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Subjective remembering and mis-remembering: The rise of memory control

in children with typical development and with disabilities

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INTRODUCTION

Remembering one's own past is an extremely important function as it is related to the human ability of constructing an identity and a sense of Self. Who we are, where we come from and what we will probably become in the future, are all intertwined aspects supported by memory. Without memory for the episodes of our past, we would float in a vague dimension, and we would not have directions for planning our episodes to be.

Tulving, one of the "fathers" of those theories that support the distinction of memory in different systems – and do not favor the view of memory as a unique phenomenon which may or may not be differentiated depending on circumstances or on the individual –, proposed an important classification of long lasting memory systems which became influential over the studies in this field: Episodic as opposed to semantic memory (Tulving, 1972). Episodic memory refers to the retrieval of specific episodes or events, which are characterized by a spatio-temporal localization in a context and are usually related - even though not necessarily - to a person's autobiographical past. Semantic memory refers to the general symbolic knowledge a person possesses about the surrounding world, without the same coordinates that characterize episodic remembering. A few years later, Tulving (Tulving, 1985) further differentiated these memory systems based upon the subjective experience that accompany them. He believed that it was possible to detect how an individual subjectively perceives his/her own memories, by asking his/her to make and introspection and to focus on the ongoing memory state: the individual could have a sense of vivid recollection, meaning that she is able to remember not only that a certain episode occurred, but also the specific context in which it happened or even the mental operations (e.g., emotions or thoughts) engaged in when she first encountered the event. This sense of recollecting the past is linked to the ability to "travel back in time" and to re-live the past. It is associated with an "autonoetic awareness", that is, according to Tulving, the conscious experience of being aware that we are

the protagonists of the memories we are re-experiencing. In other words, remembering is auto-referential in nature and it is connected to the Self. On the other hand, a person may only be familiar with a certain episode, i.e. he/she may know that something happened in the past, without associating the same sense of recollection as in the previous case. This kind of subjective experience is linked to a "noetic awareness", and it does not have the same "special phenomenal flavor" that characterizes the experience of autonoetic awareness. Tulving stepped further and proposed an experimental paradigm which could be used in the laboratory to test these subjective experiences. The Remember-Know paradigm (Tulving, 1985) is to be employed in a recognition memory task, in which, typically, a previously seen or heard item has to be identified among others not previously encountered. In a recognition memory task, Remember judgments are to be given when the person is not only able to recognize that a certain item is old, i.e. experienced before (that is, presented at the encoding phase), but also is able to retrieve peculiar qualitative details of the item, such as its perceptual characteristics or some emotions or thoughts that the person remembers to be directly connected to the moment of the encounter with the item. The person is instead required to judge as "known" – i.e., to give a Know judgment – the item that seemed to be presented in an initial encoding phase, but that the person does not connect with any particular detail or thought. In other words, the person only "knows" that the item was presented, but he/she is not able to retrieve any further information related to that particular event. Only Remember answers are considered autonoetic in nature, whereas Know answers are considered noetic. The Remember-Know paradigm allows for a specific investigation of subjective remembering, that is the metacognitive ability to qualify one's own memories from the peculiar perspective of the rememberer. Other ways of accessing this ability imply the giving of confidence ratings about an individual's performance in a memory task.

The general scope of the present dissertation is to investigate subjective remembering in children with typical development and children with certain disabilities - namely Attention Deficit/Hyperactivity Disorder (ADHD) and learning difficulties - given the importance this ability has in particular contexts (children with disabilities are increasingly asked to testify in forensic contexts, as victims or eyewitnesses of abuse; Bruck & Ceci, 1999; the ability to introspect on personal memories in thus extremely relevant), as it will be explained in the following chapters.

In the literature on adults, both the Remember-Know procedure and confidence ratings have been used as ways to assess subjective remembering and to estimate the two processes thought to be at the basis of recognition memory, namely recollection and familiarity (for a comprehensive review, see Yonelinas, 2002). At a general level, recollection refers to the process by which individuals can retrieve qualitative details of an event, like the context in which it was experienced or other pieces of information, such as to create a vivid trace of the event itself in one's own memory. In contrast, familiarity refers to the process by which individuals can judge the strength of a memory trace, without recollection of specific information or the context at the time when the stimulus was encoded (e.g., Brainerd, Reyna, & Mojardin, 1999; Jacoby, 1991; Yonelinas, 1994, 2002).

The Remember-Know paradigm (Tulving, 1985) has been criticized because it relies on subjective experiences reported by the individuals, and these personal introspections may be inaccurate in certain situations (Dunn, 2008). However, the use of the individuals' subjective interpretations represents a peculiar aspect and thus an advantage of this procedure: Recollection does not depend on the sole retrieval of information as in a recall test, for example, but it is the result of the retrieval of any detail of the studied item that the individual can think of and consider as reflecting vivid remembering (Yonelinas, 2002). Moreover, there are studies that show that estimates of recollection and familiarity found with the Remember-

Know paradigm correlate with estimates of these processes that are not found through the report of subjective experiences (Yonelinas, 2001 b).

Another criticism is that Remember and Know answers should not be considered as reflecting two distinct processes of memory but instead they represent different levels of confidence or familiarity-based judgements on a continuum (Donaldson, 1996; Hirshman & Master, 1997; Inoue & Bellezza, 1998). Thus, Remember would reflect simply a high confidence response. However, other studies which directly compared Remember-Know responses with confidence judgments showed that they can be dissociated (Gardiner & Java, 1991; Parkin & Walter, 1992; Rajaram, 1993; Yonelinas, Otten, Shaw, & Rugg, 2005).

Furthermore, both the Remember-Know procedure and confidence ratings, although relying on subjective experiences, have been found to correspond to objective measures of recollection and familiarity (Yonelinas, 2001a), such as the effect of divided attention and level of processing effect (which affect recollection more than familiarity, lending support to a dissociation of these two processes; for an explanation of the theoretical framework of dual-process models see Yonelinas, 2002). The focus of this dissertation is not that of providing evidence for a dissociation of recollection and familiarity, but rather examining the phenomenological experience that underlies the two memory processes, in order to shed light on the nature of true as well as false memories.

One concern is whether the Remember-Know procedure and confidence ratings would be suitable for children, given that they require to introspect on memory states of experienced events and thus they require metacognitive abilities, in particular metamemory knowledge and control and monitoring over memory states. I will briefly introduce the research in this field in the following paragraph.

Development of metamemory

Young children have been traditionally considered incapable of differentiating between internal and external states (e.g. Piaget, 1928, 1929). However some studies have shown that 3- and 4-year-olds can discriminate between mental and physical entities, and that they know that thinking is an internal or mental process (e.g. Wellman & Estes, 1986). Further, more recent research shows that even young children exhibit at the very least some notion about memory functioning. For example, most 3-year-olds can discriminate between the verbs "remember" and "forget", but their understanding of this difference seems limited simply to memory outcomes; that is, "remember" seems to be associated with succeeding in a memory task, whereas "forget" seems to be associated with failure in the retrieval of a particular event. An understanding that one must have acquired a memory in the first place at some point earlier in time in order to remember or forget seems to develop during the later pre-school years.

Many studies have demonstrated significant changes in children's understanding of the meaning of "know", "remember", "guess" and "think" in the pre-school years (e.g. Johnson & Wellman, 1980; Miscione, Marvin, O'Brien, & Greenberg, 1978; Perner, 1991). These changes parallel the growing understanding that because individuals possess limited perception abilities and interpret the world based on personal beliefs, what we "think" may not be true and what we "know" does not necessary reflect reality (for a review, see Perner, 1991).

Johnson and Wellman (1980) studied children's understanding of the mental verbs "remember", "forget" and "guess". They found a significant increase with age among the grade-school participants in the understanding that remembering and knowing require a knowledge base, whereas guessing does not require this previous knowledge. Although 4-year-olds can distinguish mental states from external states in a context where the individual's expectations are violated, they are nonetheless ignorant about semantic differences between

mental states. Johnson and Wellman (1980) claimed that 4-year-old children in their study did not discriminate among the conditions in which remembering, knowing and guessing were required and did not comprehend that remembering an event demands having some previous exposure to the event, and that knowing about an event demands having some evidence that the event actually took place. Five-year-olds began discriminating such differences in the mental verbs but it was not until school-age years that a deeper understanding was evident. The authors claimed that children did not completely discriminate between "know" and "remember" until they were in first grade (mean age 6-9). However, they also clarified that even though 4-year-olds did not have a clear understanding of the meaning of such terms, they were indeed able to use them quite appropriately. Nonetheless, there is some evidence that even before the age of 3, children can use the verbs "remember" and "forget" (Bretherton & Beeghly, 1982; Limber, 1973).

Lyon and Flavell (1993) found that 4-year-old children had an understanding that to remember or forget one person must have acquired a memory sometime earlier, and that the probability of forgetting would increase with longer temporal intervals (3- and 4-year-old children had to decide which of two dolls would remember where a hidden object had been placed. One of these dolls was exposed to a short retention interval, that is she would come back earlier to look for the hidden object than the other doll; this latter one was exposed to a longer retention interval in that she would come back later to look for the hidden object). Taken together Lyon and Flavell's results (1993, 1994), it seems that even 4-year-olds understand the necessity of having some prior knowledge to remember or forget something.

Further, in their experiments, Perner and Ruffman (1995) reported that the autonoetic representation develops between 4 and 6 years of age. Children up to 4 years of age seem not to understand the connection between informational access (e.g. seeing an action) and knowledge (i.e. knowing something because it has been experienced) and thus cannot possess

episodic memory in Tulving's sense. Their experiments provide insights into the emergence of episodic memory in children and their capability to use metacognitive knowledge (i.e. the awareness that they know something because they experienced it). However, they do not provide evidence as to whether or not children can introspect on their own personal memory. And if they could, whether or not they would be able to understand concepts like remembering and knowing and use them to evaluate different experiences of memory.

It seems that pre-schoolers have some metamemory competence and are able to discriminate among mental verbs like "remembering", "knowing" or "guessing" at an age of 4- and 5-years. It is thus possible to test young children on their understanding of the mental verbs "remember" and "being familiar" (i.e. "knowing") and to examine how their knowledge might affect their memory performance in a recognition test. However, it remains unclear whether they are also able to use such knowledge to perform a memory task (metamemory monitoring). Few studies tried to define this metacognitive aspect including the confidence ratings as a way to assess children's awareness of their internal states of memory and how this awareness relates to their memory performance. Some researches have provided data in favor of a higher difficulty in young children to give confidence ratings, especially when guided by misleading questions (e.g. Roebers, 2002). However, there is evidence that children can report on their confidence ratings in the absence of misleading questions. One study (Berch & Evans, 1973) demonstrated that, in a recognition memory test, both kindergartners and third graders gave low confidence judgments to old items that were less likely to being actually old. Even though third graders were more confident when they actually recognized a studied item and less confident when they incorrectly recognized an item as old, there is evidence that even 5-year-old children are able to introspect about their own memory processes while performing a memory task (metamemory monitoring).

Consistent with these findings, Ghetti and colleagues (Ghetti, Qin & Goodman, 2002) showed that 5-year-old children were able to give accurate confidence judgments in a recognition memory test. Indeed they were more confident when they correctly recognized old words presented in association with pictures than words studied without pictures. Further, it has been recently found (Ghetti, Lyons, Lazzarin, & Cornoldi, 2008), that 10-year-olds provide higher confidence ratings when they correctly remember actions that they had imagined once than when they correctly remembered actions that they had imagined twice; this did not happen among the 7 year-olds. Thus, these findings suggest that metamemory further develops during childhood and adolescence.

For what concerns the use of the Remember-Know paradigm during development, only few studies have used it in research with children (Billingsley, Smith, & McAndrew, 2002; Piolino, Hisland, Ruffeveille, Matuszewski, Jambaqué, & Eustache, 2007). Billinglsley and colleagues' study (2002) is the first one in which the Remember –Know procedure has been used with children. They found that between-group differences in the proportion of Remember and Know responses were similar to age differences in explicit and implicit memory performances. The youngest group (8-year-olds) produced fewer Remember responses compared to the older groups (14-16-year-olds and 17-19-year-olds), whereas proportion of Know responses were equivalent across groups. These findings are consistent with Tulving's (1985) prediction that Remember judgments would show an increasing response path with age. Thus, these results showed that recollection increased with increasing age, whereas familiarity remained stable across all age-groups.

We have recently studied whether the Remember-Know paradigm could be used with younger children in order to investigate their ability to introspect on and understand their internal memory states giving judgments of subjective remembering (Ghetti, Mirandola, Angelini, Cornoldi, & Ciaramelli, *in press*). In a recognition memory task, children had to

initially encode line drawings of animate and inanimate objects telling their colors (i.e., red or green) – addressing perceptual encoding - and answering questions such as "does it fit in a shoe box?" – addressing semantic encoding; subsequently children had to perform a recognition task, in which the encoded drawings were mixed with not seen ones. Children were asked, for each drawing (all presented in black) to answer "yes" whether they thought it was seen at encoding, "no" whether it was not seen and to tell their degree of confidence using the Confidence Rating Board (CRB; Ghetti, 2003; Ghetti et al., 2002; Ghetti, Papini, & Angelini, 2006); for each recognized item, they were required to give Remember-Know judgments and to tell its color and the semantic judgment they had to perform during the study phase. We found age-related improvements in subjective recollection, even though even the youngest group (6-7 year olds) proved an understanding of their memory states and an ability to introspect on them; indeed, all participants gave more Remember answers in association with correct retrieval of the color of the item and the semantic details. However, they were less differentiated in their pattern of responses relative to confidence ratings associated with Remember and Familiar judgments, showing that further improvements during development do occur.

Given this evidence, I thought it was important to shed further light on the ability of children to introspect on their memory states and use the Remember-Know paradigm as well as confidence ratings. I was interested not only in typical development, but also in studying these phenomena in children with disabilities, given that there is still paucity of research in this field. Further, I was interested in applying these procedures to false memory investigation. Indeed, applying the Remember-Know paradigm and confidence ratings to tasks that investigate the formation of memory errors (e.g., the Deese-Roediger-McDermott paradigm, see Chapter One) permits to differentiate between true and false memories at a

phenomenological level, revealing whether children do characterize accurate and inaccurate memories in a different way than older children and adults.

Overview of Experiments

In Chapter One, I will present two studies (Experiment 1 and Experiment 2) which investigated the ability of children to monitor and control their memory performance through the giving of warning instructions prior to encoding in a Deese-Roediger-McDermott (DRM) task (Roediger & McDermott, 1995) and through subjective remembering explored with the use of the Remember-Know paradigm.

In Chapter Two, I will discuss one experiment (Experiment 3) which investigated subjective remembering through confidence ratings with a different false memory paradigm (recognition memory for scripted material, adapted from Lyons, Ghetti & Cornoldi, 2010), in a group of typically developing children and in a group of children with Attention Deficit/Hyperactivity Disorder (ADHD).

Finally, in Chapter Three, I will present two studies (Experiment 4 and Experiment 5) which examined subjective remembering in a group of adolescents with learning difficulties, through the use of the Remember-Know paradigm applied to a recognition memory test for sentences included in a text.

Using different recognition memory tasks will help us understand and differentiate between accurate and false memories both at the objective and at the subjective level.

EFFECTS OF WARNING ON FALSE MEMORIES AND ON

SUBJECTIVE REMEMBERING IN TYPICAL CHILDREN AND ADULTS

1.1 Development of False Memories

Experiencing false memories – remembering events that never occurred in one's own past or that did occur but now the person is recalling in a different way from their original encountering – is very common both in adults and children. In the last decade, growing attention has been devoted to the scientific study of false memories formation during the course of development (for a review see Brainerd, Reyna, & Ceci, 2008). This is maybe due to the implications that incurring in false memories have in forensic settings. Indeed, children are increasingly required to testify in the context of legal cases, either as victims of domestic abuse or maltreatment, or as eyewitnesses (for a review, McGough, 1993). The first laboratory studies on children's false memories - which either did (e.g., Eisen, Qin, Goodman, & Davis, 2002; Holliday & Hayes, 2000; Marche & Howe, 1995) or did not (e.g., Brainerd & Reyna, 1995, 1996) employ suggestibility paradigms - showed a trend of age related decline in false memory formation.

More recently, however, other paradigms (e.g., Deese-Roediger-McDermott (DRM) paradigm, Deese, 1959; Roediger & McDermott, 1995; categorized word lists, Brainerd, Holliday, & Reyna, 2004; Howe, 2006) have shown a reversal of this trend, with false memory rates increasing substantially with growing age (see Brainerd et al., 2008 for a review). Most of this research has been conducted with the DRM paradigm (Roediger & McDermott, 1995) which involves the presentation of lists of semantically associated words (e.g., *nurse, sick, lawyer, medicine)* converging in meaning on a word, the *critical lure,* which is not presented in the study list but represents the semantic gist of the list (i.e., *doctor).* After

studying these word lists, adults falsely recall or recognize the critical lures with high frequency and claim to experience vivid recollection for the critical lures almost at the same rate as they do for studied words (Roediger & McDermott, 1995). Developmental studies have shown an increased production of false memories especially between middle childhood and early adolescence (5 to 11 years) (Brainerd et al., 2004; Brainerd et al., 2008; Holliday, Reyna, & Brainerd, 2008; but see Ghetti, et al., 2002).

It has been hypothesized that younger children fail to produce high rates of false memories with the DRM paradigm because of developmental differences in the processing of semantic associations. Two main theoretical accounts have been proposed to account for this developmental reversal. Based on Fuzzy-Trace Theory (FTT; Brainerd & Reyna, 2005), this phenomenon is due to developmental changes in the ability to form gist traces: with development, children become increasingly adept at extracting the gist of situations and this increased capacity leads to increased tendency to form false memories for events that are semantically consistent with the gist of the truly experienced events; based on FTT, gist extraction transcends the mere structure of semantic associations; that is, even if the strength of semantic associations among items is similar across ages, older children and adults compared to younger children would be more likely to appreciate the global gist shared by all of the items. In contrast, based on the Associative-Activation Theory (AAT; Howe, 2005, 2006), age-related increases in false memory reflects developmental increases in the number and strength of associations in semantic memory as well as in the automaticity with which these associations are accessed (Howe, 2005, 2006). The AAT theory well explains age increases in false memories with other connected-meaning materials such as categorized items, which include either pictures (Sloutsky & Fisher, 2004b; Fisher & Sloutsky, 2005) or word lists (Brainerd, Forrest, Karibian, & Reyna, 2006; Howe, 2006). Contrasting the predictions of these different theoretical accounts falls beyond the scopes of the current

dissertation. For the current purposes, we simply acknowledge that developmental reversals have been documented with the DRM and have been explained by integrating the role of semantic knowledge, access, and use into theories of false-memory development. Based on both of these theoretical accounts, one would predict that false memories in younger children would be enhanced if semantic cues that emphasize the semantic relations among words were given. This reasoning will be discussed in the next section.

1.2 Metamemory and Warning

An understanding of concepts related to memory functioning seems to be available to children as young as 4 and 5 years. For example, it is not until that age that children know that in order to remember something one must have acquired some knowledge or experience at some point earlier in time (e.g., Johnson & Wellman, 1980; Lyon & Flavell, 1994; Wellman & Johnson, 1979). However, this knowledge is enhanced later during development. It has also been recently found (Jaswal & Dodson, 2009) that 6-year-olds but not 5-year-olds understand that a person can misremember something due to their failure to distinguish between common objects' perceptual and semantic similarities. Five-year-olds still think that individuals can face memory errors because they are guessing and not because they are experiencing false memories.

Being able to use such knowledge to control online memory processes requires different abilities, such as introspecting on memory states, which fall in the broader definition of procedural metamemory (Schneider & Pressley, 1997). Children as young as 5 are able to monitor their memory strength through confidence ratings, for example they are able to judge their answers in a recognition memory test as related to a higher confidence when they correctly recognize distinctive items as compared to non-distinctive items (Ghetti, 2003) or when they correctly recognize some details about an observed event as compared to when

they incorrectly remember such details (Roebers, Gelhaar & Schneider, 2004). However, metacognitive monitoring as well undergoes significant improvements during development (Ghetti et al., 2008; Schneider & Lockl, 2002). Little is known about children's ability to monitor their memory when forewarned about the possibility of incurring in memory errors while performing the DRM task.

In the literature on adults' false memory illusion, researchers have investigated whether enhancing monitoring and control strategies, such as giving individuals specific explanations about the nature of the false memory illusion with the DRM paradigm, might reduce the false-memory rates in adults (Roediger, Balota, & Watson, 2001; Roediger, Watson, McDermott, & Gallo, 2001). The results showed that providing adults with direct warning indeed mitigates the DRM effect (Gallo, Roberts, & Seamon, 1997; McDermott & Roediger, 1998). For example, Gallo and colleagues (Gallo et al., 1997) had their participants perform the DRM task under three conditions: the uninformed, the cautious and the forewarned condition. In the uninformed condition, participants did not receive any warning instruction, but only standard instructions for a recognition memory task; in the cautious condition, after studying the DRM lists, participants were encouraged to be cautious in the subsequent recognition test because of the semantic overlap between studied words and distracters. Finally, in the forewarned condition, participants received warning and examples of DRM lists and critical lures prior to studying the actual DRM lists. Specifically, participants were explicitly instructed to minimize the possibility of falsely recognizing the not presented critical lures. The authors found that participants in the forewarned condition exhibited lower false-alarm rates to critical lures compared to each of the other two groups. Also the proportion of Remember responses (Remember-Know paradigm, Tulving, 1985) associated with false memories was reduced in the forewarned condition; thus, participants

were less likely to report to vividly remember false memories when they were warned prior to encoding.

The authors concluded that warning participants prior to the study phase encouraged them to rely on control strategies that helped minimize, though not eliminate, the false memory illusion (Gallo et al., 1997). Warning may function as an *identify-and-reject* process, through which people use strategies during the encoding phase which help them identify the critical lure while they process each incoming item (and the idea of list gist begins to form) and later reject it because already marked as "word not presented at study" (see Neuschatz, Beinot, & Payne, 2003 for evidence in favor of this account).

One central question addressed in the present dissertation concerns potential age-related differences in children's ability to take advantage from warnings. Metacognitive monitoring undergoes significant improvements during middle and late childhood (e.g., Ghetti et al, 2008; Schneider & Lockl, 2002). Accordingly one would expect the effect of warning to emerge over the course of childhood. Thus far, only one study has examined the effects of warning during childhood (Carneiro & Fernandez, 2010): these authors tested warning effects in 4-5 year-olds and 11-12 year-olds, and found that warnings had no effect in the younger group and reduced false memories in the older group. Given the age groups and the nature of the results, this study prevents from drawing firm conclusions about the emergence and potential age-related differences in the effects of warnings. Previous research has shown that metacognitive processes supporting false-memory rejection begin to emerge around age 7 (Ghetti, 2003), but are not reliable, or sensitive to the task characteristics until towards the end of middle childhood (Ghetti, 2003; Ghetti & Alexander, 2004; Ghetti & Castelli, 2006; Ghetti et al., 2008). Based on this research, it would be reasonable to expect the effects of warning to emerge around age 8 or 9.

While the main motivation for the present study was to assess the development of the capacity to reject false memories, we also considered an alternative hypothesis. As discussed earlier, research typically shows age-related increases in the DRM effect (Brainerd et al., 2008 for a review) and that this effect increases even in younger children if they are provided with cues that help them process the meaning of the list (Dewhurst, Pursglove, & Lewis, 2007; Lampinen, Leding, Reed, & Odegard, 2006). Given this evidence, warning could enhance elaboration and paradoxically increase false-memories in children whose capacity to process the meaning of the list is still developing. The present study allows for the assessment of this alternative hypothesis.

1.3 Subjective experience associated with true and false memories

Adults involved in the DRM task tend to claim vivid recollection of specific qualitative details related to their false memories, such as the sound of the voice of the experimenter reading it (Ghetti et al., 2002; Roediger & McDermott, 1995). This phenomenon of illusory recollection has been widely studied in adults (see Gallo, 2006), especially using the Remember/Know paradigm (Tulving, 1985). Numerous studies have demonstrated that false memories with the DRM paradigm are frequently associated with Remember judgments (for a review Gallo, 2006). This illusory recollection (i.e., recollection of non-experienced details) might be the result of a "content borrowing" process (Lampinen, Meier, Arnal, & Leding, 2005): Encountering the related lure at test might promote the rising of details that were originally bond to studied words but that are now attributed to the presentation of the related critical lure. Thus, false memories are subjectively compelling and might nevertheless share perceptual and semantic features with the details of events actually experienced.

Even though a handful of studies have deepened the knowledge about how false memories develop, some issues still remain unresolved, such as the subjective state related to

something that has not been experienced as opposed to something that has been encountered. To date, children's ability to introspect about and subjectively discriminate between true and false memories has undergone little empirical investigation.

To our knowledge, the DRM paradigm has never been used to investigate children's introspection on their subjective experiences of false memories. The few studies employing this procedure with children have examined the subjective experience of true recollection (Billingsley, et al., 2002; Ghetti, et al., *in press*), and autobiographical memory (Piolino, et al., 2007). However, age-related differences in the experience of true and false memories have been collected with other methods. For example, Ghetti and colleagues (Ghetti et al., 2002) examined age-related differences in the extent to which confidence ratings differentiated true from false memories with the DRM paradigm, and found that confidence ratings associated with true recognition were higher than those associated with false recognition for the critical lures; these authors found that this difference was increasingly larger with age, from 5-year-olds to 7-year-olds, and from 7-year-olds to adults.

The Remember-Know paradigm allows for a more precise comparison of the subjective experience associated with true and false memory. While we generally expect to replicate previous findings showing increased subjective differentiation between true and false memories, it will be also possible to assess whether this difference is driven by the subjective experience of recollection or a general sense of familiarity. Based on previous research (Ghetti et al., *in press*) showing that even 6- to 7-year olds understand and use the Remember/Familiar distinction sensibly (e.g., select the Remember option when a specific detail is actually remembered), we considered that this paradigm could be employed successfully with children ages 7 and above. We also expected to find an increasingly finer discrimination of the subjective experience related to true and false memories with age (see Ghetti et al., 2002). Thus, on the one hand we could hypothesize that adults, being more

competent at the metacognitive level, would show finer subjective discrimination of true and false memories, subjectively perceiving true memories as linked to a Remember phenomenological experience more frequently than false memories. On the other hand, however, adults are more likely to incur in the DRM effect, compared to children, and to associate false memories to a sense of recollection (Gallo, 2006 for a review), thus we could hypothesize that adults would be as well more likely to associate Remember judgments to the critical lures presented at test.

Two experiments were conducted in order to examine the effects of warning on both objective and subjective true and false memory. In Experiment 1, we tested 9-year-olds, 11-year-olds and young adults with the Deese-Roediger-McDermott paradigm (DRM paradigm: Deese, 1959; Roediger & McDermott, 1995) and we contrasted the recollective experience of participants who had received a warning before encoding with that of participants who had not. In Experiment 2, we extended the results of Experiment 1 by including an additional warning condition and examining a wider age range (7 to 13 years of age).

Given the rising of metacognitive abilities and monitoring processes over memory performance in middle childhood (Ghetti et al, 2008), it was predicted that even children would take advantage of a warning and would thus diminish the false memories production. On the other hand, we considered the alternative hypothesis that warning would promote the processing of the semantic associations in children thereby resulting in increased false memories.

In both experiments, a recall manipulation was included: half of the participants performed a free recall test after the presentation of each list. Roediger and McDermott (1995) found that recall lead to increases in subsequent true and false recognition, which is consistent with the idea that the act of recalling functions as an additional opportunity to encode the information which in turn may enhance a subsequent recognition of similar information.

However, other studies have found this effect only for true but not for false recognition (see Gallo, 2006 for a review). Thus, we wanted to explore whether the effect of warning changed as a function of the strength of the memory for studied words.

Finally, the subjective experience associated with both true and false memory was examined using an adapted version of the Remember/Know instructions used in Ghetti et al (in press) and employed them in both experiments. We hypothesized that younger children would be less prone at engaging in Remember judgments for correctly recognized target words, given that research suggests their lower ability at processing semantic information which in turn seems indispensable for subjective recollection to emerge (Ghetti & Angelini, 2008). For what concerns false memories, we were interested in evaluating whether children's subjective experiences related to critical lures would differ from adults'. We hypothesized that critical lures would be less compelling for children than for adults, thus resulting in less Remember judgments.

1.4 Experiment 1

The goal of Experiment 1 was to test the effects of warning instructions on the production of false memories with the DRM paradigm (Deese, 1959; Roediger & McDermott, 1995) in two groups of children (9- and 11-year-olds) and in a group of young adults. Further, we were particularly interested in evaluating children's ability at introspecting on their memory states through the use of an adapted version of the Remember/Know paradigm (Tulving, 1985).

1.4.1 Method

Participants

Forty six 9-year-old children ($M = 115$ months, $SD = 3.31$), 41 11-year-old children ($M = 128$ months, $SD = 3.3$) and 87 young adults (mean age: 21 years) participated in this study. All children participants were students in public primary schools in the province of Venice, Italy. Written consent was obtained from parents for all children, prior to participation. Participation was scheduled according to school activities and in agreement with the principals and teachers. Young adults were undergraduates in the Psychology Department of the University of Padova, Italy; they volunteered in this project. None of the participants had a history of learning disabilities or other cognitive or neurological impairments.

Materials

Three child-generated Italian word lists, each including 14 words, were used for the encoding phase (Pollio, 2007). These lists converged on the critical lures *dog*, *sea*, *sweet*. For the recognition phase, one randomized list of 18 words was used for all participants. The list included the 3 critical lures (i.e., dog, sea, sweet), 9 studied words (which correspond to the position 1, 8 and 10 of each list) and 6 unrelated distracters, selected from an Italian database (Barca, Burani, & Arduino, 2001) and controlled for word length and frequency.

Procedure

Children were tested individually in a quiet room at their school. Adults were tested individually at the Memory and Learning Laboratory of University of Padova. During the encoding phase, all participants were orally presented the 3 word lists. Participants in the no warning condition received standard instructions for a memory task: They were told that they were going to play a memory game and that in this game they would hear a bunch of words. They were required to listen carefully and to try to remember as many words as possible.

Participants in the warning condition were additionally instructed to be careful, because the words they were going to learn were highly similar in meaning to words they

were going to be tested on later, so they would have to pay close attention in order not to make mistakes. Thus, participants were made aware that studied words and some of the distracters included in the test were difficult to discriminate.

As for the recall manipulation, the procedure differed as follows. Participants in the recall condition were instructed to recall as many words as possible after the presentation of each of the three lists. Participants in the no recall condition proceeded to the next list. All participants were involved in a brief distraction task prior to start the recognition task which consisted in counting backward every two numbers starting from number 50.

After the distracter test, participants were given instructions for the recognition task. Specifically, they were told that the experimenter would read aloud a list of words, some of which had been previously studied, some of which had not. Participants were instructed to respond "yes" when they thought they had heard the word before, or "no", when they thought they had not heard the word before. Further, they were trained on Remember and Familiar responses. For recognized words, participants were instructed to give a Remember judgment when they could remember the word clearly and with some qualitative details related to its encounter in the study phase, such as its position in the study list, or a thought that came to mind while they were hearing that word. Instead, they were instructed to give a Familiar judgment when they had the feeling that the word had been studied before but could not remember any detail related to it. Familiar was preferred to Know because it is more understandable, especially for children (e.g., Dobbins, Kroll, & Liu, 1998).

1.4.2 Results

Preliminary analysis confirmed that there were no performance differences based on gender, ps > .05, and thus this factor is no longer considered. All post-hoc tests are performed with the Bonferroni correction for multiple comparisons.

True and False Recall

Table 1 shows the proportions of correctly recalled studied words (i.e., number of recalled target words divided by the number of studied words) and falsely recalled critical lures (i.e., number of recalled critical lures divided by the number of critical lures) as a function of warning condition. We first performed a between-subject 3 (Age group: 9-year-olds vs. 11-year-olds vs. young adults) X 2 (warning vs. no warning) univariate ANOVA, with proportions of correctly recalled studied words as the dependent measure. A main effect of age was found, $F(2,81) = 4.21$, $p<.05$, $\eta_p^2 = .09$. such that adults correctly recalled more studied words than did 9-year-olds, regardless of warning condition. We then performed the same analysis on the proportion of falsely recalled critical lures, finding no main or interactive effect ($ps>.05$). Although it did not reach statistical significance, the pattern is that of 9-year-olds recalling more critical lures in the warning condition, whereas 11-year-olds and adults recalling more critical lures in the no warning condition.

	Age Group					
	9-year-olds		11-year-olds		Young adults	
	M	*SD*	*M*	*SD*	*M*	*SD*
True recall	.45	.07	.49	.07	.52	.09
False recall	.22	.27	.19	.17	.24	.25

Table 1. Mean proportions (and standard deviations) of correctly recalled target words (i.e., true recall) and falsely recalled critical lures (i.e., false recall)

True and False Recognition

The first analysis has been performed over proportions of "yes" responses to studied items, i.e. target words, and "yes" responses to non-studied items, i.e. critical lures, to ensure that good level of performance were obtained in all groups. A 3 (Age group: 9-year-olds vs. 11-year-olds vs. adults) X 2 (Item type: studied vs. non-studied) mixed ANOVA was

conducted, with rates of "yes" responses as the dependent measure. A significant main effect of item type was found, $F(1,171) = 14.39$, $p<.001$, $\eta_p^2 = .08$, such that regardless of age group the studied words were more likely to be correctly recognized as old, $M=.80$ ($SD=.16$) than were the critical lures to be incorrectly recognized as old, $M=.71$ ($SD=.29$). False alarm rates to unrelated distracters ("yes" responses to non-studied words that were not semantically associated with the target words) reached floor effect outcomes and thus were not included in the analysis (9-year-olds: $M=.03$, $SD=.07$; 11-year-olds: $M=.06$, $SD=.1$; adults: $M=.01$, $SD=.04$).

Corrected true recognition scores were then calculated by subtracting the proportions of "yes" responses to unrelated distracters from the proportion of "yes" responses to studied words (see Table 2). Corrected true recognition scores were entered as the dependent measure in a 3 (Age group: 9-year-olds vs. 11-year-olds vs. young adults) X 2 (warning vs. no warning) X 2 (recall vs. no recall) ANOVA. We found a main effect of age, $F(2,162) = 5.1$, $p<.01$, $\eta_p^2 = .06$, such that adults exhibited higher true recognition than did both 9- and 11-year-olds (who did not differ between each other: 9-year-olds: $M=.73$, $SD=.15$; 11-year-olds: $M=.73$, $SD=.22$). We also found a main effect of recall, $F(1,162) = 7.5$, $p<.01$, $\eta_p^2 = .04$; across participants a higher true recognition was observed in the recall condition.

	Warning				No warning			
	Recall		No Recall		Recall		No recall	
	M	SD	M	SD	M	SD	M	SD
9-year-olds	.74	.12	.72	.18	.73	.15	.73	.16
11-year-olds	.72	.19	.67	.16	.90	.11	.66	.31
Young adults	.85	.15	.76	.16	.85	.12	.80	.12

Table 2. Mean proportions (and standard deviations) of correctly recognized target words (i.e., true recognition) as a function of warning and recall

Corrected false recognition scores were calculated by subtracting the proportion of "yes" responses to unrelated distracters from "yes" responses to critical lures. The corrected false recognition scores were entered as the dependent measure in a 3 (Age group: 9-year-olds vs. 11-year-olds vs. adults) X 2 (warning vs. no warning) X 2 (recall vs. no recall) ANOVA. A main effect of warning, $F(1,162) = 8.2$, $p<.01$, $\eta_p^2 = .05$, revealed that across participants the DRM effect was predominant in the warning condition. However, this effect was qualified by a 3-way interaction, $F(2,162) = 3.02$, $p<.05$, $\eta_p^2 = .04$, which is described as follows: 9-year-olds were more likely to produce false memories in the warning/ recall conditions, whereas 11-year-olds were more likely to produce false memories in the warning/ no recall conditions. On the contrary, young adults did not seem to be affected by neither manipulation (see Figure 1).
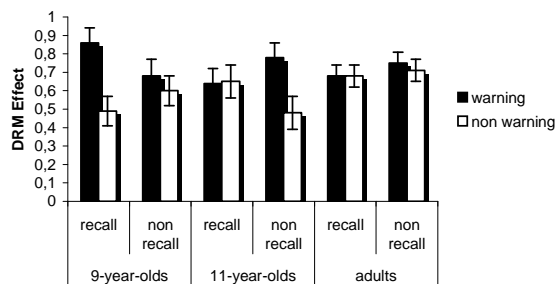
Figure 1. Mean proportions (and standard deviations) of falsely recognized critical lures as a function of warning and recall

Subjective experience associated with true and false recognition

Table 3 shows the mean proportions and standard deviations for Remember/Familiar judgments associated with hit rates and false alarms to critical lures. Proportions of Remember and Familiar judgments associated with hits were entered in a repeated measures ANOVA with judgment type (Remember vs. Familiar) as the within subject factor and age (9-year-olds vs. 11-year-olds vs. young adults), warning and recall conditions as between subject factors. We found a main effect of judgment type, such that more Remember responses were

associated with hits than Familiar responses, $F(1,162) = 14.25$, $p<.001$, $\eta_p^2 = .08$; this effect was qualified by an interaction with age, $F(2,162) = 3.1$, $p<.05$, $\eta_p^2 = .04$, such that this effect was more marked in the 9-year-olds and adults. Nor warning or recall condition had any effect of interest on the subjective experience related to hits (Fs>1, ps>.05).

Proportions of Remember and Familiar judgments associated with false memories were then entered as the dependent measure in a repeated measures ANOVA, with judgment type (Remember vs. Familiar) as the within subject factor and age (9-year-olds vs. 11-year-olds vs. adults), warning and recall conditions as between subject factors. Across participants, more Familiar responses were found to be associated with false memories compared to Remember responses, $F(1,162) = 6.61$, $p<.05$, $\eta_p^2 = .04$. In this case, the interaction between age and type of response was not significant, (Fs>1, ps>.05).

We then decided to focus on the effects of warning on the recollection experience associated with true and false memories. Thus, we conducted a 2 (item type: studied vs. non-studied critical lures) X 3 (Age group: 9-year-olds vs. 11-year-olds vs. adults) X 2 (warning vs. no warning) repeated measure ANOVA, with proportions of Remember judgments associated with "yes" responses as the dependant measure. We found a significant main effect of item type $F(1,162) = 43.9$, $p<.001$, $\eta_p^2 = .21$, such that more Remember judgments were associated with studied items compared to non-studied critical lures, in all groups. We also found a significant interaction between item type and warning condition, $F(1,162) = 3.97$, $p<.05$, $\eta_p^2 = .02$. Post-hoc analyses showed that more Remember responses were associated with hits in the no warning condition and the opposite pattern was evident for Remember responses associated with false memories, that is, more Remember responses were associated with critical lures in the warning condition compared to the no warning condition (Table 3).

	Warning		No Warning		
	Recall	No Recall	Recall	No Recall	Tot.
9-year-olds					
Remember					
Target words	.43 (.20)	.44 (.25)	.44 (.24)	.45 (.18)	.44 (.21)
Critical lures	.40 (.25)	.33 (.31)	.23 (.21)	.25 (.28)	.29 (.26)
Familiar					
Target words	.32(.24)	.30(.25)	.32(.25)	.35(.20)	.32 (.23)
Critical lures	.48 (.27)	.37 (.37)	.28 (.33)	.42 (.35)	.38 (.32)
11-year-olds					
Remember					
Target words	.37 (.21)	.32 (.19)	.57 (.21)	.37 (.24)	.41 (.23)
Critical lures	.33 (.36)	.27 (.30)	.23 (.21)	.25 (.28)	.30 (.28)
Familiar					
Target words	.37(.25)	.43 (.22)	.36 (.16)	.36 (.24)	.38 (.22)
Critical lures	.36 (.35)	.60 (.26)	.33 (.35)	.33 (.35)	.40 (.33)

Table 3. Mean proportions (and standard deviations, in parentheses) of Remember and Familiar judgments associated with true and false recognition, as a function of warning and recall

1.4.3 Discussion

The main result of Experiment 1 is that warning instructions increased false memory rates in children instead of decreasing them. In particular, in the younger group of children, the DRM effect was predominant in the condition where children had performed free recall before the recognition test, whereas in the older group of children it was predominant in the no recall condition.

Factors enhancing false memory at one point in development may counter false memory at another point, depending on the processes that such factors most likely promote (Brainerd et al., 2008; Ghetti, 2008). In the present study, warning appeared to provide child participants with an opportunity to process the theme of the lists further, instead of protecting against false memory formation; however, this result depended on whether list recall was performed. In 9-year-olds, recall in combination with warning promoted false memory, suggesting that recall provided additional opportunities for younger children to process the semantic relationships linking the words included in each DRM list. Eleven year olds did not

need such a process to strengthen their semantic knowledge, they exhibited increased false recognition following warning only when they did not have the opportunity to recall the lists, suggesting that recall provided an opportunity to process the words lists more distinctively; this result also suggests that 11-year-olds are likely competent enough at elaborating DRM word lists. This does not stand in contrast with Carneiro and Fernandez' study (2010), as it will described in the general discussion of Experiment 1 and Experiment 2.

Effects of recall aside, it is clear that to the extent that effects of warning have been found, these effects were in the opposite directions from those reported in previous research (Gallo et al., 1997). Although our warning instructions were given prior to encoding as Gallo et al (1997) did when they observed reduction of false memories, unlike Gallo et al, we did not include specific examples of lists and critical lures. Perhaps for this reason our warning instructions may have functioned as a cue to process the meaning of the words. Indeed, studies on gist cues, that is providing children with explanation of what conceptual relations among words are both in DRM experiments (Lampinen et al, 2006) or categorized list tasks (Brainerd et al, 2004), document increased false memories compared to when no semantic cues are provided. To evaluate whether reduction of false memory would be observed if warning included specific examples, Experiment 2 was conducted; it included a warning condition in which specific examples of the DRM effects were provided, in addition to a warning and a control condition as in the current experiment.

Concerning the subjective experience, an increase in the recollective experience was not evident for false alarms, suggesting that older participants are more careful in using Remember judgments for critical lures. Indeed, in the present Experiment, differently from previous research (Gallo, 2006) the Familiar responses for the critical lures were more frequent than Remember responses for all age groups. Furthermore, no interaction was found between age and type of responses, suggesting that the adults were very cautious to use

Remember responses and did not extend to lures the tendency to have a greater recollective experience than children. It is possible that the use of a small number of lists affected how subjectively compelling false memories were despite not reducing the overall DRM effect which was very robust in the present experiment. When we compared the recollective experience alone related to true and false recognition scores, we found in all age groups the tendency to experience a more compelling recollective experience for true recognition. This is better explained by the effect of the interaction with warning, that is, all age groups had a higher recollective experience associated with the hit rate in the no warning condition, whether they had a higher recollective experience for critical lures when not previously warned. This effect did not vary according to age group, we were thus interested in clarifying this finding in a wider age range. Furthermore, the use of a small number of lists which were child-generated may be the reason for strong false recognition effects in children resulting in overall age-invariance in these effects. Thus, Experiment 2 was also conducted to examine whether the effect of warning was replicated with a larger number of traditional DRM lists. It was predicted that the use of more traditional materials along with the involvement of a wider age range of participants would result in the frequently observed age-related increase in the DRM effect (Brainerd et al., 2008; for a review).

1.5 Experiment 2

The goal of Experiment 2 was to better evaluate the effect of warning on the DRM illusion. We thus added a warning condition in which participants received an example of the DRM effect along with a thorough explanation of the effect. We assessed a wider age range to ensure that the design captured the emergence during development of both warning-related increases and decreases of false memories. Thus, 7- to 8-year-olds, 10- to 11- year-olds, 12- to 13- year-olds and young adults were included. Finally, we employed the Remember-Know

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paradigm to test whether there would be age-related differences in subjective recollection with respect to both accurate and inaccurate memories (as reported by literature, Brainerd et al., 2008; Gallo, 2006).

1.5.1 Method

Participants

Sixty five 7- to 8-year-old children (*M*=7.6, *SD*= 0.34, 41 females), 68 10- to 11-year-old children (*M*=10.7, *SD*= 0.39, 33 females), 76 12- to 13-year-olds (*M*=12.9, *SD*=0.53, 35 females) and 52 young adults (*M*=18.7, *SD*= 0.5, 46 females) participated in this study. All children participants were students in public primary schools in the middle or north of Italy. Written consent from parents was obtained for all children, prior to participation. Participation was scheduled according to scholastic activities and in agreement with the principal and teachers. Young adults were high school students. None of the participants had a history of learning disabilities or other cognitive or neurological impairments.

Materials

Twelve DRM lists were selected from the 24 lists of Italian words (Ciaramelli, Ghetti, Frattarelli, & Ladavas, 2006), which were the translations of the lists of semantic associates used by Stadler, Roediger & McDermott (1999). Each list included 12 words. Three blocks of 4 lists each were created for counterbalancing purposes. Lists were randomly assigned to each block. Each participant encoded lists from two blocks (i.e., 8 lists), whereas the remaining block of 4 lists were included as distracters in the recognition phase. Blocks were counterbalanced among participants, to ensure that every list was used the same number of times as target or distracter list. One unique list of 48 words was created for the recognition phase. This list included 24 target words (words corresponded to positions 1, 8 and 10 of each of the 8 studied list), 12 semantically non-related distracters (words corresponded to position

1, 8 and 10 of the 4 non-studied lists) and the 12 critical lures (of which, 8 were the critical lures of the studied word-lists and 4 were the critical lures of the non studied word lists, i.e. control lures). The order of words in the recognition test list was randomized, with the constraints that no more than 4 target words or unrelated distracters appeared consecutively between the critical lures.

Procedure

Procedure was the same as in Experiment 1 except for the following differences. An additional warning condition was included in the experiment. Specifically, participants received an example of the DRM effect; they were told: "For example, if I read to you the words: bark, leash, collar, muzzle, stray, snarl, bone, puppy… what would you think of?" If the child answered *dog*, then the experimenter would give feedback and tell him/her: "Good, all these words go along together because they all refer to the word *dog*, even if I did not read that word to you. So, later I can ask you: Was the word *stray* in the list? If your answer is "yes", that would be correct because the word *stray* was actually present in the list of words that I just read to you. I can also ask you, was the word *dog* present among the words that I just read to you? If your answer is: "No *dog* was not there, I don't remember it", that would be correct because I did not read the word *dog* to you; maybe you could remember having thought about that word, even though I did not read it to you. But you may also tell me "yes *dog* was among the words you read to me" because *dog* is similar in meaning to all the other words that I read to you and you may be confused and may think that I read it to you even though I did not." Participants were further encouraged to pay close attention and be very careful not to make mistakes.

The recall manipulation was included in this experiment. Thus, half of the participants in this warning condition were asked to recall lists prior to recognize the word lists. Finally,

unlike in Experiment 1, words were recorded by a female voice on a computer and presented to the participants at a rate of 2500 msec.

1.5.2 Results

Preliminary analysis confirmed that there were no performance differences based on gender, ps > .05, and thus this factor is no longer considered. All post-hoc tests are performed with the Bonferroni correction for multiple comparisons.

True and False Recall

We performed two 4 (Age group: 7- to 8 -year-olds, 10- to 11-year-olds, 12- to 13-year-olds and young adults) X 3 (no warning, warning, warning example) ANOVAs, with true recall and false recall as the dependent measures. The first analysis with true recall as the dependent measure revealed a main effect of age $F(3, 119) = 44.23$ $p<.001$, $\eta_p^2 = .53$. Post-hoc comparisons showed that the younger children had a worse performance than all the other age groups and the young adults had a better performance than all the other age groups (see table 4). Further, the main effect of warning was found, $F(2, 119) = 3.76$ $p<.05$, $\eta_p^2 = .06$, such that, regardless of age, all participants produced a higher proportion of correctly recalled words in the warning condition. No interaction was found. The analysis with false recall as the dependent measure did not show any significant main or interactive effect ($p>.05$).

	No Warning				Warning				Warning Example			
	True Recall		False Recall		True Recall		False Recall		True Recall		False Recall	
	M	SD	M	SD	M	SD	M	SD	M	SD	M	SD
7-8-year-old	.33	.08	.11	.09	.37	.08	.16	.15	.34	.07	.21	.18
10-11-year-old	.49	.08	.17	.13	.50	.15	.14	.09	.48	.08	.22	.21
12-13-year-old	.48	.10	.25	.14	.53	.07	.26	.20	.50	.09	.21	.21
Young adults	.55	.05	.16	.15	.65	.07	.14	.15	.62	.10	.16	.14

Table 4. Mean proportions (and standard deviations) of correctly recalled target words (i.e., True Recall) and falsely recalled critical lures (i.e., False Recall) as a function of warning

True and False Recognition

As in Experiment 1, the first analysis was performed on the proportions of "yes" responses to studied items (i.e., hits), and "yes" responses to non-studied critical lures (i.e., false memories). A 4 (Age group: 7- to 8 -year-olds, 10- to 11-year-olds, 12- to 13-year-olds and young adults) X 2 (Item type: studied vs. non-studied) mixed ANOVA, with rates of "yes" responses as the dependent measure, was performed. A significant main effect of item type, $F(1,256)=54.3$, $p<.001$, $\eta_p^2 = .17$, showed that, regardless of age, the studied items were more likely to be correctly recognized ($M=.73$, $SD=.15$) than were the critical lures to be incorrectly recognized ($M=.62$, $SD=.24$).

In order to analyze the effect of age and warning on true recognition (i.e., hits), we performed a 4 (Age group: 7- to 8 -year-olds, 10- to 11-year-olds, 12- to13-year-olds and young adults) X 3 (no-warning, warning, warning with example) X 2 (recall vs. no recall) ANOVA, with corrected true recognition scores as the dependent measure. Corrected true recognition scores were calculated by subtracting the proportions of "yes" responses to unrelated distracters from "yes" responses to studied words, (see table 5). A main effect of age was found, $F(3, 236) = 17.51$, $p<.001$, $\eta_p^2 = .18$. Post-hoc comparisons showed that the 7-

to 8-year-olds exhibited lower levels of true recognition than the other three age groups, and the young adults exhibited higher levels of true recognition than the other three age groups.

There was also a main effect of recall, $F(1, 236) = 27.99$, $p<.001$, $\eta_p^2 = .11$, which was qualified by a significant interaction with warning, $F(5, 236) = 5.14$, $p<.01$, $\eta_p^2 = .04$, such that, in both warning and warning example conditions, higher levels of true recognition were observed in the recall condition compared to the no recall condition.

	No Warning		Warning		Warning example	
	Recall	No Recall	Recall	No Recall	Recall	No Recall
7-8-year-olds						
Target words	.47 (.16)	.49 (.15)	.67 (.13)	.44 (.19)	.51 (.25)	.60 (.18)
Critical lures	.25 (.18)	.33 (.22)	.52 (.33)	.39 (.32)	.48 (.24)	.51 (.25)
Unrelated lures	.08 (.18)	.12 (.13)	.09 (.12)	.16 (.15)	.13 (.20)	.09 (.12)
10-11-year-olds						
Target words	.69 (.15)	.65 (.15)	.67 (.32)	.57 (.14)	.74 (.05)	.62 (.12)
Critical lures	.54 (.22)	.61 (.22)	.50 (.33)	.51 (.29)	.62 (.26)	.54 (.18)
Unrelated lures	.03 (.05)	.08 (.10)	.08 (.20)	.13 (.10)	.01 (.02)	.08 (.11)
12-13-year-olds						
Target words	.74 (.10)	.60 (.12)	.74 (.13)	.40 (.21)	.74 (.10)	.56 (.22)
Critical lures	.63 (.18)	.68 (.25)	.57 (.23)	.42 (.20)	.53 (.28)	.44 (.20)
Unrelated lures	.05 (.05)	.09 (.08)	.07 (.09)	.24 (.15)	.05 (.08)	.17 (.16)
Young adults						
Target words	.72 (.14)	.74 (.12)	.81 (.08)	.71 (.09)	.81 (.08)	.67 (.10)
Critical lures	.61 (.23)	.78 (.16)	.40 (.21)	.64 (.23)	.65 (.28)	.49 (.22)
Unrelated lures	.05 (.04)	.07 (.05)	.07 (.08)	.10 (.12)	.01 (.03)	.07 (.09)

Table 5. Mean proportions (and standard deviations) of correctly recognized target words (i.e., hits), and falsely recognized critical lures and unrelated lures as a function of warning and recall

We performed a 4 (Age group: 7- to 8 -year-olds, 10- to 11-year-olds, 12- to 13-year-olds and young adults) X 3 (no warning, warning, warning example) X 2 (recall vs. no recall) ANOVA, with corrected false recognition scores as the dependent measure. Corrected false recognition scores (i.e., the DRM effect) were calculated by subtracting "old" responses to unrelated distracters from "old" responses to critical lures. We found a main effect of age, $F(3, 236) = 6.06$, $p<.01$, $\eta_p^2 = .07$. Post-hoc analyses showed that 7 to 8-year-old children showed lower false recognition than all the other age groups, whereas no differences were found among the other age groups. We also found an interesting interaction between warning

and age group, $F(11, 236) = 3.039$, $p<.01$, $\eta_p^2 = .072$. The post-hoc analyses showed that 7- to 8-year-old children produced higher false recognition in the warning example condition compared to the no warning condition, whereas the 12- to13- year- olds produced more false memories in the no warning condition respect to the warning example condition (Table 5 and Figure 2).
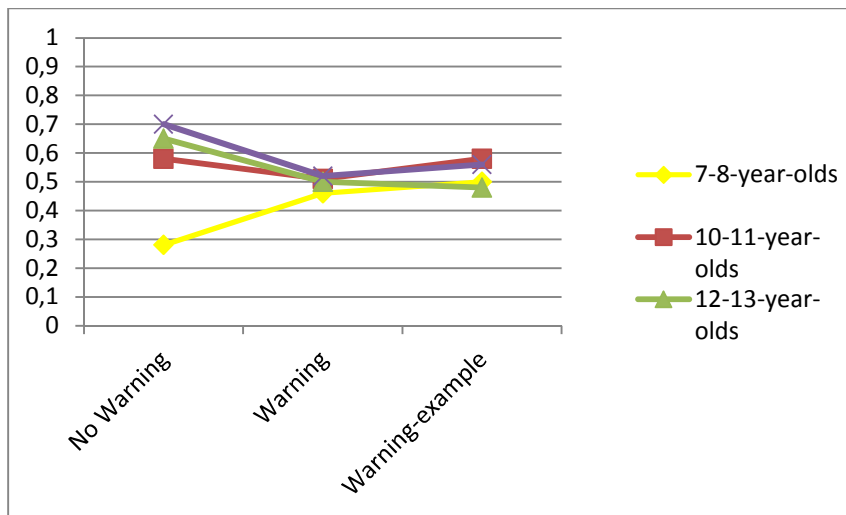

Figure 2. Effects of warning conditions on proportions of false memories

Subjective experience associated with true and false recognition

The results about the subjective experience related to both true and false recognition scores are presented in Table 6. Proportions of Remember and Familiar judgments associated with hits were entered in a repeated measures ANOVA with judgment type (Remember vs. Familiar) as the within subject factor and age (7- to 8 -year-olds, 10- to 11-year-olds, 12- to 13-year-olds and young adults) , warning and recall conditions as between subject factors. A significant main effect of judgment type was found, such that more Remember responses were associated with hits than Familiar responses, $F(1,235) = 252.34$, $p<.001$, $\eta_p^2 = .52$; this effect was qualified by an interaction with age, $F(1,235) = 3.52$, $p<.05$, $\eta_p^2 = .04$, such that the youngest group of children gave significantly fewer Remember judgments in association with hits than all the other age groups. Nor warning or recall condition had any effect of

interest on the subjective experience related to hits. As for the subjective experience associated with the false recognition scores, we performed a 2 (Remember vs. Familiar) X 4 (Age group: 7- to 8 -year-olds, 10- to 11-year-olds, 12- to 13-year-olds and young adults) X 3 (no warning, warning, warning example) X 2 (recall vs. no recall) mixed ANOVA. A main effect of judgment type was found, such that, differently from Experiment 1, more Remember responses were associated with false memories than Familiar responses, $F(1,235) = 25.75$, $p<.001$, $\eta_p^2 = .10$. As in Experiment 1, the interaction age x type of response was not significant, $(p>.05)$.

We then compared, as in Experiment 1, the recollective experience associated with true and false memories in order to see whether there would be differences in discrimination due to age or warning condition. We performed a 2 (item type: studied vs. non-studied critical lures) X 4 (Age group: 7- to 8 -year-olds, 10- to 11-year-olds, 12- to 13-year-olds and young adults) X 3 (warning vs. no warning vs. warning example) mixed ANOVA with proportions of Remember judgments associated with "yes" responses as the dependent measure. As in Experiment 1, we found a main effect of item type $F(1,248) = 127.83$, $p<.001$, $\eta_p^2 = .34$, such that across age groups, more Remember judgments were associated with studied items compared to non-studied critical lures. The difference between the recollective experience related to hits and that related to false memories becomes larger with age, as can be seen through the significant interaction between age group and item type, $F(3,248) = 3.61$, $p<.05$, $\eta_p^2 = .04$. Thus, subjective recollection related to true recognition increases with age, whereas the subjective recollection related to false recognition remains invariant.

	No Warning		Warning		Warning example	
	Recall	No Recall	Recall	No Recall	Recall	No Recall
7-8-year-olds						
Remember						
Target words	.44 (.20)	.41 (.20)	.54 (.24)	.37 (.21)	.38 (.15)	.51 (.25)
Critical lures	.24 (.23)	.30 (.24)	.44 (.35)	.33 (.24)	.26 (.17)	.38 (.32)
Familiar						
Target words	.12 (.09)	.21 (.21)	.23 (.22)	.23 (.17)	.25 (.19)	.17 (.10)
Critical lures	.10 (.13)	.16 (.13)	.18 (.22)	.23 (.20)	.35 (.25)	.22 (.20)
10-11-year-olds						
Remember						
Target words	.57 (.13)	.55 (.17)	.56 (.26)	.46 (.28)	.56 (.15)	.54 (.16)
Critical lures	.44 (.22)	.50 (.31)	.31 (.18)	.40 (.32)	.37 (.18)	.36 (.21)
Familiar						
Target words	.14 (.09)	.17 (.14)	.19 (.16)	.24 (.16)	.18 (.13)	.16 (.07)
Critical lures	.12 (.12)	.20 (.22)	.28 (.17)	.25 (.22)	.25 (.15)	.26 (.19)
12-13-year-olds						
Remember						
Target words	.59 (.22)	.47 (.14)	.67 (.10)	.42 (.08)	.65 (.11)	.52 (.20)
Critical lures	.43 (.23)	.50 (.24)	.41 (.22)	.32 (.13)	.42 (.16)	.33 (.19)
Familiar						
Target words	.21 (.18)	.22 (.13)	.14 (.08)	.22 (.10)	.14 (.08)	.21 (.17)
Critical lures	.25 (.17)	.26 (.18)	.24 (.18)	.34 (.17)	.17 (.19)	.29 (.18)
Young adults						
Remember						
Target words	.61 (.23)	.58 (.12)	.75 (.08)	.58 (.13)	.65 (.19)	.54 (.12)
Critical lures	.40 (.27)	.43 (.21)	.29 (.23)	.47 (.10)	.36 (.29)	.23 (.14)
Familiar						
Target words	.16 (.14)	.23 (.13)	.13 (.06)	.22 (.10)	.17 (.12)	.20 (.10)
Critical lures	.26 (.22)	.43 (.22)	.18 (.17)	.28 (.25)	.30 (.17)	.33 (.17)

Table 6. Mean proportions (and standard deviations, in parentheses) of Remember and Familiar judgments associated with true and false recognition, as a function of warning and recall

1.6 Discussion of Experiment 1 and Experiment 2

These Experiments intended to examine two main issues, i.e. the effect of receiving warnings on children's production of false memories in the DRM paradigm and age-related differences in subjective experience associated with true and false memories. These issues will be discuss in turn.

Effects of warning on false memories

Experiment 1 and Experiment 2 consistently showed that the provision of a warning increases the presence of false memories in the younger groups, and this effect was affected

by the presence vs. the absence of an example in the warning instructions. In a very recent study, Carneiro and Fernandez (2010) reported that 11/12 year olds (but not 4/5 year olds) were more likely to reject critical lures when previously warned about the possibility they had to incur in false memories. The results of Experiment 1 and Experiment 2 confirm this pattern with older children, and offer interesting insight about age-related differences in warning effects. Carneiro and Fernandez (2010) found that 11- year-olds evinced lower false recognition after receiving a warning; this result stand in apparent contrast with the finding in Experiment 1 that even 11-year-olds produced more false memories in the warning condition. However, the instructions used in Experiment 1 provided a general word of caution, without providing specific examples. When specific examples were provided in Experiment 2, which resembled those provided by Carneiro and Fernandez (2010), then reduction of false memories were observed in this age group. Thus, in order for warnings to reduce false memories the warning must be specific. Simply warning children by telling them "to be aware", does not provide sufficient grounds to reject critical lures.

Why do warning effects change as a function of whether examples are provided? A possibility is related to the interplay between children's understanding and reliance on the warning instructions, and the development of the processing of semantic relationships. Several studies have shown that warning reduces false memories and this effects becomes increasingly stronger with the child age, possibly because children become increasingly apt at attending to the critical dimensions of the task at hand (Ghetti & Castelli, 2006; Ghetti et al., 2006). Based on this research, the ability to understand warning instructions and use them to counter false-memory formation may be present around 9 years of age and may lead to the prediction that the DRM effect may be reduced in 9-year-olds as well as 11-year-olds.

On the other hand, given the typical increment in the production of false memories during development found with the DRM and related tasks, warning could function more like

an additional cue for children, thus making them experience more memory errors. Previous studies (see Brainerd et al., 2008) have shown that children compared to adults are less susceptible to false-memory formation in the DRM paradigm due to reduced semantic elaboration. This evidence was here confirmed by the results of Experiment 2. It is possible that warning acted as a stimulus to pay more attention to the task in thereby enhancing effort and elaboration.

Consistently with previous studies (Gallo et al., 1997; McDermott & Roediger, 1998) warning instructions in Experiment 2 favored the reduction of false memories in 12-to-13-year-olds and young adults; this effect is more marked when the warning is accompanied by an example, as in Gallo et al.'s experiment (1997) warning instructions were effective in the forwarned, but not the caution, condition. We note that the DRM illusion is a very robust phenomenon, likely beginning at the encoding of the material at hand, thus telling older children and adults to be aware that they may incur in memory distortions does not prevent them from false recognizing related lures; this is also supported by the demonstrated ineffectiveness of warnings after the encoding phase (e.g., McCabe & Smith, 2002; Neuschatz, Payne, Lampinen, & Toglia, 2001). However, the provision of clear warnings before encoding does reduce, but not eliminate, the DRM illusion in adults (and older children, as showed in Experiment 2 of this study). These warnings likely provide with the basis for monitoring strategies that highlight the conceptual relatedness between studied items and critical lures but allow for differentiating the latter ones from the truly encountered words.

Subjective experience associated with true and false memories

The second main goal of the present research was to examine the subjective experience associated both with true and false recognitions. Children appeared to be able to differentiate between true and false memories, and Remember states were most sensitive to

this difference. In fact, in both Experiment 1 and Experiment 2 we found that all groups of children had a higher subjective recollection (i.e., Remember judgments) when correctly remembering target words respect to when incorrectly remembering critical lures; thus, it seems that even at age 7 (Experiment 2), children are able to introspect on their true and false memories and understand that a truly experienced item could be retrievable also because richer in its contextual details or because linked to a qualitatively richer memory trace; this also suggests a convergence between objective and subjective indices of recollection (Ghetti & Angelini, 2008). However, this discrimination, as predicted, increases and becomes finer with increasing age (Experiment 2). In contrast, the pattern for false recognition did not show any increase of recollective experience with development. This result suggests that adult participants had some specific subjective experience related with the recognition of the critical lures. Indeed, the proportion of Remember responses was lower for critical lures than for hits. Thus, although dominant, the recollective experience associated with false recognition of critical lures is not as strong as that associated with hits.

In conclusion, false memories likely emerge from a heterogeneous combination of factors, including conceptual elaboration and rejection mechanisms rooted in metacognitive monitoring and control, all of which undergo robust development during middle and late childhood, and whose operation leads false memories in opposite directions, towards increase in the former case and decreased in the latter. One question is whether, in reducing false recognition, the effects of warnings affect subjective recollection and familiarity similarly or one of these experiences is preferentially affected. An answer to this question could provide insight onto the mechanism underlying the effects of warning. In the present study (Experiment 2) we found a suggestion that this might be the case: while the effect of warning failed to achieve conventional levels of statistical significance in decreasing subjective recollection associated with false memories, across all age groups, there is evidence from

adults that warnings can affect subjective recollection of false memory (Gallo et al., 1997; Gallo, Roediger, & McDermott, 2001b); while this study does not provide any firm evidence in favor or against developmental trends this may be in part due to an overall weak effect of warning on subjective false recollection; thus, more research is needed in order to clarify whether age-differences do exist in the subjective experience associated with false recognition. Nevertheless, the present study provides interesting new insight onto factors affecting the formation of false memories and introspection on these states.

CHAPTER TWO

SUBJECTIVE REMEMBERING IN TYPICALLY DEVELOPING CHILDREN AND CHILDREN WITH ADHD

2.1 Experiment 3

As seen in more details in Chapter One, the examination of developmental trends in spontaneous memory distortions (i.e., distortions that are not induced by provision of misleading information or social pressure) has motivated a large number of studies (for reviews: Brainerd, et al., 2008; Gallo, 2006). It has been shown that false memories increase with age when paradigms which involve the semantic processing of information are employed (e.g., Deese-Roediger-McDermott paradigm: Roediger & McDermott, 1995), revealing an important role of conceptual knowledge on the susceptibility to these memory errors. The result suggests that children with learning difficulties and poor semantic processing abilities could produce fewer false memories than typically developing children, with important implications for judging their eyewitness reliability in legal cases in which children with disabilities are required to testify; indeed these cases are increasing in frequency. However, special populations of children with disabilities have only been studied in a handful of studies. For example, Brainerd and colleagues (Brainerd, Forrest, Karibian, & Reyna, 2006) found that children with learning disabilities compared to a control group were less prone to evince false memories induced with the Deese-Roediger-McDermott (DRM) task, which requires to memorize lists of semantically related words and results in high levels of false recognition for distracters that represent the theme of each of the studied lists; this result is likely due to their less efficient semantic processing abilities. Furthermore, Weekes and colleagues (Weekes, Hamilton, Oakhill, & Holliday, 2008) showed that this false-memory effect was reduced in disabled children with a specific reading comprehension difficulty.

While these studies provide convincing evidence that semantic processing may result in fewer false memories for children with learning disabilities, it is not clear whether other paradigms, involving different processes at the basis of illusory memories, may also differentiate children with typical development from children with certain disabilities. We thus decided to focus on two types of memory errors which have been found to influence recognition performance in a memory task which involves the presentation of materials organized in scripts, both in adults (Hannigan & Reinitz, 2001) and children (Lyons, et al., 2010).

Early research on the organization of general event knowledge supported evidence in favour of children as young as three years being able to temporally organize sequences of recurring events and report on them (Nelson & Gruendel, 1981); children's event knowledge improves with age, and children's reports - in the form of scripts - about their familiar experiences become richer and with a greater amount of component actions as they grow older (e.g., Hudson & Shapiro, 1991). Although script knowledge facilitates recall and story comprehension, it also induces memory distortions when a person ought to make memory decisions about events that were not previously experienced but are consistent with a known script. In particular, if an individual is presented with images which are consistent with the script initially studied but that were nonetheless absent, s/he may incur in a *gap-filling error*, i.e., thinking that the image was part of the script when indeed it was not (Hannigan & Reinitz, 2001; Lyons, et al., 2010). If the person is presented with an image that represents an effect of a possible, but not typical, action embedded in a script, then s/he may mistakenly recognize the inferred, but not presented, corresponding cause (*backward causal inference error*) (Hannigan & Reinitz, 2001; Lyons et al., 2010). In Hannigan and Reinitz' study (Experiment 2, 2001), gap-filling errors were reported to be associated, at the subjective level, to a sense of familiarity with the encountered event (i.e., adults report more Know judgments

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in association with this memory errors compared to Remember judgments; Remember-Know paradigm, Tulving, 1985), whereas the backward causal inference errors to a vivid recollection (i.e., adults report more Remember judgments associated with this type of error). This is also supported by developmental evidence which suggests that the production of causal errors increases with increasing age, likely resulting from the influence of recollection, which is known to develop during childhood, whereas the production of gap-filling errors remains invariant, likely resulting from the process of familiarity, which is known to be stable from about age 7 (Ghetti & Angelini, 2008; Lyons et al., 2010).

The present study examines these phenomena in a special population of children, namely children with Attention Deficit/Hyperactivity Disorder (ADHD). This population is of particular interest, because an impaired semantic memory elaboration has been sometimes observed (Cornoldi, Barbieri, Gaiani, & Zocchi, 1999; Shallice, Marzocchi, Coser, Del Savi, Meuter, & Rumiati, 2002). Based on this research, lower rates of gap-filling errors were predicted in children with ADHD compared to typically developing children.

Of interest, some studies indicate that episodic memory and autobiographical memory are surprisingly articulated in children with ADHD (e.g., Skowronek, Leichtman, & Pillemer, 2008). If this is the case, in this population, we should expect higher production of backward causal inference compared to gap-filling errors, given that the former errors are thought to largely depend on episodic recollection processes (Lyons et al., 2010). There is an additional reason why these errors should be more frequent in children with ADHD. The recollective nature of these errors makes their experience vivid and subjectively compelling (Lyons et al., 2010). Thus, they should be particularly difficult to inhibit. The main deficits of ADHD revolve around executive dysfunction (Pennington & Ozonoff, 1996; Willcutt, Doyle, Nigg, Faraone, & Pennington, 2005), including impulsivity and lack of attentional control, which can be assumed to influence the performance in a false memory paradigm. Executive

dysfunction has been associated with the generation of memory errors (Barkley, 1990), and previous research showed that children with ADHD exhibited higher memory errors due to intrusions of irrelevant information (Cornoldi et al, 1999; Marzocchi, Lucangeli, De Meo, Fini, & Cornoldi, 2002). Thus, children with ADHD may encounter great difficulty at inhibiting backward causal inference errors.

However, one alternative hypothesis should be considered. Given the evidence of inhibitory difficulties in ADHD (e.g., Marzocchi et al., 2002), one could predict that children with ADHD will generate more errors overall thereby reducing our ability to detect specific errors such as gap filling errors and backward causal inferences. Furthermore, if children with ADHD encounter particular difficulty at controlling and monitoring their cognitive processes, then they should be expected to manifest higher confidence in their errors, compared to control children, likely resulting from their impulsivity.

Thus, the general goal of this study was to investigate long-term episodic memory in children with ADHD, using a recognition memory paradigm for material organized in scripts (adapted from Lyons, et al., 2010) and subjective remembering using confidence ratings. We decided to employ this type of material because of its ecological validity and its interesting appearance for children, especially for those who have problems keeping their attention on a particular task. The employed paradigm, initially proposed to adults (Hanningan & Reinitz, 2001) and then to typical children (Lyons et al, 2010), has been further adapted. As in its original version, it allows for the investigation of memory accuracy and memory errors that may occur when a person sees pictorial images that represent the typical actions that compose a script, for example eating at a restaurant, and then remembers elements not presented, although consistent with the presented material. In the present study four scripts were administered: eating at a restaurant, going grocery shopping, getting up in the morning and attending a lesson in school. Embedded in the scripts were images of effects of peculiar

scenes whose causes were not presented. In the recognition phase some target photographs were presented with distracter images which could be either consistent with the script or causes whose effects had been previously presented. Participants had to perform a *yes/no* recognition test and tell their degree of confidence relative to their responses.

2.1.1 Method

Participants

Twenty-six children with symptoms of ADHD (3 females) and 28 control children (15 females) participated in this study. The two groups were matched for age and educational level. Mean age was 9.5 years (*SD* = .83) for the ADHD group and 9.8 years (*SD* = .75) for the control group. Children in the control group were recruited from local schools. Children with ADHD symptoms were recruited either from schools based on teachers' reports, or from a clinical service based on a diagnosis made by an expert in ADHD. Children had a mean score per item above 1.5 either in the hyperactivity or in the attention subscale (or in both) of the *SDAI* ('Scala per i Disturbi di Attenzione/Iperattività per Insegnanti', *ADHD scale for teachers*, Marzocchi, Re, & Cornoldi, 2010); The SDAI includes 18 items, each giving precise descriptions of one of the 18 symptoms of ADHD as indicated in the DSM-IV (APA, 1994). The scale has been validated and standardized for the Italian population (Marzocchi & Cornoldi, 2001) and has shown good reliability (*r* = .81) and inter-rater agreement (*r* = .78; Marzocchi & Cornoldi, 2001). The scale includes two subscales, one for Inattention (9 items), and one for Hyperactivity/Impulsivity (9 items). Teachers are required to observe closely the child's behavior for about two weeks, and report the frequency of symptomatic behaviors described in each item. Scores range from 0 (problematic behavior never present), to 1 (sometimes present), 2 (often present), 3 (very often present). On the basis of the cut-offs for ADHD validated for the scale (Marzocchi & Cornoldi, 2001), children whose mean score

exceeded 1.5 on one of the two subscales were considered for inclusion in the ADHD group, while those not meeting this criterion were considered for inclusion in the control group.

Materials

Pictorial stimuli. A series of color photographs depicting one of four scripts were used. The scripts were: eating at a restaurant, a lecture at school, going grocery shopping and getting up in the morning. For each script, 24 photographs were created: 20 photographs depicted the typical sequence of actions in the script (16 used in the presentation, the remaining 4 photographs were used as distracters in the recognition phase), 4 photographs depicted two sets of cause-effect scenes, in particular 2 negative sequences (e.g., effect: wiping the table at the restaurant; cause presented only at test: knocking over a glass of coke) and 2 positive sequences (e.g., wearing new shoes before going to school; cause: mum giving new shoes in a wrapped box). Pilot testing with younger children confirmed that the material was understandable even at age of five years. Further, the study stimuli also included 10 photographs that were inconsistent with any of the script. They represented other children doing different actions such as playing in the yard, playing at the beach etc.

Recognition phase. A unique randomised sequence of 72 photographs was used for all participants. The test included, for each script: (a) 6 old script-consistent photographs, (b) 4 new script-consistent photographs, (c) 2 causes photographs whose effects had been presented during the encoding phase, (d) 2 control cause photographs (e.g., photographs of effects whose causes had not been seen at the encoding phase), (e) 2 old script-inconsistent photographs and (f) 2 new script-inconsistent photographs.

Confidence Rating Board (CRB; Ghetti, et al., 2002*).* Two photographs depicting respectively a child with a confident expression and the same child with a doubtful expression were positioned on the opposite sides of the board. Three dots were drawn between these photographs which represent the three degrees of confidence (very sure, somewhat sure, not

sure at all). Children were instructed to point to the dot near the picture of the child with a confident facial expression when they were very sure (that the saw or that they did not see the photograph), the middle dot, when they were somewhat sure, and the dot near the doubtful facial expression when they were not at all sure.

Procedure

Encoding phase. All participants were tested individually in quiet rooms in their schools (children tested at the clinical service for Developmental Disabilities were tested in a room at the clinical centre). They were told that they would view a series of photographs in logical order representing other children performing everyday actions. They were also told to pay close attention to every picture and to try to understand what the situation represented depicted. For each of the 4 scripts, participants studied 18 photographs in a logical sequence. Embedded in these photographs, there were 2 effect photographs (e.g., oranges on the floor of a grocery store) whose corresponding causes (e.g., a child removing an orange from the bottom of a stack) were not viewed. Each photograph was shown on the computer screen for 2 seconds followed by a 3-second interval during which a black slide was presented. Scripts were presented sequentially without interruptions among them. Script order was counterbalanced. Five script-inconsistent photographs were presented at the beginning and at the end of the encoding phase to reduce primacy and recency effects. Overall, the encoding phase lasted approximately 7 minutes.

Recognition phase. After a 15-minute filler task (in which participants performed a series of search tasks) participants were administered a self-paced *old/new* recognition task. The test included a sequence of 72 photographs (see the Materials section) presented in a randomized sequence. For each photograph, participants had to tell "yes" if they recognized the picture as seen during the encoding phase, and "no" if they thought the picture had not been seen in the encoding phase. Further, for each recognition answer, participants gave confidence ratings

using the CRB. The overall duration of the task (including encoding, interval, and recognition test) was approximately 30 minutes.

2.1.2 Results

The control group included a higher number of females than did the group of children with ADHD symptoms; thus, a preliminary analysis examined whether gender could affect the pattern of results. Such a comparison with the control group did not show any gender effect ($p > .6$) and therefore the subsequent analyses were conducted collapsing across genders.

To assess memory accuracy, the following dependent variables were calculated, consistent with previous research (Lyons et al., 2010): (1) rate of "yes" responses to target photographs consistent with the script (i.e., Hit Consistent), (2) rate of "yes" responses to target photographs inconsistent with the script (i.e., Hit Inconsistent); (3) rate of "yes" responses to script-consistent distracters *minus* rate of "yes" responses to script inconsistent distracters (i.e., Gap filling errors); and (4) rate of "yes" responses to distracters representing the unseen cause of a seen effect *minus* rate of "yes" responses to distracters representing the unseen cause of an unseen effect (i.e., Backward Causal Inference errors).

A 2 (group: ADHD vs. control) X 2 (item type: script consistent vs. inconsistent) mixed ANOVA with rates of "yes" responses to target images as the dependant measure was conducted. A main effect of item type was found, $F(1,52) = 24.8$, $p < .001$, $\eta_p^2 = .32$, such that in both groups of children, more target images inconsistent with the script were correctly recognized ($M=.93$, $SD=.20$) than were target images consistent with the script ($M=.77$, $SD=.16$). However, no significant main effect of group or interaction effect between group and item was found ($ps \geq .49$). In contrast, group differences emerged when we examined memory errors (see Table 1a). As evident in Table 1a, participants overall showed low levels

of false alarms for script inconsistent and cause control distracters; and these levels were nearly identical in the two participant groups. We compared the two types of memory errors, namely gap filling errors and inferential causal errors by conducting a 2 (group: ADHD vs. control) X 2 (error type: script consistent distracter vs. causal distracters) mixed ANOVA, with corrected false recognition rates for the two types of errors (calculated as described above) as the dependent measures. A main effect of error type was found: $F(1,52) = 16.27$, p <.001, $\eta_p^2 = .24$, such that all participants produced a higher rate of gap-filling errors compared to backward causal inference errors. We also found a tendency toward significance for the interaction between group and type of error, $F(1,52) = 3.27$, p <.07, $\eta_p^2 = .06$: the control group tended to produce more gap-filling errors than the ADHD group and the opposite was true for backward inference errors (see Table 1a). We also computed an error relative score, computing the proportion of gap filling errors with respect to the overall proportion of errors (causal + gap filling) and we found that the score was respectively .63 ($SD = .48$) for the ADHD group and .89 ($SD = .40$) for the controls, a difference which was significant, $t(48) = 2.06$, $p < .05$. Thus, children with ADHD symptoms exhibited a decreased propensity for gap-filing errors.

Subjective remembering: Confidence ratings

We first compared the two groups on their confidence judgments relative to the hit rates (both consistent and inconsistent) by performing a 2 (group: ADHD vs. control) X 2 (item type: script consistent vs. inconsistent) mixed ANOVA with confidence judgments associated with the hit consistent and inconsistent rates. A main effect of item type was found, $F(1,52) = 9.6$, p <.01, $\eta_p^2 = .16$, such that both groups of children reported higher confidence when they correctly endorsed script inconsistent photographs ($M=1.89$, $SD=.19$) than the script consistent ones ($M=1.82$, $SD=.23$). Further, a main effect of group was found, $F(1,52) = 6.4$, p <.05, $\eta_p^2 = .11$, which was qualified by an interaction with item type, $F(1,52) = 6.5$, p

<.05, η_p^2 = .11: post-hoc comparisons showed that the group of children with ADHD associated higher confidence with the hit consistent rate (M=1.92, SD=.12) compared to the control group (M=1.73, SD=.26).

As for memory errors (shown in Table 1b), confidence ratings associated with backward causal inference errors and gap-filling errors were entered in a 2 (group: ADHD vs. control) X 2 (error type: script consistent distracter vs. causal distracter) mixed ANOVA. A significant main effect of type of error was found, $F(1,18) = 6.9$, p <.05, η_p^2 = .28: all participants gave higher confidence ratings associated with backward causal inference errors than gap-filling errors (Table 1b). We also found a main effect of group, $F(1,18) = 6.3$, p <.05, η_p^2 = .26, with ADHD children reporting higher confidence (M=1.76, SD=.10) than the control group (M=1.39, SD=.10) when committing memory errors, regardless of the type of error.

2.1.3 Discussion

The main goal of this study was to examine memory for script-based material in children with ADHD, focusing on their tendency to form false memories, and their subjective experience related to true and false memories. To our knowledge, performance in false-memory paradigms has never been examined in children with ADHD; yet given the high frequency of ADHD in the population and the frequency with which children with developmental disabilities provide allegations in forensic contexts (Bruck & Ceci, 1999), it is important to establish the extent to which their behaviour matches normative developmental trends.

The first main result of the present study is that ADHD children do not produce a higher overall number of false memories than the control group. This result stands in apparent contradiction with the assumption that executive dysfunctions may promote memory errors

and the observation that ADHD children may exhibit increased intrusion errors in memory tasks compared to matched controls (Cornoldi et al., 1999; West, Houghton, Douglas, & Whiting, 2002). However, in these studies, errors concerned intrusions of irrelevant, semantically unrelated, material. In contrast, in the present study false memories concerned plausible, semantically associated, materials. In the present experiment we found that children with ADHD and control children do differentiate their performance in the production of false memories based upon the peculiar type of error: children with ADHD produce less gap-filling errors than their peers, but more backward causal inference errors. Gap-filling errors have been shown to be supported by the familiarity that the item at test shares with the target scripted material and thus reflect ease of access to script knowledge (Lyons et al, 2010). These results show that children with ADHD may somewhat be protected from this false-memory effect because of a slower or less adept access to script knowledge. A poorer organization of script knowledge in semantic memory may also underlie this reduce propensity to gap-filling errors.

In contrast, backward causal inference errors likely emerge from a recollective state: When the individual is tested on the unseen cause of a seen effect they likely recollect inferring the cause, and misattribute this inference to direct experience of the photograph. If children with ADHD exhibit particularly good episodic recollection, they should have greater difficulty at differentiating such inferential mental state from a true memory, because both would be vividly recollected. These results are consistent with this view. Of interest, these results also indicate that while script knowledge seems to be less readily accessible in children with ADHD, this difficulty does not extend to causal inferences: Thus, to the extent that studied material depicts relatively unique or distinctive events, children with ADHD draw causal inferences readily and later recollect them. It may also be that backward causal inference errors have more direct implications in applied forensic contexts, given that

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erroneously inferring the cause of an experienced effect could have severe consequences on the reconstruction of the event itself.

The second main result of the present study concerns the differences in metacognitive judgments between the children with ADHD and controls. Despite the differences in type of false memories produced in the two groups, children with ADHD exhibited higher levels of confidence than controls across types of false memories (and, in part, in true memories as well). One of the hypotheses we set out to test was that children with ADHD compared to control participants would exhibit increased memory errors and confidence in these errors due to the documented impulsivity and reduced inhibition and control capacity in ADHD (Cornoldi et al., 1999; Marzocchi et al., 2002). While we found no evidence of such a tendency in memory performance, confidence judgments appeared to be generally inflated compared to control participants. This tendency cannot be interpreted as reflecting generally faulty metacognitive mechanisms; the high levels of memory performance observed suggest that monitoring and control mechanisms operated well enough not to interfere with memory performance. In addition, in some cases, high levels of confidence may be well justified given the high levels of memory discrimination. Nevertheless, it is possible that this over-confidence may be a reflection of a response style. Furthermore, we found that both groups of children attributed higher confidence to backward causal inference errors compared to gap-filling errors, thus, even children with ADHD maintain a certain ability to introspect on their memory states and discriminate between them.

Some limitations of the present study should be acknowledged and overcome in future research. Specifically, ADHD is notoriously heterogeneous (Barkley, 1990); thus, future research should further differentiate children with ADHD into the specified subgroups of ADHD of clinical relevance to evaluate whether these findings would differ as a function of types and severity of ADHD symptoms (prevalence of inattention vs. hyperactivity).

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Furthermore, research should better understand the level of elaboration of scripts at which differences between ADHD children and controls emerged.

Nevertheless, Experiment 3 offers important theoretical and practical information on the nature of memory function in children with ADHD, with an emphasis to circumstances that can generate false-memory formation. The present results provide initial evidence that the nature of false-memory formation may differ in children with ADHD compared to control participants. While children with ADHD appear to produce false memories based on associative encoding errors linking effects to their causes resulting in false recollection, in control children false memories seem to emerge from prompt access to script knowledge and processing of semantic gist of the situation.

Table 1*a*. Mean proportions (and standard deviations) of the raw scores of false-alarm rates: "yes" responses to script-consistent distracters (i.e., False alarms Consistent), "yes" responses to script-inconsistent distracters (i.e., False alarms Inconsistent), "yes" responses to causal distracters (i.e., False alarms Causal) and "yes" responses to control causal distracters (i.e., False alarms Control causal), and corrected indices of gap-filling errors and backward causal inference errors in the group of children with ADHD symptoms and in the control group of children. Table 1*b*. Means of the raw scores of confidence ratings relative to both gap-filling errors and backward causal inference errors (scores went from 0=unsure to 2=very sure).

	ADHD group		Control group	
	M	*SD*	*M*	*SD*
a				
False alarms Consistent	.20	.16	.26	.23
False alarms Inconsistent	.00	.00	.009	.04
Gap-filling errors	.20	.16	.25	.24
False alarms Causal	.18	.26	.12	.15
False alarms Control causal	.05	.09	.05	.10
Backward causal inference errors	.13	.21	.07	.13
b				
Confidence relative to gap-filling errors	1.57	.39	1.15	.66
Confidence relative to backward causal inference errors	1.94	.16	1.63	.50

CHAPTER THREE

SUBJECTIVE EXPERIENCE RELATED TO MEMORY FOR TEXT IN STUDENTS WITH AND WITHOUT LEARNING DIFFICULTIES

3.1 Introduction

In the previous Chapters, two memory paradigms employed to investigate true as well as false memories (DRM paradigm, Chapter One; memory for scripted material, Chapter Two) have been described. In this Chapter a particular recognition memory paradigm specifically created for the purposes of Experiment 4, will be presented. The literature on learning difficulties and memory, in particular the link between poor text comprehension and memory at both objective and subjective levels, will first be introduced.

In everyday life, students continually face the necessity to understand and elaborate complex materials such as written texts (i.e., either in the form of narrative or expository texts, newspaper articles, short essays, etc.) or lectures at school. Some students may encounter difficulties at studying and elaborating texts and may thus fail to fully achieve in educational settings. These students may have specific deficits at the cognitive level (such as attentional, mnestic or linguistic difficulties), or may be impaired at the metacognitive level being thus less competent at understanding the adequate strategies to be used while attending and processing discourses or studying written texts (e.g., Schneider & Pressley, 1997); however, they may have the correct knowledge of the appropriate strategies, but may lack a consistency between such knowledge and its adequate use. An effective text processing approach implies that the student is able not only to use particular devices such as note taking, or the use of schemas and graphs, but also to monitor his/her understanding of a certain passage: If the content of the passage is unclear, then it will be necessary to take notice of the

problem and adequately react, for example rereading it in order to fully understand the main ideas or to find some critical details.

A particular case of interest in the field is represented by adolescents as, despite the fact that they may have developed the basic reading skills and have adequate intellectual skills, they frequently fail in tasks that require the processing and the active study of a text. Indeed, it is often reported (e.g., Meneghetti, De Beni, & Cornoldi, 2007) that some students, aged between 12 and 18, apparently master all the skills required for studying textbooks, but they nevertheless fail at school, showing poor memory of the texts they had processed, sometimes also for relatively long periods of time. The comparison between these adolescents and successful adolescents may offer information on why some students fail in processing texts. For example, it has been shown that students with high achievement at school have higher memory for the content of a written passage (Beishiuzen & Stoutjesdijk, 1999) because they are more likely to organize their study through the use of schemas and notes and to monitor their comprehension throughout the reading. Other studies have considered alternative aspects underlying the difficulties of adolescents in text processing which have consequences on school success (Wolters, 1998).

The ability to recall relevant information about a text (such as who are the main characters, what are the relevant places in which the episodes took place, etc.) and to extend it and integrate it with the general knowledge a person possesses, seems important in order to highlight the differences between those students who fail at school (despite having intact cognitive abilities) and those who are successful at school. However, research still lacks studies which not only do evaluate objective memory for information included in a text (such as free recall of ideas included in a passage), but also subjective memory experiences which may, in turn, enhance the comprehension itself and thus the school performance.

Most of the research on text comprehension difficulties to date has been guided by the study of working-memory. Indeed, understanding a text requires that an individual maintains relevant information, suppresses irrelevant information that may be automatically activated during reading, and continually updates the content of memory (Gernsbacher, Varner, & Faust, 1990). All of these abilities depend critically on working memory. Thus, the existence of a relation between working memory and comprehension skills is intuitively appealing and has been substantiated empirically. For example, poor comprehenders manifest a deficit in working-memory tasks (e.g., Carretti, Cornoldi, De Beni, & Palladino, 2004; De Beni & Palladino, 2000) and their performance is particularly low when they are first asked to activate important information and are subsequently asked to inhibit it because it is no longer relevant to the task, suggesting an impairment in inhibition processes (Carretti, Cornoldi, De Beni, & Romanò, 2005). Further, semantic processing skills are selectively impaired in students with poor comprehension of written texts. For example, compared to typical comprehenders, children with poor text comprehension skills have impoverished knowledge of abstract words and are less able to generate exemplars of semantic categories (Nation & Snowling, 1998b), and fail to connect meanings among words (Cain, Oakhill, & Bryant, 2000; Nation & Snowling, 1998a, 1998b). In line with these findings, poor comprehenders' performance in verbal short-term memory tasks is impaired when they are required to process semantic contents deeply (Nation, Adams, Bowyer-Crane, & Snowling, 1999).

These deficits in semantic processes have direct consequences for memory functioning. For example, poor comprehenders compared to more skilled comprehenders show reduced false-memory rates for semantic lures (Weekes et al., 2008) when tested with the *DRM paradigm* (Deese, 1959; Roediger & McDermott, 1995); this paradigm involves the memorization of lists of semantically associated words and typically leads to robust false memory for a lure capturing the theme of the lists. Compared to children with good reading

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comprehension, children with comprehension deficits produce lower rates of false memories for these semantic lures, consistent with a difficulty at identifying the general meaning or theme of the word list. In contrast, they evince typical levels of false memories when they are tested on a phonological DRM (i.e., a version of the task that includes lists of words that rhyme together; Weekes et al., 2008). Together these results point to an impaired ability to process semantic information in poor comprehenders, but the origin of this deficit remains unclear.

In the next set of experiments presented here (Experiment 4 and Experiment 5), we were particularly interested in studying the subjective phenomenological experience related to memory for text ideas in students with learning difficulties as manifested through low text comprehension, for two main reasons: (1) we thought it was important to deepen the current knowledge of this subjective experience associated with a narrative text because it actually enhances the relevance that the text itself has for the person and this could have implications for the particular case of those texts, presented at school, which need to be studied and elaborated by the students. If the text is well processed and thus not only well remembered at the objective level (i.e., accuracy in a recall or recognition task) but also subjectively perceived as compelling, then it is more likely that it will be later remembered in more details. (2) There is now evidence that semantic encoding not only of simple items (see Yonelinas, 2002, for a review) but also of complex materials such as written texts promotes subjective recollection more than subjective familiarity (Long & Prat, 2002; Long, Wilson, Hurley, & Prat, 2006; Long, Prat, Johns, Morris, and Jonathan, 2008). For example, Long and Prat (2002) employed the *Remember-Know* paradigm (Tulving, 1985) to compare a group of experts about the science-fiction saga *Star Trek* to a group of novices on their memory for a text taken from the fiction and another expository text taken from a general psychology book. The experts experienced greater recollection for text details (i.e., they gave a higher

proportion of Remember answers) than novices, likely resulting from more complex discourse models integrated with previous knowledge in experts (Long & Prat, 2002). Further, the advantage of prior knowledge on memory was observed mostly on less coherent texts, that is, texts which required readers to make more inferences based on previous knowledge. High-knowledge readers exhibited greater recollection for low-coherence texts than did low-knowledge readers (Long et al., 2006). Finally, Long and her colleagues (Long et al., 2008) have recently reported strong evidence that the ability to retrieve contextual information about ideas from a text largely depends on background knowledge relative to other potentially relevant predictors. Indeed, previous knowledge was the only reliable predictor of recollection, whereas other individual differences in reading skills such as decoding, verbal ability, working-memory capacity and reasoning failed to predict recollection. Thus, the ability to recollect text ideas seems to rely on the individuals' ability to create complex text representations; background knowledge is important because it provides a foundation for integrating even disparate ideas included in the text. These complex text representations result in vivid memory traces of the story episodes (Long et al., 2008).

If semantic elaboration of texts promotes recollection, then it should be possible to detect deficits in recollection when poor ability to process semantic information is suspected, both in adults and children. Relatively little research has examined the development of recollection and familiarity in childhood and adolescence (as seen in the previous Chapters as well), but there is converging evidence that recollection develops gradually during childhood and adolescence, whereas familiarity seems to reach stability during childhood (Billingsley et al., 2002; Brainerd et al., 2004; Ghetti & Angelini, 2008). It is interesting to note that in Ghetti & Angelini's study (2008), age-related increases in recollection were found only when semantic encoding was required, but not when perceptual processing was required. Furthermore, with development, children become increasingly more likely to give Remember

responses when they recall accurate semantic details, whereas younger children are more likely to give Remember responses when they recall perceptual details (Ghetti et al., in press). Together these findings suggest that semantic processing gains increasing importance for recollection as conceptual knowledge and semantic elaboration abilities develop (e.g., Dewhurst & Robinson, 2004), which leads to the concern that conditions hindering semantic processing may be particularly detrimental for recollection during development. To date, no study has examined potential deficits in recollection for text ideas or individual single words in special populations of children, such as adolescents with learning difficulties. Thus, it is not known whether poor learners are able to create vivid and contextually detailed memories for events included in a text. Recollection may have powerful implications for learning in that, when recollected, a text may be experienced as more salient and thus more personally relevant. Given that the semantic elaboration of texts promotes recollection, it was reasonable to hypothesize that difficulties at processing semantic information, or, in general, difficulties at processing complex passages of a text, may result in a recollection deficit. We thus wanted to investigate whether adolescent students with learning difficulties had a reduced recollection for text sentences, resulting thus in an inability to retrieve information from the narrative passage along with the related qualitative features (for example, features of the main characters or the main actions of the plot). We specifically developed a recognition memory task for the purpose of the present study and employed the Remember-Know paradigm (Tulving, 1985) to gain estimates of subjective recollection and familiarity. The choice of testing a group of adolescents, instead of younger children, with a recognition memory task for a text is due to the fact that during adolescence school requirements increase and learning difficulties are at this age primarily related to difficulties at processing texts (see Meneghetti et al, 2007); further, it seems that the ability to recollect details from certain events' original

context and the ability to judge one own's memory internal states develop with growing age, as conceptual abilities also improve (see Ghetti & Angelini, 2008; Ghetti et al., in press).

3.2 Experiment 4

Experiment 4 examined poor learners' recognition memory and subjective recollection for text ideas. In Experiment 4, a text story was presented orally to adolescents with different reading comprehension abilities, and their memory for it was subsequently tested with a recognition task. In addition to being asked to recognize old sentences (targets) from new sentences (distracters), participants were asked to provide Remember-Familiar judgments (Remember-Know paradigm, Tulving, 1985) on recognized sentences thereby providing measures of subjective recollection and familiarity. We hypothesized that, compared to a matched control group, poor learners would exhibit reduced recollection, but similar familiarity, for text ideas, given that: (1) semantic encoding of materials promotes recollection more than familiarity, and (2) poor learners with a specific difficulty at processing texts, compared to typical comprehenders, likely construct less elaborated text representations (e.g. Cain, 2006; Gernsbacher, 1997), which are indispensable for recollection of text ideas (Long & Prat, 2002; Long et al., 2006). Participants' recognition memory was tested using three types of distracters: Novel sentences (i.e., sentences that were incongruent with the meaning of text), Inferences (i.e., sentences that represented ideas that were not included in the text, but that could be inferred from the text), and Paraphrases (i.e., sentences that represented, but with different wording, ideas that were included in the text). Previous research showed that the false-alarm profile to these distracters depended on the readers' level of knowledge for the text topic (Long et al., 2008; see also Arkes & Freedman, 1984; Graesser, Gordon, & Sawyer, 1979). High-knowledge compared to low-knowledge individuals produced more false alarms (associated with higher Remember responses) for inferences (Long et al., 2008). Although

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levels of knowledge were not examined in this study, distinct classes of distracters were included because it was hypothesized that text comprehension, which is related to the ability to create a discourse model of the text, would lead to differences in response to distracters reflecting inferences, paraphrases and semantically incongruent sentences.

3.2.1 Method

Participants

Ninety three adolescents, ages 15 to 19 ($M = 16$, $SD = .94$), participated in the present study. They were divided into two groups: a group of 47 poor learners and a group of 46 peers with typical comprehension, based on their performance on the *MT Test* (Cornoldi, Friso, & Pra Baldi, 2010), a standardized test of reading comprehension, and on the teachers' ratings of school achievement. The test was administered to students in a public high-school specializing in vocational education in a small town in Northern-Eastern Italy (United States grade level equivalent of 9th and 10th grade). These types of vocational high schools are mainly attended by students of generally low academic achievement. Based on the test norms, students who received a score on the comprehension test below the 10th percentile and received low school achievement ratings by their teachers, were classified as "poor learners," whereas students above this percentile were classified as average comprehenders and were included in the control group. Participation was arranged based on the schedules of the teachers and the principal of the school.

Materials

Standardized Written Text Comprehension Test. The test included two written stories, taken from a pool of standardized materials created for Italian students (Cornoldi et al., 2010).

Each story (Section A, for 9th graders and Section B, for 10th graders) is accompanied by 20 multiple choice questions; only one of the response options is correct.

Text. A text story (entitled *Art Thief*, including 1356 words; Marsh, 2004) was translated and adapted to the Italian language. All of the participants were read the same story aloud by the experimenter at a slow pace. *Recognition test*. The test included 32 sentences: Sixteen target sentences, which were taken verbatim from the text, and 16 distracters. The distracters included 8 sentences that were semantically congruent with the content of the story (i.e., 4 inferences and 4 paraphrases) and 8 sentences that were semantically incongruent with the content of the story (i.e., they were created by combining different verbatim parts of propositions that did not result in a meaning consistent to the text plot). The test required participants to answer whether they recognized each sentence, by writing "yes" if they thought the sentence was old (i.e., included in the story previously heard), or "no" if they thought it was a new one. For items that were recognized as old, the test further required participants to tell whether the sentence was "remembered" or "familiar." One randomized sequence was used for all participants.

Procedure

Participation included two sessions: in the first session, the standardized MT Test was administered, and in the second session, recollection and familiarity for text were assessed. Students completed the MT Test in their classroom in groups of approximately 15 students. Students were given a written text and they were told that they had to read it carefully to later answer 20 questions about its content. They were also informed that they would be allowed to keep the text while answering the questions because it was not meant to be a memory task; thus, they could go back to re-read those passages that were unclear and that they needed to better understand in order to answer to the questions. The test took approximately 20-25 minutes.

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A few days later, participants were tested again. As for the first session, participants were tested in groups in their classroom. To maintain motivation, students were told that the experimenter would be reading a text aloud, and that they would have to listen to it very carefully because they would be later questioned about it. The duration of the text was approximately three minutes. We decided to present the text orally, instead of written, to ensure that all participants were exposed to the text for the same amount of time, and given the reassuring evidence that reading comprehension measures are highly correlated with listening comprehension measures during the high school years, indicating that similar abilities are required to comprehend either a written or an oral text (Sticht & James, 1984; see also, Cain & Oakhill, 2007). After listening to the text, participants received the instructions for the recognition task and were provided with an answering sheet. Participants were told they were going to be read several sentences aloud, one at a time. Participants were informed that some of the sentences were part of the text, whereas other sentences were new. They were told that for each sentence, they had to circle "yes" on their answering sheet when they recognized the sentence as being taken directly from the text and "no" when they thought the sentence was not taken from the text and had not been heard before. Of importance, the experimenter emphasized that participants had to recognize as old only those sentences that included exactly the same words as the sentences encountered in the text. They were also told that for each "yes" answer they would have to select the option "Remember" if they had a clear memory of their encounter with the sentence in mind, and they could further remember some qualitative and contextual information related to the memory itself (e.g., Who did the content of the sentence refer to?) or select the option "Familiar" if they had the feeling that the sentence was part of the text story but they could not recollect any qualitative detail about the encoding of the sentence. Before starting the actual task, participants were given several examples to ensure that everyone understood the instructions. The items were presented orally

by the experimenter, who read each sentence aloud and waited a few seconds for the students to answer. The recognition test started approximately 5 minutes after the end of the presentation of the passage and lasted approximately 7 to 8 minutes.

3.2.2 Results and Discussion

Recognition Performance

To examine whether students with learning difficulties and control participants differed in their overall performance on the recognition memory test we conducted a 2 (Group: poor learners vs. controls) X 2 (Item type: studied items vs. distracters) mixed ANOVA, with rates of old judgments as the dependent measure. Results are reported in Table 1. A significant main effect of item type was found, $F (1, 91) = 151.47$, $p < .001$, $\eta_p^2 = .62$, such that regardless of group, the studied items were more likely to be correctly recognized than were the distracters. Further, a significant interaction between item type and group was found, $F (1, 91) = 18.50$, $p < .001$, $\eta_p^2 = .17$: poor learners, compared to controls, obtained lower hit rates and higher false-alarm rates, indicating an overall impairment in the ability to recognize pieces of information at the text level. This pattern is captured by a significant difference in the ability to discriminate between old and new items as measured by d' scores (the statistic d' or *d-prime,* derived from the signal detection theory, is a measure of the difference in familiarity between old items and new items; in a recognition memory task, it is assumed that old/studied items are more familiar, on average, than new/non-studied items; both the memory strength or familiarity of old items and that of new items are assumed to be distributed normally: the difference between the distribution of old items and the distribution of new items, measured in z-scores, is the parameter d', which quantifies how stronger the studied items are compared to the non-studied items and thus the ability to discriminate between them), $t (86) = 3.90$, $p < .001$ (Poor learners: $M = .51$, $SD = .61$; Controls: $M = 1.04$,

SD = .66, where higher *d'* scores indicate that control participants are better at discriminating between old and new items).

A further analysis of the false-alarm rates revealed that the two groups responded differently depending on the type of distracter. A 2 (group: poor learners vs. controls) X 3 (type of distracters: inferences vs. paraphrases vs. novel sentences) mixed ANOVA with false-alarm rate as the dependent measure revealed a significant main effect of group, F (1, 91) = 10.02, p = .002, η_p^2 = .1, which was qualified by a significant interaction between group and type of distracters, F (2, 182) = 4.65, p = .01, η_p^2 = .05; post-hoc analyses (Bonferroni) showed that controls were better at correctly rejecting inferences compared to paraphrases, suggesting that their inferential processes were distinctive enough to be used to reject distracters, whereas surface changes in the sentence form preserving the meaning of a studied sentence were not. This difference was not observed among poor learners (see Table 1 and Figure 1).

| | Group | | | |
| | Poor learners | | Controls | |
	M	*SD*	*M*	*SD*
Hits **	.70	.17	.77	.16
False Alarms**	.52	.18	.41	.14
Inferences **	.53	.28	.32	.21
Paraphrases	.55	.27	.51	.26
Novel sentences	.50	.22	.42	.17

Table 1. Mean proportions and standard deviations of "yes" responses to old items (i.e., hits) and "yes" responses to distracters (i.e., false alarms); the "yes" responses to distracters are further characterized as follows: "yes" responses to distracters that included plausible but not stated information (i.e., inferences), "yes" responses to distracters that included the same information of the text sentences, but with different words (i.e., paraphrases) and "yes" responses to distracters that included a new combination of text details (i.e., novel sentences). (Asterisks are referred to significant differences between groups; * = p < .05, ** =p < .01)
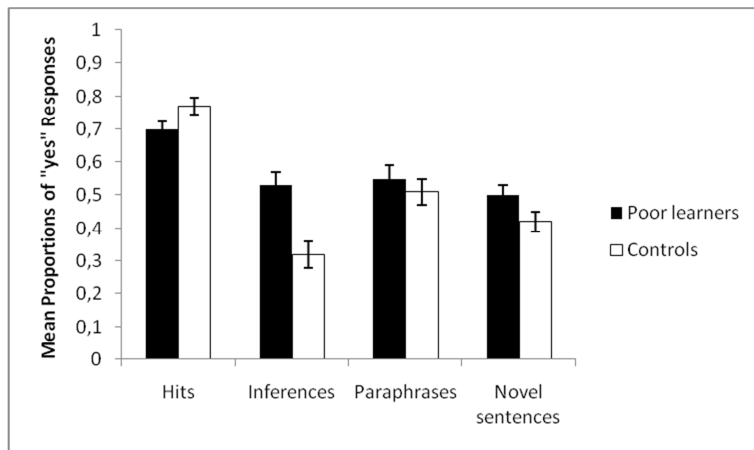
Figure 1. Mean proportions of "yes" responses to target sentences (i.e., hit rate) and inferences, paraphrases and novel distracters (i.e., false-alarm rates).

Previous studies showed that individuals with poor text comprehension encounter greater difficulty at drawing inferences from a text (Cain & Oakhill, 1999; Long, Oppy, & Seely, 1997; Oakhill, 1984). We contend that poor learners are less able to elaborate and subsequently differentiate at test between inferences and paraphrases. Our results may appear to be in contrast with previous results showing increased false recognition of inferences in experts compared to novice individuals (Long et al., 2008), which would lead to the prediction that richer elaboration results in decreased not increased ability to discriminate inferences from actually presented sentences. This apparent contradiction raises interesting questions about the nature of semantic elaboration in populations with unusual capacities, in either direction, to elaborate text information. We will return to this issue in the Conclusions.

There was also a trend ($p = .07$) for poor learners to falsely recognize more novel distracters than controls. I acknowledge that false alarms to novel sentences were generally higher than those typically observed in other research (e.g., Oakhill, 1982; Spooner, Gathercole, & Baddeley, 2006). As described earlier, this class of distracter differed from the other classes of distracters in that it included verbatim parts of the studied text rearranged in such a way for the meaning to change. This choice was due to pilot testing showing robust floor effects for semantically incongruent distracters that did not include verbatim

information. Nevertheless, the presentation of verbatim parts may have induced individuals to use somewhat lax acceptance criteria for these distracters.

Subjective Recollection and Familiarity

The next set of analyses was conducted to examine the subjective experience associated with memory for text ideas. We were interested in evaluating whether poor learners' subjective recollection for text ideas would be lower than more skilled learners'. Mean proportions of studied items characterized as Remember or Familiar are reported on Table 2. A 2 (group: poor learners vs. controls) X 2 (response type: Remember vs. Familiar) mixed ANOVA revealed a significant main effect of response type, F (1, 91) = 63.52, $p <$ .001, η_p^2 = .41, such that, regardless of group, hits were more likely to be associated with Remember than Familiar judgments. Also, a significant main effect of group was found, F (1, 91) = 5.70, $p <$.05, η_p^2 = .06, which was fully qualified by a significant interaction between group and response type, F (1, 91) = 10.38, $p <$ .01, η_p^2 = .10, such that poor learners showed a significantly lower rate of Remember responses associated with hits. This result lends support to our proposal that poor learners exhibit deficits in elaborating text and that this deficit has direct consequences on the experience of recollection for text ideas. These text ideas in poor learners are remembered less vividly and with weaker context-specific information than in skilled learners. Thus, not only do poor learners exhibit a lower hit rate, demonstrating to have a reduced recognition memory for text ideas at the objective level, but also they exhibit a lower sense of recollective experience at the subjective level.

	Group			
	Poor learners		Controls	
	M	*SD*	*M*	*SD*
Remember responses				
Hits*	.42	.20	.57	.21
False alarms	.26	.17	.22	.11
Inferences**	.31	.29	.11	.15
Paraphrases	.23	.26	.25	.22
Novel sentences	.25	.14	.25	.20
Familiar responses				
Hits	.27	.14	.20	.15
False alarms	.25	.15	.19	.12
Inferences	.22	.21	.21	.17
Paraphrases	.31	.26	.26	.21
Novel sentences *	.24	.15	.16	.17

Table 2. Mean proportions and standard deviations of Remember and Familiar responses associated with hits and false alarms (false alarms are further characterized in inferences, paraphrases and novel distracters). (Asterisks are referred to significant differences between groups; * = p < .05, ** p =< .01)

Finally, an additional 2 (group: poor learners vs. controls) X 2 (response type: Remember vs. Familiar) X 3 (type of distracters: inferences vs. paraphrases vs. novel distracters) mixed ANOVA was performed, with proportions of false-alarm rate characterized either with a Remember or Familiar response as the dependent measures (Table 2). A significant three way interaction was found F (2,178) = 5.63, $p < .01$, $\eta_p^2 = .06$. Simple effect analyses with subjective recollection as the dependent measure showed that poor learners were significantly more likely than controls to falsely recollect inferences, $p < .001$; indeed, controls were more likely to falsely recollect paraphrases than inferences, $p < .05$, a pattern that was not found for poor learners. Thus, not only did students without learning difficulties exhibit lower false alarms to inferences, but when false alarms occurred, they were also less likely than were students with difficulties to find them subjectively compelling, that is they did not associate high levels of recollective experience to sentences that were not presented in

the text but that could have been inferred from the contextual information. As for subjective familiarity, poor learners compared to more skilled comprehenders were significantly more likely to experience false familiarity for novel distracters, $p < .05$. Furthermore, poor learners were more likely to experience familiarity for paraphrases than inferences, $p = < .05$, a pattern that was not found in typical learners; this result suggests that false memories stemming from the full semantic congruence represented by paraphrases are less subjectively compelling for poor learners than for good learners, which is in line with Weekes et al.'s results using the semantic DRM paradigm (Weekes et al., 2008).

3.3 Experiment 5

Experiment 5 was conducted to examine whether the reduced subjective recollection found in students with learning difficulties was specific to text comprehension or whether, instead, it could be extended to individual word lists. To address this question, we had participants encode a series of words either semantically or perceptually. The semantic judgment involved the assessment of likability of each word, thus requiring individuals to focus on characteristics of each item and not on the relation among items.

If semantic processing difficulties in poor learners are specific to text comprehension, then semantic encoding (i.e., deep encoding) should result in higher levels of recollection than perceptual encoding (i.e., shallow encoding) in both poor and typical learners, and these two groups should perform comparably on single word items. Alternatively, if semantic processing difficulties in poor learners are not specific to text but extend to individual words, then we should expect reduced or no benefit of deep compared to shallow encoding in poor learners' performance and recollection.

Two indices of recollection were examined: Subjective recollection as in Experiment 4, and the actual ability to remember specific details about the encoding experience.

Participants were required not only to report whether they recollected the item or thought it was familiar, but were also asked to retrieve two details about the to-be-remembered words, namely, the words' ink color (which could be either red or green) and the word's position on the screen (which could be either left or right). If poor learners' reduced recollection is specific for recognition of text ideas, then we should expect correct source memory for details to be associated more often to Remember responses in both students with learning difficulties and student without such difficulties. If, on the other hand, poor learners' phenomenological experience of Remembering reflects a general recollective impairment, then we should expect a difference in the correct identifications of context details between the two groups of students.

3.3.1 Method

Participants

Participants in Experiment 5 were the same as those in Experiment 4.

Materials

Sixty Italian words (between 4 and 8 letters long) selected from an Italian database (see Barca et al., 2001) were used to create 4 sets of 15 words each. These sets were comparable in average word length and frequency based on Barca et al. (2001). One set was used as study material in the shallow encoding condition, one set was used as study material in the deep encoding condition, and the remaining two sets were used as distracters in the subsequent recognition test. Set use for encoding condition and for study versus distracter status was counterbalanced.

Procedure

All participants were tested individually in a quiet room in their school. Based on Ciaramelli and Ghetti (2007), each participant was asked to remember two word lists; words were presented on a computer screen at a rate of 3 seconds per word with 1-second interval between words. Words were presented either in red or green ink, and appeared either on the left or the right side of the computer screen. Visual presentation of the stimuli was selected because it facilitated the inclusion of a semantic encoding manipulation. Words from one list were learned under shallow encoding conditions (i.e., participants had to tell whether the word included the letter "E"), whereas words from the other list were learned under deep encoding conditions (i.e., participants had to report whether or not they liked the word). The presentation of each list was immediately followed by a recognition memory test in which the 15 studied words were mixed with 15 distracters. Each word was presented in black ink at the centre of the monitor. Students were told that they had to discriminate between words that had been presented before and new ones. For each recognized word participants had to report whether the word was remembered or familiar (Tulving, 1985). They were instructed to select Remember when they could clearly remember that the word was presented in the study phase, and they could retrieve further information or details about its presentation. They were instructed to select Familiar when they had the feeling that the word had been studied but they could not recollect any further information related to it. Finally, for each word recognized as "old", participants were asked to tell its color (i.e., red or green) and its position on the screen (i.e., left or right).

3.3.2 Results and Discussion

To examine group differences in recognition performance, we focused on the hit rates; false alarm rates were close to floor (shallow-encoding condition: $M = .05$, $SD = .1$ for poor

learners and $M = .05$, $SD = .06$ for control students; deep-encoding condition: $M = .02$, $SD = .07$ for poor learners and $M = .01$, $SD = .03$ for control students); we conducted a 2 (group: poor learners vs. controls) X 2 (encoding condition: shallow vs. deep) mixed ANOVA, with proportions of correct responses on the studied items (hits) as the dependent measure. This analysis revealed only a significant main effect of encoding condition, $F (1, 91) = 137.6$, $p < .001$, $\eta_p^2 = .60$, such that regardless of group, better recognition performance was observed under a deep encoding condition, indicating that the advantage of semantic processing generalizes across groups. Results are shown in Table 3.

	Group							
	Poor Learners				Controls			
	Remember		Familiar		Remember		Familiar	
Encoding	M	SD	M	SD	M	SD	M	SD
Shallow	.42	.26	.31	.22	.48	.22	.28	.21
Color	.29	.21	.14	.13	.32	.17	.13	.12
Position	.31	.19	.17	.15	.33	.19	.16	.14
Deep	.68	.30	.26	.28	.73	.25	.20	.23
Color	.46	.24	.15	.17	.48	.22	.11	.14
Position	.50	.26	.14	.17	.47	.21	.11	.14

Table 3. Mean proportions and standard deviations of hits and correct color and position identifications that received either a Remember or Familiar response as a function of encoding condition.

We thus wanted to see whether there was a difference in subjective recollection and familiarity as a function of comprehension skills and encoding condition. As can be seen in Table 3, the Remember responses were more frequent after deep encoding. A 2 (group: poor learners vs. controls) X 2 (encoding: shallow vs. deep) X 2 (response type: Remember vs. Familiar) mixed ANOVA showed both a main effect of response type, $F (1, 91) = 137.60$, $p < .001$, $\eta_p^2 = .60$ and a significant interaction between encoding and Remember-Familiar

experience, $F (1, 91) = 42.78$, $p < .001$, $\eta_p^2 = .32$], such that more Remember responses were given under deep encoding conditions, in both groups. The two groups did not significantly differ in either condition for the Remember or Familiar responses ($Fs < 1$). This finding shows that poor learners did not manifest a reduced subjective recollection and thus a different memorial representation of episodic traces of isolated words.

Finally, it was investigated whether this pattern of result extended to objective indices of recollection (i.e., the ability to retrieve accurate details). With this analysis, we also sought to verify that poor versus more skilled learners used the Remember-Familiar distinction similarly. Thus, two separate ANOVAs were conducted. The first 2 (group: poor learners vs. controls) X 2 (encoding condition: shallow vs. deep encoding) X 2 (judgment type: Remember vs. Familiar) ANOVA was conducted with rates of correct memory for item color associated with Remember and Familiar responses as the dependent measures. An identical ANOVA was conducted with rates of correct memory for item spatial positions associated with Remember and Familiar responses as the dependent measures. Both analyses confirmed the main effect of encoding condition (Color: $F (1, 91) = 58.83$, $p <.001$, $\eta_p^2 = .40$; Position: $F (1, 91) = 41.60$, $p<.001$, $\eta_p^2 = .31$) qualified by the interaction with type of response, such that more Remember responses were more strongly associated with correct detail memory in the deep encoding condition compared to the shallow encoding condition (Color: $F (1, 91) = 28.43$, $p < .001$, $\eta_p^2 = .24$; Position: $F (1, 91) = 29.24$, $p <.001$, $\eta_p^2 = .24$) (Table 3).

Overall, the results of Experiment 5 show that poor learners do not suffer from reduced recollection for individual words; they perform similarly to more skilled learners with respect to both subjective and objective indicators of recollection.

3.4 Discussion of Experiment 4 and Experiment 5

The goal of Experiment 4 and Experiment 5 was to establish whether students with learning difficulties would show a reduced subjective recollection for text and whether this deficit would be specific to complex materials or would extend also to simple word items. Results of Experiment 4 revealed differences in memory performance in adolescents with poor text comprehension compared to controls: Poor learners evinced lower hit rates and higher false-alarm rates, indicating poorer memory for sentences. The examination of the subjective phenomenology of these memories provided converging evidence about the nature of this deficit: Poor learners compared to control students were less likely to subjectively recollect the sentences. Recollection allows for the retrieval of qualitative information about an episode or item, such as its contextual features, including information about the mental operations individuals engaged in when they first processed the information (e.g., Rajaram, 1993). Recollection is enhanced when information is processed semantically (e.g., Yonelinas 2002, for a review). Poor learners' difficulty in creating a discourse model for the text (e.g., Gernsbacher, 1997) or more generally in processing the semantic relations among words (Nation & Snowling, 1998a, 1998b) likely contributes to both their reduced objective recognition (correctly recognizing target sentences presented in the text) and subjective recollection (associating Remember judgments to correctly recognized target sentences).

Further, poor learners exhibited similar rates of false alarms to all types of distracters, indicating a reduced ability to respond to differences in the semantic content of these propositions. Conceptually, this result is in line with the results of Weekes and colleagues (Weekes et al., 2008) documenting poor learners' reduced rates of false recognition in the DRM effect indicative of their difficulty at processing semantic relations among list items.

In contrast, more skilled learners were less likely to falsely recognize inferences than paraphrases, suggesting that these participants are better at rejecting ideas that could have

been activated during text comprehension: Evidently, these inferences can be later recognized as personal thoughts and not as part of the narrated plot. This result stands in contrast with previous findings (Long et al., 2008) in which inferences were more frequent and more likely to be associated with Remember responses compared to paraphrases. However, in Long and colleagues' study, all of the participants had a typical text comprehension. Increased false alarms and false recollection for inferences were observed in experts on the text topic.

This apparent contradiction raises a question about the relation between text comprehension, reader domain knowledge, and the probability that individuals will recollect text ideas, and falsely recognize or reject inferences from texts. Several testable hypotheses could be advanced. Specifically, Long and Prat (2002) proposed two ways in which recollection may result from the construction of a situation model during text processing. First, recollection may result from associative relations among text ideas, and between text ideas and prior knowledge. When memory for text ideas is tested with a recognition task, sentence presentation should reactivate the network of associations that was created during the initial elaboration of the text processing. This operation should result in a recollection advantage for good learners with high domain knowledge compared to good learners without high domain knowledge, and for this latter group compared to poor learners.

Second, recollection may result from drawing inferences from the ideas directly presented in a text. These inferences may be later retrieved when evaluating whether true sentences were actually presented (i.e., individuals may remember having consciously made an inference), but they may also be so closely integrated in the situation model to be less distinguishable from the actual text. Long and Prat (2002) argue that this close integration may lead to false recognition particularly in high knowledge readers. When this occurs, good comprehenders with high domain knowledge compared to good comprehenders without such knowledge will still recollect more sentences, but they may also be more likely to falsely

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recollect inferences. Thus, there may be conditions under which individuals with good comprehension skills and relatively limited domain knowledge may outperform experts, as well as individuals with poor comprehensions skills. Identifying the boundary condition of these differences in memory accuracy should be pursued in future research.

Experiment 5 demonstrated that poor learners' semantic impairment and its consequences for recollection do not extend to memory for individuals words. We found no difference between poor and more skilled learners in their use of the Remember-Familiar distinction, as both groups associated more Remember responses to hits under deep versus shallow encoding, or in the overall recognition performance (i.e., poor learners did not differ in the production of hits from control students). The two groups also did not differ in their rates of accurately recollected details (i.e. ink color and spatial position).

The absence of this effect suggests that evidence of deficits in semantic processing at the individual word level may be detected only when the task requires the processing of the semantic relation among multiple words. Weekes et al.'s findings (2008), which showed reduced false recognition effects with the semantic DRM but comparable false recognition in the phonological DRM, indicate that individuals with poor comprehension skills preserve an ability to identify what is common among a series of word items and they can successfully store this "gist" as long as it is not semantic in nature.

Before concluding some caveats should be noted. The tasks used in Experiment 4 and 5 are not equated for difficulty. Thus, we cannot directly exclude that the differences in patterns between the two experiments may be in part accounted for by task difficulty. This problem has been noted in other studies as well. For example, Landi and Perfetti (2007) conducted an electrophysiological investigation to examine semantic and phonological skills of good and poor comprehenders, using both verbal and pictorial material. The authors found a difference in the semantic word task (but not in the phonological task), with poor

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comprehenders being worse at determining whether two words were similar in meaning when the material was presented verbally, but not when the material was presented pictorially. As conceded by the authors, the semantic picture task was less challenging than the semantic word task, thereby being perhaps less sensitive to group differences. We note, however, that group differences in false recognition of semantic lures were detected in Weekes et al. (2008) despite high recognition performance levels (i.e., discriminating studied words from lures that were semantically unrelated to the studied material). Thus, it is unlikely that differences in task difficulty *per se* fully explain the differences in the pattern of results between Experiment 4 and 5. Tasks similar to that used in Experiment 5 have been proved to be a sensitive method to assess recollection deficits in several populations of neurological patients (e.g. Ciaramelli & Ghetti, 2007; Duarte, Ranganath, & Knight, 2005). Further, even in the current study the effect of encoding condition could be detected (i.e. level of processing effect), indeed higher subjective and objective (i.e. proportions of recalled details) recollection was observed under deep encoding in both groups of participants. Furthermore, a recent study (Spooner et al, 2006) tested memory performance in skilled and less-skilled comprehenders using a sentence recognition task which varied in terms of difficulty; the authors did not find differences among the memory performances of the two groups according to the difficulty of the task (Spooner et al., 2006).Thus we argue that even though the two tasks in our study were not equated for difficulty it is unlikely that the nature of the task in Experiment 5 accounts for different results in the performance of poor and more skilled learners in the two experiments.

Finally, we cannot rule out the possibility that differences in attentional control and/or working memory demands required in Experiment 4 and 5 contribute to explain differences in results patterns between the two experiments. In the current study, working memory measures were not available, thus it is not possible to examine the additive value of working memory. Working memory deficits could have contributed to making memory encoding less effective

in the group of students with learning difficulties. However, in readers with typical comprehension, even when working memory capacity and other reading related cognitive abilities (i.e. decoding, verbal ability, reasoning) are controlled for, only previous knowledge predicts recollection. Indeed, working memory capacity does not predict differences in subjective recollection outcomes (Long et al., 2008). Thus, it is unlikely that working memory capacity could explain the differences in subjective recollection between the two groups of students, respectively with and without learning difficulties. Rather, we argue that in Experiment 4 not only do poor learners recognize less detailed sentences from the text, but also their memory for them is not as vivid as that of good readers. Not only do they have difficulty at the objective level, being thus less competent at creating a representation of the text, but also they form less vivid memory traces of the text which in turn, in what seems a reciprocal relationship, influences a further and deeper comprehension.

This result seems critical because it does not only show that memory for a text may be qualitatively different in good and poor learners even when from a quantitative point of view seems similar, but also because it has a series of critical implications. In fact, recalled knowledge which is not accompanied by a recollective experience can be contextualized, used, applied to new contexts, associated with other information and retrieved with a greater difficulty. Therefore, it seems that the ability to recollect details from stored episodic memory traces should be enhanced through appropriate instructions in students with learning difficulties given that this could have implication for their learning and, ultimately, school success.

CONCLUSIONS

The main scope of this dissertation was to investigate subjective remembering related to both true and false memories in children with typical development and children with disabilities, namely Attention Deficit/Hyperactivity Disorder and learning difficulties characterized by low text comprehension and low school achievement.

Age related differences in the ability to introspect on memory states and use them while performing a memory task have been reported both in younger children compared to older children and adults and in children with disabilities compared to their typically developing peers. Whereas age-related differences in subjective recollection or familiarity have not been found when dealing with false memories (Experiment 1 and Experiment 2), age related improvements in subjective recollection related to correct memory rates have been reported in Experiment 2. Indeed the youngest group of children – 7-year-olds – associated a lower amount of Remember judgments to the target words respect to the older children and young adults. This is in line with previous research (Ghetti et al., in press, Ghetti & Angelini, 2008) showing age-related increases in recollection along with an increasing ability at endorsing the semantic aspects of studied items. Age differences in memory control have also been found (Experiment 1 and Experiment 2) concerning the ability to use warning instructions as strategies to control one own's memory states. Of particular interest, 7 year olds did increase their memory errors in the DRM task after receiving a warning with a through explanation of what a false memory is (Warning with example condition, Experiment 2), likely resulting from an increased understanding of the gist of the lists caused by the warning itself, which functions as a semantic cue for the youngest children.

Differences in subjective recollection (proportion of Remember judgments) have been also found between adolescents with and without learning difficulties (Experiment 4).

Adolescents with learning difficulties, while performing similarly to their peers in a recognition memory task for isolated words, showing to be equally able to understand and use the Remember-Know paradigm (Experiment 5), associated lower rates of Remember responses to the hit rates in a recognition task for text ideas (Experiment 4), revealing to have a less subjectively compelling memory for complex materials such as a text. The semantic processing of information, deteriorated in children with learning difficulties (Nation & Snowling, 1998a,b), likely contributed to their lower subjective recollection. Indeed, recollection both at the objective and at the subjective level is more affected by semantic encoding than familiarity (Yonelinas, 2002).

Finally, although it needs further investigation, it seems that subjective remembering as measured through confidence ratings differs between children with ADHD and control children (Experiment 3). Indeed children with ADHD were more confident when committing memory errors, regardless of the type of error considered (i.e., gap-filling errors and backward inference errors), showing to be less competent at introspecting on their memory states and report on them. This finding may be the result of their higher impulsivity and lower ability at controlling their cognitive performance (Cornoldi et al., 1999; Marzocchi et al., 2002). Children with ADHD seem to behave as younger groups of typically developing children in other researches (e.g., Ghetti et al., 2002).

One question that needs further investigation is whether children with disabilities (or learning difficulties) are more or less prone at producing memory distortions and whether this depends on the memory paradigm employed. Both groups of children with disabilities in the Experiments presented here (Experiment 3 and Experiment 4) produced more memory errors of certain types, compared to their typically developing peers. Indeed, children with ADHD produced more inferential causal errors than their control group and poor learners produced more false alarms, in particular inferential errors, than their control group.

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Future research should highlight under what conditions memory distortions may or may not be enhanced in children with certain types of developmental disabilities or difficulties. Finally, future research should investigate whether the seemingly lower ability at differentiating true from false memories in younger children and in children with disabilities affects memory performance in particular applied situations, such as the forensic context in which these children may be asked to testify, and thus be competent at introspecting on their memories.

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APPENDIX A

Examples of photographs used in Experiment 3

Cause-effect scenes of the "getting up in the morning" script:

cause   effect

Cause-effect scenes of the "going grocery shopping" script:

cause   effect

APPENDIX B

Text used in the recognition memory task (Experiment 4)

Italian version:

"L'arte di rubare"

Le persone fanno spesso domande del tipo "come stai?" o "bella giornata no?" per le quali non vogliono una risposta vera e propria. Piuttosto, gradiscono risposte scontate, brevi e soddisfacenti. A volte la vostra risposta può non essere così semplice, e vi tocca raccontare tutta la storia che ci sta dietro. Sono qui in questo piccolo e squallido bar di Parigi e voi mi avete appena chiesto perché ho scelto di frequentare questo bar in particolare. Non posso semplicemente rispondere "perché è vicino a casa mia" o "perché la birra costa poco", perché nessuna delle due risposte è vera ed è necessario raccontare una storia….Incontro persone nuove da qualsiasi parte io vada – alle feste, sugli aerei, nei negozi di libri. In questo modo riesco a sentire storie di ogni tipo. Ma nessuna può essere messa a confronto con quella che vi sto per raccontare – riguarda un tipo che ho conosciuto l'anno scorso mentre ero qui a Parigi per le vacanze di primavera. Dunque, entrai in questo buco di bar perché mi ero perso e avevo bisogno di un posto tranquillo dove poter leggere la mia guida turistica, lontano dai borseggiatori. Mi sedetti accanto a questo tipo trasandato che aveva di sicuro bevuto un po' troppo e che iniziò subito a parlare! "Ah, amico mio, la città! Le luci! La gente! Mio caro amico americano, ci credi che siamo a Parigi? Certo anch'io provengo da una città abbastanza imponente, la capitale del Kentucky, Frankfort-- ma confronto a questa – niente!" Gettai un'occhiata al tipo, c'era scuro nel bar, come oggi. Non potevo vederlo bene e francamente non ero poi così interessato a sapere quello che aveva da dire. Perché dovrei aver voglia di parlare con un americano a Parigi? Un vecchio ubriaco americano, che sembra non essersi lavato da alcuni giorni. Il tipo si accorse del mio sguardo. "Dunque, piccolo americano, pensi che io non sia altro che uno sciocco, patetico turista? No, tu sei il turista – sei uno studente, giusto? Bene, ascolta me, e potresti imparare una o due cosette." Mi guardai attorno nel bar, pensando che forse avrei dovuto cambiare posto. Ma le buone maniere imparate da piccolo mi lasciarono lì seduto vicino al vecchio americano. "Dunque, cosa fai?" mi chiese. "Tuo papà ti sta pagando il viaggio? Ti sei mai guadagnato qualcosa? Non fai mai cose azzardate e pericolose, o vai semplicemente nei posti turistici e controlli le cose da fare nel tuo itinerario?" Si bevve un'altra vodka tutta d'un fiato e sbattè il bicchiere sul bancone del bar. Pensai che forse se l'avessi semplicemente ignorato avrebbe smesso di parlare e nel frattempo avrei potuto finire di leggere le informazioni nella guida, finendo il mio drink. "In quanto a me, sono un intenditore d'arte. Faccio tutto ciò che mi è richiesto per riuscire ad avere quadri belli e interessanti, e poi me li gusto, completamente, non come tutte quelle persone sciocche che si recano nei musei solo perché pensano di doverci andare. Hai sentito della scomparsa del gotico americano di Wood? Uno dei miei quadri preferiti, è così carino sulla parete sopra al mio letto…..sembri a disagio amico. Non preoccuparti. Non sono un ladro. Non sto per rubarti qualcosa dalla tasca. Che, non crederai che io sia come quell'idiota che cerca di convincere una vecchia signora a disfarsi del suo anello rosso di rubino?" Assolutamente pazzo, pensai. Solo la mia fortuna poteva farmi incontrare un pazzo americano a Parigi. "Ma qual è il dipinto più bello di tutti? La Mona Lisa, naturalmente, è per questo che devo averlo a casa mia". Rise per il mio sguardo diffidente. "Non mi credi? Ma vedi, è stato facilissimo. Ci sono tunnel sotterranei naturali in corrispondenza del museo, mi sono calato in uno di quelli dal seminterrato di un palazzo adiacente. La parte difficile, amico mio, è stata togliere il quadro dal muro. Ciò che l'ha reso possibile, tuttavia, è stato il fatto che nessuno pensava che qualcuno avrebbe mai provato a rubare la Mona Lisa – e quando si assume che qualcosa sia impossibile, si è destinati a lasciarsi sfuggire qualcosa." L'ubriacone si fermò e mi scrutò. "Vuoi fare un po' di soldi? Con le tue stesse mani?" si avvicinò e mi sussurrò all'orecchio. Il suo alito era pesante. "Guarda cosa ti do se mi aiuti…" detto questo mise una mano in tasca e ne estrasse una pietra blu che luccicò nella fioca luce del bar. "E' uno zaffiro. E' come l'occhio blu di un gatto Siamese, no? Credo che interpretò erroneamente il mio silenzio come una sorta di accordo o interesse. "Ecco cosa vorrei che tu facessi. Vai all'aereoporto di Heathrow a Londra e usa il

mio biglietto aereo per tornare indietro nel Kentucky. Questo è tutto. Voglio solo che sembri che io abbia lasciato l'Europa. Poi, se qualcuno volesse comunque rintracciarmi, l'ultimo posto dove proverebbero a cercarmi è qui a Parigi. O forse girerò un po' l'Europa. Ci sono così tante opere artistiche meravigliose da vedere in Europa… Vorrei vedere il famoso affresco di Michelangelo sul soffitto della Cappella Sistina, o forse andrò a vedere il suo "David" a Firenze. Si, questo sarebbe perfetto – l'Italia. Ho sempre desiderato andare a Venezia per un giro in gondola…." Terminò le sue fantasticherie e mi guardò duramente. "Cosa dici? Vuoi lo zaffiro?" A questo punto avevo già finito il mio drink, pagato il conto, e deciso dove sarei andato subito dopo. Non avevo più motivo di stare lì seduto ad ascoltare un vecchio pazzo. Così mi alzai, riposi la mia guida nello zaino e mi allontanai verso la porta. Per essere ubriaco, il vecchio scattò rapidamente – prima che fossi lontano anche solo due passi, mi prese prontamente il braccio destro.

"Tu piccolo arrogante Americano" sibilò. "Non credi ad una parola di quello che ti ho detto. Probabilmente pensi che io sia solo un pazzo che si porta dietro un fermacarte blu. Sono stato gentile – offrendoti una possibilità di fare qualcosa di emozionante e tu mi pianti qui." Strinse la presa sul mio braccio, mi faceva male. "Prima che te ne vada, amico, ti chiedo di guardare in questa borsetta della spesa." Mi indicò con il piede una sporca borsetta della spesa che era sotto al suo sgabello. Non l'avevo nemmeno notata prima. Mi liberai della presa, e solo perché così mi lasciasse in pace, guardai dentro alla borsa. Ciò che vidi fu una pistola. Dopo che la ebbi osservata per trenta secondi, mi accorsi che in realtà lui voleva che io guardassi qualcos'altro – un pezzo di pergamena arrotolata. Tutto ciò che potei notare fu che era un dipinto ad olio, con le estremità verdine – dorate. Ma non poteva essere di sicuro…Non ricordo per quanto tempo rimasi così con la borsa aperta tra le mani. Improvvisamente l'aria si riempì di suoni penetranti di sirene, il vecchio bruscamente mi strappò la borsa di mano, e mi ritrovai solo. Il giorno dopo aspettai impazientemente il giornale – nessun furto d'arte. Nemmeno il giorno successivo, e quello dopo ancora. L'avevo ormai classificato nella mia mente come uno scherzo da parte del vecchio fino a quando non tornai a casa, a New York. Sulle scale di casa c'era un pacco indirizzato a me che mi aspettava, e conteneva il fermacarte di zaffiro con una nota: "Ti perdono, amico mio, per la tua mancanza di immaginazione. Grazie per avere ascoltato un vecchio. Ora fai qualcosa di eccitante con questo occhio di gatto. Ti ho lasciato il pezzo vero, diversamente da quanto ho lasciato invece a loro al Louvre." Non so come il vecchio avesse fatto ad avere il mio indirizzo e tanto meno il mio nome. Non so a cosa pensare riguardo alla Mona Lisa attualmente posizionata al Louvre. Tutto ciò che so è che mi ha spedito uno zaffiro che ho venduto per 50,000 $ -- sufficiente per pagare il resto delle tasse del college ma che invece ho sfruttato per fare un viaggio intorno al mondo. Sto facendo qualcosa di entusiasmante, come il vecchio mi ha suggerito – ed è per questo che ora sono qui in questo bar a parlare con voi. Di nuovo sul luogo del delitto, per rivelarlo.

English version:

"Art thief"

People are always asking you questions like "How are you?" or "Having a nice day?" for which they don't really want the real answers. Instead they want stock, short, acceptable answers. But sometimes your answer isn't simple, and you just gotta tell the whole story. I'm sitting in this seedy little bar in Paris, and you've just asked me why I've chosen to hang out in this particular bar. I can't just answer "Because it's close to my place" or "because the beer is cheap", because neither is true and there's a story to be told…I meet people wherever I go -- at parties, on planes, in bookstores. I get some great stories that way. But nothing compares to the story I'm about to tell you -- it's about a guy I met last year when I was here in Paris for spring break. So I wandered into this bar, this little hole-in-the-wall kind of bar, because I was lost and I wanted someplace to read my guidebook away from the pickpockets. I sat down next to this kinda scruffy looking guy who had obviously had way too much to drink, and he just started talking! "Ah, my friend, the city! The lights! The people! My American friend, can you believe we are in Paris? I am from a fairly impressive city myself, the capital of Kentucky, Frankfort, but compared to this - nothing!" I glanced over at the guy, it was dark in the bar, like it is today. I couldn't really see him, and frankly I wasn't very interested in what he had to say. Why would I want to talk to an American in Paris? A drunk, old American who looked like he hadn't showered in a few days. The guy caught my glance. "So, little American, you think I am nothing but a

silly, pathetic tourist? No, you are the tourist -- you are a student, correct? Well, listen to me, and you can learn a thing or two." I glanced around the bar, thinking maybe I should switch seats. But prep-school manners kept me politely seated next to the old American. "So, what do you do?" he asked me. "Is your daddy paying for your trip? Do you ever make any money for yourself? Do you ever live dangerously, or do you just go to all the tourist sites and check things off your itinerary?" He polished off another vodka shot and banged his glass down onto the bar. I decided that maybe if I just ignored him he'd stop talking and meanwhile I'd just look up things in my guide book while finishing my drink. "Me, I am an art connoisseur. I do what it takes to get myself pretty, interesting paintings, and then I appreciate them, fully, unlike all those silly people who go to the museums just because they feel like they should. You have heard of the disappearance of Wood's American Gothic? One of my favorite paintings, it looks so nice above my bed… you look uneasy my friend. Don't worry. I am not a thief. I am not about to pick your pocket. What, you compare me to that idiot who convinces an old lady to part with her red ruby ring? Definitely crazy, I decided. Just my luck, to meet a crazy American in Paris. "But what is the most beautiful painting of them all? The Mona Lisa, of course, and that is why I must have it for my home." He laughed at my look of disbelief. "You don't believe me? But you see, it was surprisingly simple. There are natural tunnels under the museum, I just dug into one of them from the basement of a nearby building. The hard part, my friend, was getting the painting off the wall. What made it all possible, though, was that no one believed that anyone would ever try to steal the Mona Lisa -- and when people assume something is impossible, they are bound to overlook something." The drunkard paused and considered me. "You want to make some real money? By yourself?" he leaned closer and whispered into my ear. His breath was foul. "See what I will give you if you help me…" with that, he reached into his pocket and produced a blue stone which glistened even in the dim light of the bar. "It's a sapphire. It's like the blue eye of a Siamese cat, no?" I think he misinterpreted my silence as some kind of agreement or interest. "Here's what I need you to do. Go to Heathrow airport in London and use my plane ticket to fly back to Kentucky. That's all. I just need it to look as if I left Europe. Then, if anyone should even think to track me, the last place they will look for me is here in Paris. Or maybe I will travel round Europe. There is so much beautiful art in Europe to see… I would like to see that famous ceiling artwork of Michelangelo in the Sistene Chapel, or maybe I will go see his "David" in Florence. Yes, that would be perfect -- Italy. I've always wanted to go to Venice for a gondola ride….". He ended his reverie and looked sharply at me. "What say you? You want the sapphire?" By this point in time I had finished my drink, settled my check, and figured out where I was headed next. I had no more reason to sit listening to a crazy guy. So I stood up, put my guidebook back in my backpack, and started towards the door. But for a drunk, the old guy moved quickly -- before I was two steps away, he had an incredibly firm grip on my upper right arm. "You arrogant little American" he hissed. "You don't believe a word I've said. You probably think I'm a crazy carting around a blue paperweight. I was being nice -- offering you a chance for a little excitement and you walk out on me." His grip on my arm tightened, it was actually painful. "Before you go, my friend, I ask you to look in this shopping bag." He pointed with his foot to a dirty shopping bag under his bar stool. I hadn't noticed it before. I shook his grip off, and just so he'd leave me alone, I looked in the shopping bag. What I saw was a gun. After I stared at that for thirty seconds, I realized he actually wanted me to look at something else -- a rolled up piece of parchment. All I could see was that it was an oil painting, with greeny-golds at the edges. But surely it couldn't be… I don't know how long I just stood there with the open shopping bag in my hands. Suddenly the air was pierced with the sound of sirens, the old man brusquely grabbed the shopping bag away from me, and I was alone. The next day I eagerly bought a newspaper -- no art theft. Nor the next day, nor the day after that. I had classified it all in mind as a hoax on the old man's part until I got home to New York City. Waiting on my doorstep was a box addressed to me, and it contained the sapphire paperweight with a note attached: "I forgive you my friend for your lack of imagination. Thanks for listening to an old man. Now do something exciting with this cat's eye. I've given you the real thing, unlike what I left them in the Louvre." I don't know how the old man got my address or even my name. I don't know what to think about the Mona Lisa currently sitting in the Louvre. All I know for sure is that he sent me a sapphire that I sold for $50,000 -- enough to pay off the rest of my college tuition but instead I used it to take a trip around the world. I'm doing something exciting like the old guy said -- and that's how I've come to be here in this bar talking to you. Revisiting the scene of the crime, so to speak.

Examples of sentences used as targets or distracters (paraphrases, inferences or novel sentences) in the recognition memory task (Experiment 4):

Target	*Dopo che la ebbi osservata per trenta secondi, mi accorsi che in realtà lui voleva che io guardassi qualcos'altro – un pezzo di pergamena arrotolata.* After I stared at that for thirty seconds, I realized he actually wanted me to look at something else - a rolled up piece of parchment.
Paraphrase	*Entrai in questo bar di Parigi per avere un po' di tranquillità e poter controllare la mappa senza impedimenti.* I entered this bar in Paris because I wanted some peace and a safe place to read my city map without being disturbed.
Inference	*Tornai in Francia, sfruttando la somma ricavata dalla vendita del regalo che il vecchio americano mi aveva fatto trovare sulle scale.* I came back to France, taking advantage of the amount of money that I got after selling the present that the old american left on the stairs in front of my house.
Novel	*"Guarda cosa ti do se mi aiuti...una pistola."* "Look what I'll give you if you help me…a gun."