, $\eta_p^2 = .212$ ($M_{Preschoolers} = 64.25$, $M_{Second\ graders} = 78.40$) for receptive vocabulary (PPVT-R); $F(1, 202) = 77.80$, $p \leq .001$, $\eta_p^2 = .278$ ($M_{Preschoolers} = 6.23$, $M_{Second\ graders} = 9.85$) for WM; $F(1, 202) = 39.55$, $p \leq .001$, $\eta_p^2 = .164$ ($M_{Preschoolers} = .85$, $M_{Second\ graders} = .92$) for inhibition; $F(1, 202) = 11.42$, $p \leq .001$, $\eta_p^2 = .054$ ($M_{Preschoolers} = .91$, $M_{Second\ graders} = .95$) for cognitive flexibility; $F(1, 202) = 11.52$, $p \leq .001$, $\eta_p^2 = .054$ ($M_{Preschoolers} = 4.19$, $M_{Second\ graders} = 4.90$) for listening comprehension.

To explore profiles of metacognitive and metacomprehension performance in EF and listening comprehension in the preschool versus the early elementary school years, a series of cluster analyses were performed. The following ten measures were entered into the analysis conducted per age group: (a) the z-scores calculated for the fluid intelligence (CPM-Raven) and crystallized intelligence (PPVT-R) measures, (b) the z-scores calculated for the sets of sentences correctly recalled in the listening recall task, the mean accuracy measures obtained from the inhibition and cognitive flexibility tasks, and the mean performance on the listening comprehension task, and (c) the four metacognitive-metacomprehension measures described above, tapping deviation of children's estimations regarding performance on each task following its completion from their actual task performance (calculated based on the respective z-scores).

First, a hierarchical cluster analysis was performed per age group. We employed Ward's (1963) minimum variance and squared Euclidian distance methods, which are considered highly efficient in retrieving underlying data structures (Aldenderfer & Blashfield, 1984; Borgen & Barnett, 1987) while minimizing within-cluster variance in every step of the algorithm. The agglomeration schedules suggested that the largest change in error coefficients in our data occurred when clusters were reduced to two. Inspection of the dendrograms per age group also indicated a significant typology at a two-cluster solution.

The k-means cluster analyses that followed indicated similar patterns in the two age groups, denoting persistence of inaccurate monitoring within the specific age range (see Figures 1 and 2, and Table 1): (a) a cluster consisting of 32.63% of the preschoolers and 44.95% of second graders respectively, characterized by performance at a lower level, but overestimated metacognitive judgements of their cognitive performance (*low cog-lenient meta* cluster), and (b) a cluster consisting of 67.37% of the preschoolers and 55.05% of second graders, characterized by performance at a higher level, but underestimated metacognitive judgements of their cognitive performance (*high cog-strict meta* cluster). The percentages of children in the two clusters were not statistically differentiated between age groups (χ^2 = 3.23, *df* = 1, *p* = .072).

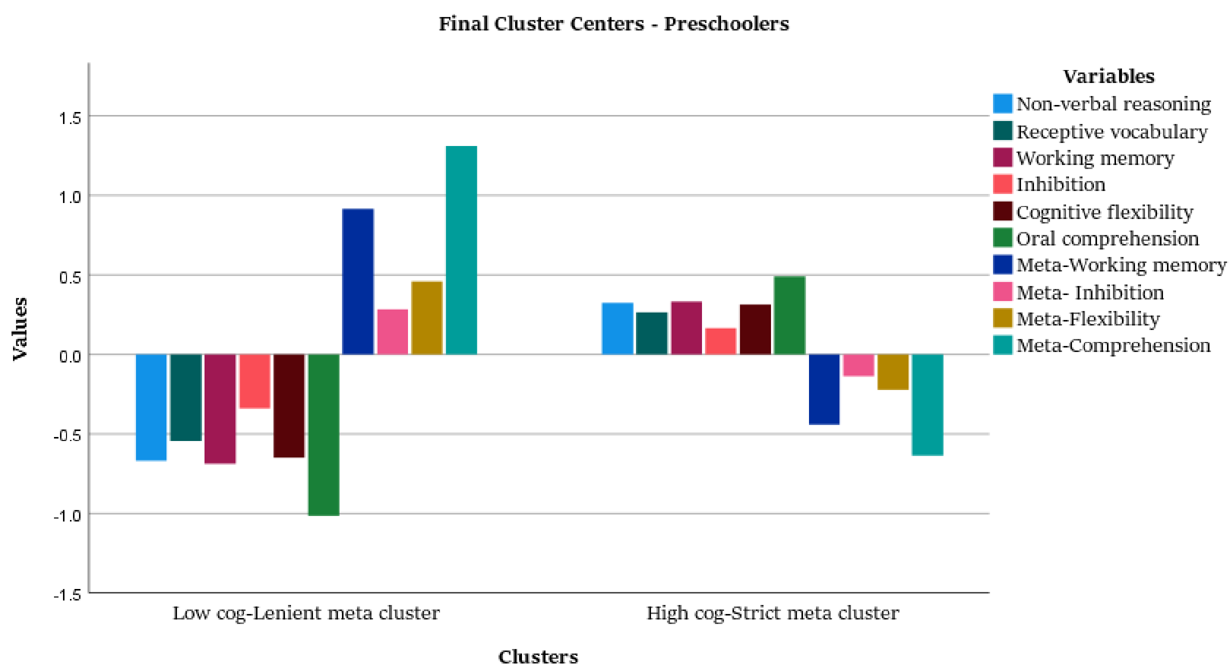

Figure 1. The two clusters identified in the k-means cluster analysis performed in the preschoolers' sample

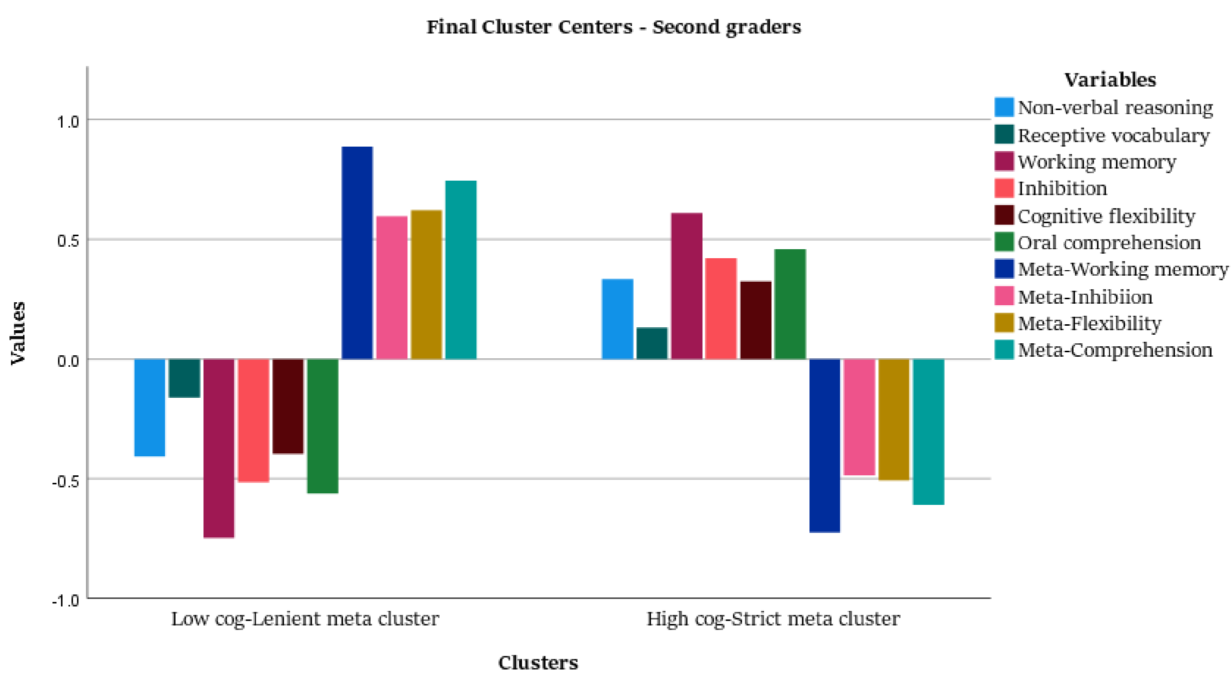

Figure 2. The two clusters identified in the k-means cluster analysis performed in the second graders' sample

Table 1

Results of the k-means cluster analyses (cluster centers, ANOVA statistics) per age group

	Cluster 1 (center)	Cluster 2 (center)	ANOVA
Preschoolers (N =95)	N = 31	N = 64	
Non-verbal reasoning	-.67	.32	$F(1,93) = 26.26, p \leq .001$
Receptive vocabulary	-.55	.26	$F(1,93) = 15.93, p \leq .001$
Working memory	-.69	.33	$F(1,93) = 28.18, p \leq .001$
Inhibition	-.34	.16	$F(1,93) = 5.57, p = .020$
Cognitive flexibility	-.65	.31	$F(1,93) = 24.09, p \leq .001$
Listening comprehension	-1.01	.49	$F(1,93) = 94.28, p \leq .001$
Meta - Working memory	.91	-.44	$F(1,93) = 27.73, p \leq .001$
Meta - Inhibition	.28	-.14	$F(1,93) = 2.37, p = .127$
Meta - Flexibility	.46	-.22	$F(1,93) = 5.80, p = .018$
Meta-Comprehension	1.31	-.64	$F(1,93) = 71.88, p \leq .001$
2nd graders (N = 109)	N = 49	N = 60	
Non-verbal reasoning	-.41	.33	$F(1,107) = 17.01, p \leq .001$
Receptive vocabulary	-.16	.13	$F(1,107) = 2.33, p = .130$
Working memory	-.75	.61	$F(1,107) = 90.85, p \leq .001$
Inhibition	-.52	.42	$F(1,107) = 29.96, p \leq .001$
Cognitive flexibility	-.40	.32	$F(1,107) = 16.01, p \leq .001$
Listening comprehension	-.56	.46	$F(1,107) = 37.42, p \leq .001$
Meta - Working memory	.89	-.72	$F(1,107) = 49.88, p \leq .001$
Meta - Inhibition	.60	-.49	$F(1,107) = 22.12, p \leq .001$
Meta - Flexibility	.62	-.51	$F(1,107) = 26.36, p \leq .001$
Meta - Comprehension	.75	-.61	$F(1,107) = 37.51, p \leq .001$

Discussion

In the present study, we examined children's metacognitive offline monitoring in relation to EFs (i.e., WM, inhibition, and cognitive flexibility) and listening comprehension, by asking preschool and school-aged children to provide metacognitive judgments of their actual EF and metacomprehension performance. Our aim was to examine how accurate children were about their performance on EF and comprehension tasks as a function of age, as well as to explore whether EF and listening comprehension are metacognitively transparent in the phases studied.

Our findings can be summarized as follows: Despite the older group children performing at a higher cognitive level (WM, inhibition, cognitive flexibility, listening comprehension), metacognitive monitoring did not improve as a function of age, in the sense that cluster analyses revealed only two inaccurate profiles; that is, a group of children performing at a lower level, but providing overestimated metacognitive judgements of their cognitive performance (*low cog-lenient meta* cluster) and a group of children performing at a higher level, but metacognitively underestimating their cognitive performance (*high cog-strict meta* cluster). A third, metacognitively accurate cluster did not emerge in the analysis conducted in either age group.

This finding did not confirm our first hypothesis expecting second graders to perform better than preschoolers; in the case of comprehension, our finding does not corroborate data suggesting that monitoring appears at about grade 2 for effective comprehenders (Annevirta & Vauras, 2006). It did confirm, though, our second, alternative hypothesis, showing that older children do not show a metacognitive benefit compared to younger ones. Put it differently, metacognitive monitoring does not improve with age when the task at hand is domain-specific (targeting EF and listening comprehension in our study). We think that is an important finding that raises a series of theoretical and practical issues to be investigated in the future: It might be the case that although metacognitive monitoring does improve with age (at least in the age phases examined in our study; e.g., see Roebers & Spiess, 2017), this development is not generalized and transferable to all cognitive domains or activities. Alternatively, it could be the case that the specific cognitive aspects that we examined in our study (i.e., EFs and listening comprehension) are confounded and automatically applied in almost all facets of our everyday and academic activities, making it difficult to disentangle their activation and consequently, metacognitively reflect on or evaluate them.

The question of possible metacognitive transferability to other cognitive domains, as compared to the non-transferability when it comes to EF and listening comprehension, can only be answered with a multidimensional experimental – intervention design. Given the importance of EF, comprehension, and metacognitive monitoring for cognitive development and school success, we suggest that further related research is a good step to investigate how domain-specific training could be incorporated into the school curriculum to achieve higher performance in the areas examined. As Marulis and collaborators (2020, p. 50) point out, "...the way metacognition can help children to build agency over their own learning is by making it clear when, how and why to use EF", something that formal education can advance.

Our finding that children either overestimated or underestimated their cognitive performance is in full accordance with our third hypothesis (see also related findings; Prinz et al., 2020; Yang et al., 2023). It appears that the development of EF may not be similarly reflected in the accuracy of metacognitive estimations at the ages studied. Children do not seem to be capable of building agency over their own learning; they do not exhibit understanding of appropriate uses of EF (Marulis et al, 2020), which may, in turn, hinder the cognition-metacognition interplay. It is of interest that even though executive operations exert an obvious cognitive load after school entrance, they do not become more transparent. Such an observation would mean that mere exposure to EF demands along with general metacognitive feedback (as reflected in teachers' comments on student homework) does not necessarily result in strategic EF application.

The finding about overestimation corroborates evidence arguing that preschoolers and early school-aged children tend to overestimate the accuracy of their actual performance (Destan et al., 2017; Kälin & Roebers, 2022; Lipko et al., 2009; O'Leary & Sloutsky, 2017; Roebers & Spiess, 2017). The finding is also in harmony with other research showing that individuals often appear overconfident while their performance is poor and vice versa; they appear underconfident while their performance is high. Related to this are the meta-analyses by Prinz et al. (2020) and Yang et al (2023), which strikingly reveal that individuals perform very poorly on metacomprehension accuracy and monitor their comprehension capacity very ineffectively.

A theoretical question arising from the finding that children either performed lower cognitively and overestimated their monitoring or exhibited the exact opposite profile is *why this occurs*. Some possible explanations may be ventured. One is that stricter metacognitive judgment (i.e., the false perception that actual cognitive performance is not up to the expected level) increases alertness and motivates greater effort to meet related cognitive demands. In the opposite fashion, more lenient metacognitive judgment (i.e., the false perception that actual cognitive performance is better than the expected level) may decrease alertness and may not motivate children as much as required to succeed in the related cognitive task. On the other hand, from a developmental point of view, previous trends to underestimate performance could perhaps result in a relative cognitive advantage in the ages examined. Overall, an interesting finding of our study is that no cluster group was formed with students performing accurately in the metacognitive tasks. It seems that children in the ages examined have not managed to exert appropriate metacognitive and metacomprehension control in the form of offline monitoring of their performance. It may be the case that over- or under-estimates are a necessary developmental step to accomplish more metacognitive accuracy. An interesting, related reference is made in the Ohtani and Hisasaka (2018) meta-analysis. These questions merit further, extensive investigation using designs such as interventions, longitudinal studies, obtaining online monitoring judgments, providing targeted feedback or experimentally manipulating EF demands and strategic/motivated engagement.

Finally, further exploration of the clustering solution revealed the following patterns: Working memory and comprehension made the greatest contribution to cluster formation in both age groups, even though metacognitive estimates were not accurate. Regarding WM in particular, several studies have confirmed its significant contributions to reading comprehension efficiency (see Nouwens et al., 2017; Haft et al., 2019), irrespective of either word reading ability and vocabulary (e.g., Cain et al., 2004; Chrysochoou et al., 2011; Seigneuric & Ehrlich, 2005), or attention and fluency contributions (Sesma et al., 2009). In their meta-analysis, Carretti et al. (2009) showed that domain-specific factors as well as general factors of WM contribute to reading comprehension efficiency, and they also underpin specific reading comprehension difficulties (in the absence of decoding difficulties or intellectual disability). The independence of WM contributions from word (lexical or decoding) level implies its important role in the higher-order processing that underlies comprehension capacity irrespective of presentation modality (e.g., integration or bridging inference processes, implicit inference generation with the aid of related long-term memory traces, or simile comprehension, besides metacomprehension monitoring).

On the other hand, the inhibition (interference resolution) measure contributed the least in the preschoolers, while in the older group both the latter and its metacognitive counterpart were stronger profile determinants. There is also evidence showing attentional capacity contributions (independent of WM) to the comprehension of orally presented narrative passages (Kim, 2016). Although evidence regarding the relationship between listening comprehension and the specific inhibition aspect we measured is scarce, our related finding in the younger age group might be attributed to the fewer opportunities that preschoolers have to exert conflict resolution; opportunities that become much more available in formal education years.

As far as fluid intelligence (non-verbal reasoning test) is concerned, contribution to the cluster solution was reduced with age. This finding may be expected, as research shows that metacognition as a higher-order process contributes to cognitive and academic performance when controlling for intelligence. Finally, crystallized intelligence (receptive vocabulary test) was one of the least important cluster characteristics across ages, particularly in the second graders. The result is in harmony with the notion that both fluid and crystallized intelligence are capacities with limited contributions to the metacognitive profiles of developing children (see Ohtani & Hisasaka, 2018, for a meta-analysis). We think that both these findings are important, for they show that intelligence is not of utmost importance for children to achieve cognitively (and, subsequently, academically), while metacognition is. Thus, curriculum design that promotes metacognitive exposure and training seems to be a desired avenue for school success (see Dignath & Büttner, 2008; Zepeda et al., 2015).

Limitations and future research

The present study constitutes a first exploration of developmental profiles related to EF, listening comprehension, and corresponding metacognitive-metacomprehension monitoring in periods marking their emergence and interplay. Our findings provided insight into the inaccuracy of children's estimations regarding performance and the lack of metacognitive transparency of EF components and listening comprehension within this early phase of development. One limitation of the present study is that a third, older group was not investigated. We think that such a group would provide further information about the links between cognitive, comprehension and metacognitive-metacomprehension monitoring development. Another future research avenue is further investigation of the finding that children either showed lower cognitive and comprehension performance while they overestimated their monitoring, and vice versa. Could it be the case that strict metacognitive estimates derive from higher cognitive and comprehension performance, thus allocating extra cognitive resources to the metacognitive task? Similarly, could it be the case that lenient metacognitive estimates derive from lower cognitive and comprehension performance because children do not handle efficiently their cognitive resources? These questions could be addressed in a future study employing online monitoring assessments. Finally, a research topic deserving attention is tracing trajectories of metacognitive-metacomprehension monitoring development, as a function of cognitive-comprehension improvements over childhood, via longitudinal investigations.

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ΕΜΠΕΙΡΙΚΗ ΕΡΓΑΣΙΑ | RESEARCH PAPER

Επιτελικές λειτουργίες, κατανόηση προφορικού κειμένου και μεταγνωστικές δεξιότητες στην παιδική ηλικία: Αναπτυξιακά προφίλ

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Αναπτυξιακά προφίλ,
Επιτελικές λειτουργίες,
Κατανόηση,
Μεταγνωστική παρακολούθηση,
Μετακατανόηση,
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ΠΕΡΙΛΗΨΗ

Παρά την τεκμηριωμένη αλληλεπίδραση μεταξύ επιτελικών λειτουργιών και μεταγνώσης, υπάρχουν περιορισμένα ευρήματα για την ικανότητα των παιδιών να παρακολουθούν μεταγνωστικά την επίδοσή τους σε έργα επιτελικών λειτουργιών μετά την εκτέλεσή τους. Επιπλέον, γνωρίζουμε ελάχιστα για τις σχέσεις μεταξύ ακουστικής κατανόησης, επιτελικών λειτουργιών και μεταγλωσσικής επίγνωσης στα παιδιά. Η μελέτη διερευνά για πρώτη φορά αναπτυξιακά προφίλ που σχετίζονται με τις επιτελικές λειτουργίες, την ακουστική κατανόηση και αντίστοιχες ικανότητες μεταγνωστικής-μεταγλωσσικής παρακολούθησης σε περιόδους που σηματοδοτούν την ανάδυση και αλληλεπίδρασή τους. Συμμετείχαν 95 παιδιά προσχολικής ηλικίας (Μ.Ο. = 5,5), και 109 παιδιά δευτέρας δημοτικού (Μ.Ο. = 7,5). Χορηγήθηκαν έργα επιτελικών λειτουργιών (εργαζόμενης μνήμης, αναστολής και γνωστικής ευελιξίας), ακουστικής κατανόησης, και εκτίμησης της επίδοσης σε κάθε έργο μετά την ολοκλήρωσή του. Συλλέχθηκαν επίσης μετρήσεις ρέουσας και αποκρυσταλλωμένης νοημοσύνης. Εφαρμόσαμε αναλύσεις συστάδων. Και στις δύο ηλικιακές ομάδες, μια συστάδα χαρακτηριζόταν από χαμηλότερες γνωστικές επιδόσεις, αλλά από μεταγνωστικές υπερεκτιμήσεις, ενώ μια δεύτερη συστάδα παρουσίασε το ακριβώς αντίθετο μοτίβο. Τα μεγαλύτερα παιδιά είχαν υψηλότερες γνωστικές επιδόσεις. Ωστόσο, η μεταγνωστική παρακολούθηση δεν βελτιώθηκε ως συνάρτηση της ηλικίας, με την έννοια ότι μια τρίτη, μεταγνωστικά ακριβής συστάδα δεν αναδύθηκε στη δευτέρα δημοτικού. Και στις δύο ηλικίες, η εργαζόμενη μνήμη και η ακουστική κατανόηση με την αντίστοιχη μεταγνωστική και μεταγλωσσική εκτίμηση επέδειξαν τη μεγαλύτερη συνεισφορά στη διαμόρφωση των συστάδων. Οι μετρήσεις της αναστολής-μεταανασταλής καθόρισαν ισχυρότερα τα προφίλ στα μεγαλύτερα παιδιά. Η μέτρηση της ρέουσας νοημοσύνης παρουσίασε μειωμένη συνεισφορά με την ηλικία, ενώ του λεξιλογίου αποτέλεσε ασθενές και ασήμαντο διαφοροποιητικό χαρακτηριστικό, αντίστοιχα, των προφίλ στην προσχολική ηλικία και στη δευτέρα δημοτικού. Τα ευρήματα συζητιούνται στη βάση σχετικών ερευνητικών δεδομένων και θεωρητικών προτάσεων για την ανάπτυξη γνωστικών και μεταγνωστικών λειτουργιών.