Age differences in memory control: Evidence from updating and retrieval-practice tasks

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Abstract

Some contemporary approaches suggest that inhibitory mechanisms play an important role in cognitive development. In addition, several authors distinguish between intentional and unintentional inhibitory processes in cognition. We report two experiments aimed at exploring possible developmental changes in these two types of inhibitory mechanisms. In Experiment 1, an updating task was used. This task requires that participants intentionally suppress irrelevant information from working memory. In Experiment 2, the retrieval-practice task was used. Retrieval practice of a subset of studied items is thought to involve unintentional inhibitory processes to overcome interference from competing memories. As a result, suppressed items become forgotten in a later memory test. Results of the experiments indicated that younger children (8) were less efficient than older children (12) and adults at intentionally suppressing information (updating task). However, when the task required unintentional inhibition of competing items (retrieval-practice task), this developmental trend was not found and children and adults showed similar levels of retrieval-induced forgetting. The results are discussed in terms of the development of efficient inhibition and the distinction between intentional and unintentional inhibitions.

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1. Introduction

A central idea in Cognitive Psychology is that cognitive development involves changes in the cognitive system which allows more efficient information processing (for example, Case, 1995; Hitch & Towse, 1995; Salthouse & Babcock, 1991; Siegel, 1994; Swanson, 1999; Verhaeghen & Salthouse, 1997). One of the most significant changes is the improvement in the inhibitory processes and mechanisms which permit more efficient control of performance in situations where there is interference between different responses or information (for example, Dempster & Corkill, 1999; Harnishfeger, 1995; Harnishfeger, Digby, Scott, Nicholson, & Liberty, 1992; Reyna & Brainerd, 1995; Wilson & Kipp, 1998). The developmental hypothesis of deficit in inhibitory processes states that young children are less effective both at suppressing memories which are no longer relevant and at inhibiting the recovery of irrelevant information (for example, Bjorklund & Harnishfeger, 1990; Harnishfeger & Bjorklund, 1993; Hasher, Stoltzfus, Zacks, & Rypma, 1991; Hasher & Zacks, 1988; Hasher, Zacks, & May, 1999). According to this hypothesis, children acquire a greater inhibitory control as they grow older, and as a result they increase their effectiveness in performing complex cognitive tasks (such as solving mathematical problems).

Results found in different studies and with different tasks support this hypothesis and demonstrate that between childhood and adolescence the ability to inhibit irrelevant information greatly improves (for example, Demster, 1992; Harnishfeger, 1995; Harnishfeger & Bjorklund, 1993; Kail, 2002; Wilson & Kipp, 1998). One of the main pieces of evidence in support of this hypothesis is the results obtained in children in the directed forgetting task (for example, Bray, Justice, & Zahm, 1983; Harnishfeger & Pope, 1996). For example, Harnishfeger and Pope (1996) found an improvement in the ability to inhibit irrelevant information during the first school years (1st, 3rd, and 5th grades).

However, the results of some studies have questioned the generality of the hypothesis of an inhibitory deficit in childhood. For example, although clear developmental differences appear to exist in negative priming with the Stroop task (Tipper, 1985), recently Pritchard and Neumann (2004) obtained negative priming already in 5-year-old children with three different tasks. In addition, the negative priming effects were of the same magnitude for all the ages included in their experiments. These authors conclude that from the age of five years there are no developmental changes in the inhibitory mechanism underlying this task. Similarly, Ford, Keating, and Patel (2004) have shown that there are no age differences in retrieval-induced forgetting (Anderson, Bjork, & Bjork, 1994) (another phenomenon in which inhibition is supposedly involved). Thus, they obtained retrieval-induced forgetting in 7-year-old children and there were no differences in the magnitude of the effect when comparing the performance of children with that of a group of adults.

Taken together, these developmental studies seem to show contradictory results: whereas some tasks show developmental differences in the effectiveness of inhibitory mechanisms (for example, in direct forgetting tasks), other tasks do not show changes related to age (for example, in retrieval-practice tasks). One way of interpreting these different findings is by considering what type of inhibitory mechanism may be responsible for the effect.

In recent years, there has been a discussion as to whether there is a single type of inhibitory process which applies to all the different paradigms and situations (for example, Dagenbach & Carr, 1994; Demster, 1993; Harnishfeger, 1995; McDowd, Oseas-Kreger, & Filion, 1995). Thus, some authors have proposed the existence of different types of inhibitory processes (Friedman & Miyake, 2004; Nigg, 2000; Wilson & Kipp, 1998) based on
studies which have shown that performance in different inhibition tasks (for example, retrieval-induced forgetting and directed forgetting) do not correlate (Conway, Harries, Noyes, Racsmány, & Frankish, 2000) and on studies which show that some inhibitory tasks show greater impairment than others in older people (for example, Kramer, Humphrey, Larish, Logan, & Strayer, 1994; Moulin et al., 2002; Shilling, Chetwind, & Rabbitt, 2002).

A large number of the studies which have found clear developmental changes have used tasks which are assumed to require intentional inhibitory processes (for example, the directed forgetting task used by Harnishfeger & Pope, 1996). However, the studies in which no developmental differences were obtained, used tasks which involved unintentional inhibitory mechanisms (for example, the retrieval-practice task in Ford et al., 2004).

In this study, we intend to explore possible developmental changes in two types of tasks which supposedly vary in the degree of intention involved in inhibiting irrelevant information. In the first experiment, we used a working memory updating task. This task requires the participant to listen to a series of words, and then recall only part of the series. The criteria for selecting the words to recall involve making judgements about the size of the objects or animals in the series of words. These judgements determine in each moment which words should be later recalled (and therefore must be actively maintained in working memory) and which words should not be recalled (and therefore should be intentionally suppressed). In the second experiment, we used a retrieval-practice task in which suppression is less intentional in nature. In this task, the participants learn a set of items and then practice retrieving part of the information. Although prior retrieval increases the probability of retrieving the recovered items in a subsequent memory test, those items that were not initially recovered and were associated to the same retrieval cue are less likely to be recalled in a subsequent memory test relative to control items. This effect is known as “retrieval-induced forgetting” and seems to be the result of a mechanism which inhibits the “internal distraction” caused by the different competitors during the retrieval-practice phase (Anderson et al., 1994; Anderson & Spellman, 1995). The aim of these two experiments was to assess the developmental hypothesis of deficits in inhibitory processes and to explore to what extent there are differences depending on the type of inhibition involved in the task.

2. Experiment 1

The purpose of this first study is to explore if failures in inhibiting irrelevant information may explain the worse performance in working memory tasks observed in children as compared to that observed in young adults (Chiappe, Hasher, & Siegel, 2000; De Beni & Palladino, 2000; Palladino & De Beni, 1999; Passolunghi, Cornoldi, & De Liberto, 1999). The updating task proposed by Palladino, Cornoldi, De Beni, and Pazzaglia (2001) would allow us to assess the retention of information in working memory (WM), but also the ability to update and intentionally suppress information from this memory. As we have mentioned, this task involves a person listening to a series of words, and then recalling only part of this series. Selection of the to-be-recalled words is based on the size of the objects that they represent. Thus, the smaller objects or animals should be recalled (and therefore maintained active in WM) whereas the larger objects or animals should not be recalled (and therefore should be suppressed from WM). Failures in inhibiting irrelevant information can lead to increments in the number of intrusion errors in this task (De Beni & Palladino, 2004; De Beni, Palladino, Pazzaglia, & Cornoldi, 1998).
active in memory (not suppressed), it is likely that it would be recalled later, even if it is not relevant to the task. Hence, intrusion errors can be considered an indicator of the effectiveness of suppression processes (De Beni & Palladino, 2000). An additional feature of this task is that it is possible to manipulate the amount of information to be retained in WM (memory load) and the degree of suppression required in an independent way by varying the number of small objects to be retained (memory load) and the number of larger objects to be suppressed (suppression requirements). Thus, the independent contribution of maintenance and inhibition processes to memory development can be assessed.

In this study, we adapted the task used by Palladino et al. (2001) in order to be used with different groups of Spanish participants that varied in age. If the hypothesis of a deficit in the inhibitory processes is correct, we expect to find better performance in young adults than in children (12-year-olds), who in turn should perform better than younger children (8-year-olds). These differences in performance should show in the percentage of recall in an immediate and in a delayed test, but also in the number of intrusion errors. We also expect that young children would be more affected by the degree of suppression required by the task. In addition, the possible interaction between memory load, memory suppression and age would give us some insight about the relation between memory capacity and inhibition skills in WM.

2.1. Method

2.1.1. Participants

A total of 34 children and university students participated in this study. They were split into three different groups according to age. Thus, one group comprised 10 young children (five boys and five girls) aged between 8 and 9 years (average age: 8 years 6 months). The second group comprised 10 older children (four boys and six girls), aged between 11 and 12 years (average age 11 years 5 months). The children in both groups were selected at random from a middle-class school in the city of Granada. The third group was made up of 14 university students, two men and 12 women (average age 18 years 6 months), from the Faculty of Humanities and Education Sciences of the University of Jaén. This group was also selected at random. The children were given a milkshake when they completed the task, and the university students were given points which served to improve their mark in a course.

2.1.2. Design

The study used a mixed factorial design $3 \times (2 \times 2)$. The between-groups independent variable was the age of the participants (8 years, 11 years and 18 years), whereas the within-subjects variables were WM load (high and low), and degree of suppression (high suppression and low suppression). The dependent variables were “number of intrusions”, defined as the number of irrelevant items recalled by the participant, and “recall proportion”, defined as the proportion of critical items recalled by the participant.

2.1.3. Material

We formed 28 lists of 12 words. Each list was composed of concrete nouns (relevant items) which represented objects or animals of different sizes (for example, wasp and kangaroo) and of abstract nouns (for example, beauty and clarity). Both concrete and abstract words were selected from the Computerised database of Spanish words (Algarebel, Ruiz, & Sanmartín, 1988). The abstract words had concreteness values of less than 4.5.
The number of concrete words varied according to the type of list to which they were assigned. There were four types of lists depending on the memory load and suppression conditions (high load–high suppression; high load–low suppression; low load–high suppression and low load–low suppression). Memory load refers to the number of concrete words that the participants were required to keep in memory and recall at the end of each list. The number of critical word in a list (concrete words to be recalled from the list) was either 3 (low load) or 5 (high load). The degree of suppression was manipulated by varying the number of concrete words in each list that the participant should discard from WM because they were not the smallest in the list (irrelevant items). The number of irrelevant items in a list could be 2 (low suppression) or 5 (high suppression). Table 1 shows the composition of the lists under different conditions. In order to make sure that the younger children were able to rank order the test items correctly in terms of their size, we conducted a pilot study.

Fourteen 8-year-old children were presented each of the experimental lists (excluding the abstract items) and were asked to order the items in terms of their size. The results of this pilot study indicated that the mean percentage of correct classifications was 91% indicating that the 8-year-old children were able to perform the task adequately. De Beni and Palladino (2004) also conducted a pilot study to construct their materials and they included in the list only those items that were selected as small by 90% of the participants. Therefore, the percentage of correct classification that we obtained in our pilot study was very similar to the criterion that they used to select their materials.

A total of 28 lists were formed and assigned to seven blocks of four lists which corresponded to the four types of lists described above. The order of the lists in each block was random. Six blocks were used in the experimental phase and one block was used for practice.

2.1.4. Procedure

All the participants were tested individually and they had to perform two tasks: an updating task and a delayed recall task. Before starting the updating task, the participants were told that they were to listen to lists of words and that they would have to recall at the end of each list a given number of the smallest animals or objects on the list. The exact number of items to recall and whether these items were animals or objects was indicated just before each list was presented. Participants were then presented the first list and instructed to orally recall the critical items. Once the participant finished recalling the critical items for the list, the next list was presented. This procedure continued until all the lists had

<table>
<thead>
<tr>
<th>Suppression</th>
<th>Load</th>
<th>5 Key items</th>
<th>5 Irrelevant items</th>
<th>2 Filler items</th>
<th>5 Irrelevant items</th>
<th>2 Filler items</th>
<th>5 Filler items</th>
<th>7 Filler items</th>
</tr>
</thead>
<tbody>
<tr>
<td>High</td>
<td>High</td>
<td>5 Key items</td>
<td>3 Key items</td>
<td>5 Irrelevant items</td>
<td>3 Key items</td>
<td>5 Irrelevant items</td>
<td>3 Key items</td>
<td>5 Irrelevant items</td>
</tr>
<tr>
<td>Low</td>
<td>Low</td>
<td>5 Key items</td>
<td>3 Key items</td>
<td>5 Irrelevant items</td>
<td>3 Key items</td>
<td>5 Irrelevant items</td>
<td>3 Key items</td>
<td>5 Irrelevant items</td>
</tr>
</tbody>
</table>
been presented and recalled. In each list, the words were presented at a constant speed, with an interval of 2 s between each word. The start and the end of the list were signalled with a sound.

At the end of this first phase (updating task), the participants were instructed to perform a surprise delayed recall task. They were asked to recall all the words that had been presented during the session, including critical items, irrelevant words and fillers (abstract words). No time limit was given for recall. Before the experimental task each participant carried out a practice phase which consisted of the presentation/recall of one block of lists.

2.2. Results

Three analyses were performed on the data. First, we analysed the proportion of critical items recalled from the lists; second, we analysed the number of intrusions from each list, and third, we analysed the proportion of recall for each type of item in the delayed recall task. In the first two analyses, we performed a mixed 3×(2×2) ANOVA, with one between-groups factor (age) and two within-subjects factors (load and suppression). For the analysis of data from the delayed recall tasks, we performed a mixed factorial 3×2 ANOVA, with age as a between-groups factor and type of word recalled (critical, irrelevant or filler) as a within-subjects factor.

2.2.1. Proportion of recall of key items in the immediate recall task

Table 2 shows the percentage of recall in each of the conditions and for each age group. The statistical analysis showed that the main effects of the three variables were statistically significant.

First, there was a significant effect of age, $F(2,31)=26.97$, $\text{MSe}=.014$, $p<.05$, $\eta^2=.63$. Tukey’s tests indicated that the recall differences between the groups of 8-year-olds and 11-year-olds, and between the group of 8-year-olds and 18-year-olds were significant ($p<.05$). There were no significant differences between the group of 11-year-olds and 18-year-olds ($p>.3$). Thus, the younger children showed lower levels of recall (70%) than the 11-year-old children (84%) and the adults (88%).

Secondly, there was a significant effect of memory load, $F(1,31)=102.79$, $\text{MSe}=.004$, $p<.05$, $\eta^2=.77$. All the age groups showed higher levels of recall of critical words in the low load condition (86%) compared to the high memory load condition (75%).

Third, the effect of the level of suppression was also significant, $F(1,31)=22.90$, $\text{MSe}=.004$, $p<.05$, $\eta^2=.42$. However, this effect was modulated by its interaction with age, $F(2,31)=8.31$, $\text{MSe}=.004$, $p<.05$, $\eta^2=.35$. The analysis of this interaction indicated that the effect of the suppression variable was only significant in the group of 8-year-old,

| Table 2
Mean proportion of recalled words and standard deviations (in brackets) as a function of age, load and suppression in the immediate recall task of Experiment 1

<table>
<thead>
<tr>
<th></th>
<th>Low load</th>
<th></th>
<th>High load</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Low suppression</td>
<td>High suppression</td>
<td>Low suppression</td>
<td>High suppression</td>
</tr>
<tr>
<td>8 Years</td>
<td>0.82 (0.13)</td>
<td>0.70 (0.11)</td>
<td>0.69 (0.08)</td>
<td>0.58 (0.07)</td>
</tr>
<tr>
<td>11 Years</td>
<td>0.91 (0.09)</td>
<td>0.86 (0.05)</td>
<td>0.80 (0.08)</td>
<td>0.79 (0.08)</td>
</tr>
<tr>
<td>18 Years</td>
<td>0.95 (0.04)</td>
<td>0.94 (0.05)</td>
<td>0.81 (0.06)</td>
<td>0.80 (0.06)</td>
</tr>
</tbody>
</table>
$F(1, 9) = 16.12, \text{MSe} = .016, p < .05, \eta^2 = .64$, and was not significant in the other age groups ($p > .15, \eta^2 = .21$ and $p > .20, \eta^2 = .12$, respectively). Thus, the 8-year-old children recalled a higher percentage of critical items in the low suppression condition (76%) as opposed to the high suppression condition (64%).

No other interactions were significant load $\times$ age: $F(2, 31) = 2.13, \text{MSe} = .008; p > .13; \eta^2 = .12$; load $\times$ suppression: $F < 1, \eta^2 = .01$; and load $\times$ suppression $\times$ age, $F < 1, \eta^2 = .03$.

### 2.2.2. Proportion of intrusion errors in the immediate recall task

Table 3 shows the average number of intrusion errors for the different conditions of the experiment for each of the age groups. The results of the ANOVA performed on the data indicated that the effect of age was significant, $F(2, 31) = 23.59, \text{MSe} = 4.09, p < .05, \eta^2 = .60$. Tukey’s test indicated that there were significant differences between 8-year-old and the 11-year-old children ($p < .05$) and between the group of 8-year-olds and the group of 18-year-olds ($p < .05$). There were no significant differences between the group of 11-year-olds and the group of 18-year-olds ($p > .98$). Thus, the youngest children showed more intrusion errors ($M = 5$) than the other age groups ($M = 2.43$ and 2.35; for 11-year-olds and adults).

We also found a significant effect of WM load, $F(1, 31) = 95.61, \text{MSe} = 2.38; p < .05, \eta^2 = .75$. Irrespective of the group, more errors were committed in the high load condition ($M = 4.57$) than in the low load condition ($M = 1.95$). The interaction of load and age was close to significance, $F(2, 31) = 2.75, \text{MSe} = 2.38, p < .08, \eta^2 = .15$, indicating a tendency to make more intrusion errors in the high load condition, as age decreased.

Both the level of suppression, $F(1, 31) = 27.29, \text{MSe} = 1.70, p < .05, \eta^2 = .47$, and the interaction of suppression and age, $F(2, 31) = 3.87, \text{MSe} = 1.70, p < .05, \eta^2 = .20$, were significant sources of variance. Analyses of simple effects indicated that the level of suppression was significant for the 8-year-old children, $F(1, 9) = 13.33, \text{MSe} = 6.0, p < .05, \eta^2 = .60$, and for the 11-year-old children, $F(1, 9) = 11.37, \text{MSe} = 1.94, p < .05, \eta^2 = .56$, but not for the adult group, $F(1, 13) = 2.68, \text{MSe} = 2.61, p > .13, \eta^2 = .17$. This indicated that 8- and 11-year-old children had higher numbers of intrusions in the high suppression condition as opposed to the low suppression condition. These results show a divergence in the pattern of intrusions with respect to that obtained in the analysis of recall. In that case, the level of suppression affected in a similar way the performance of the 11-year-old children and the 18-year-old students. Neither the interaction load $\times$ suppression nor the interaction of suppression $\times$ age was significant (both with $F < 1$).

In order to better understand the source of the intrusion errors, we performed additional analyses. Following De Beni and Palladino (2004), we distinguished three main categories of errors: same-list intrusions (incorrect recall of items belonging to the current list), previous-list intrusions (incorrect recall of items presented in previous lists) and inventions.

### Table 3

Mean number of intrusion errors and standard deviations (in brackets) as a function of age, load and suppression in the immediate recall task of Experiment 1

<table>
<thead>
<tr>
<th>Age</th>
<th>Low load</th>
<th>High load</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Low suppression</td>
<td>High suppression</td>
</tr>
<tr>
<td>8 Years</td>
<td>2.50 (1.90)</td>
<td>4.60 (1.83)</td>
</tr>
<tr>
<td>11 Years</td>
<td>1.00 (0.66)</td>
<td>2.10 (0.99)</td>
</tr>
<tr>
<td>18 Years</td>
<td>0.64 (0.84)</td>
<td>0.85 (0.86)</td>
</tr>
</tbody>
</table>
(items not presented in any list). Table 4 presents the mean number of different types of errors for each of the age group.

A 3 (age) × 3 (type of error) ANOVA on the mean number of errors showed a significant main effect of age, $F(2, 31) = 22.20$, MSe $= 5.32$, $p < .05$, $\eta^2 = .59$, indicating a decrease of the number of errors as the age increased. Also, the main effect of Type of errors was significant, $F(2, 62) = 243.24$, MSe $= 4.64$, $p < .05$, $\eta^2 = .89$, indicating a higher number of same-list intrusions than previous-list intrusions or inventions. The interaction Age × Type of errors was also significant, $F(4, 62) = 8.79$, MSe $= 4.64$, $p < .05$, $\eta^2 = .36$. Tukey’s test indicated that the younger children produced more same-list intrusions than any of the two older groups ($p < .05$) that did not differ from each other ($p > .8$). Similarly, the younger children produced more previous-list intrusions than both the 11-year-old children and the adults ($p < .05$). However, regarding inventions, the only significant difference was between the two extreme age groups (8 and 18 years, $p < .05$).

### Table 4
Mean number of errors and standard deviations (in brackets) as a function of age and type of errors

<table>
<thead>
<tr>
<th></th>
<th>Same-list intrusions</th>
<th>Previous-list intrusions</th>
<th>Inventions</th>
</tr>
</thead>
<tbody>
<tr>
<td>8 Years</td>
<td>15.90 (3.98)</td>
<td>2.40 (1.51)</td>
<td>1.40 (1.26)</td>
</tr>
<tr>
<td>11 Years</td>
<td>8.80 (3.49)</td>
<td>0.80 (0.42)</td>
<td>0.60 (0.97)</td>
</tr>
<tr>
<td>18 Years</td>
<td>8.57 (3.27)</td>
<td>0.57 (0.94)</td>
<td>0.21 (0.58)</td>
</tr>
</tbody>
</table>

2.2.3. Delayed recall task

The proportion of recall in the delayed recall task is shown in Table 5.

An ANOVA on these data indicated that age was significant, $F(2, 31) = 26.14$; MSe $= .006; p < .05; \eta^2 = .63$. Tukey’s test indicated significant differences in recall between the group of 8-year-olds and the group of 11-year-olds ($p < .05$), between the group of 8-year-olds and the group of 18-year-olds ($p < .05$) and also between the group of 11-year-olds and the group of 18-year-olds ($p < .05$). Thus, the youngest children showed a proportion of recall (12%) which was significantly lower than that for the 11-year-olds (21%), whose recall was in turn lower than the group of adults (28%).

Also the effect of the type of word was significant, $F(1, 31) = 56.09$; MSe $= .002; p < .05; \eta^2 = .64$. Thus, the three age groups showed significantly higher proportions of recall for critical words (25%) than for irrelevant words (16%).

The interaction between the variable age and word type was close to statistical significance, $F(2, 31) = 2.98$; MSe $= .002; p < .07, \eta^2 = .16$. This tendency was due to the fact that in the case of the 8-year-old children the difference between the critical items and the irrelevant items was less pronounced than in the case of 11-year-old children and adults.

### Table 5
Mean proportion of recalled words and standard deviations (in brackets) as a function of age and type of words in the delayed recall test of Experiment 1

<table>
<thead>
<tr>
<th></th>
<th>Key words</th>
<th>Irrelevant words</th>
</tr>
</thead>
<tbody>
<tr>
<td>8 Years</td>
<td>0.14 (0.06)</td>
<td>0.09 (0.02)</td>
</tr>
<tr>
<td>11 Years</td>
<td>0.27 (0.05)</td>
<td>0.15 (0.06)</td>
</tr>
<tr>
<td>18 Years</td>
<td>0.33 (0.07)</td>
<td>0.23 (0.06)</td>
</tr>
</tbody>
</table>
2.3. Discussion

As predicted, results of Experiment 1 indicated that there were changes associated to age both in the percentage of recall and in the number of intrusion errors. The improvement in recall as age increases replicates the results of other studies that have also shown increments in the amount of information recalled in WM tasks, suggesting that there are developmental changes in the efficiency with which this memory is used (for example, Gathercole & Pickering, 2000).

In addition, the fact that the youngest participants committed more intrusion errors than the older participants seems to indicate that these developmental changes might be related to the ability to suppress irrelevant information from WM. These results and this interpretation are in line with those reported by De Beni and Palladino (2004) for young and elderly people in a similar updating task. The fact that the younger children produced both more same-list intrusions and more previous-list intrusions is interesting because it provides additional support to the idea that young children are relatively less efficient than older children and adults in their ability to suppress irrelevant information. It could be argued that the results regarding irrelevant words from the same list might be due to younger children having more difficulties discriminating differences in the size of the presented objects. However, this same argument does not hold for the intrusions from previous list. In this case, irrespective of the size judgement made by the children, the items should have been suppressed from memory since they were no longer relevant. Thus the higher number of intrusions from previous list shown by the younger children indicates a failure to inhibit irrelevant information.

This interpretation is also supported by the interaction between age and level of suppression found in both the percentage of recall of critical items and the number of intrusions from irrelevant items. In general, when the degree of suppression required was high, fewer items were recalled and irrelevant information was suppressed less efficiently. Interestingly the level of suppression affected performance differently according to the age group. Specifically, the youngest children found it comparatively more difficult than adults to suppress the information when larger numbers of irrelevant items were presented (high suppression condition). This difficulty was reflected in both dependent variables: recall and number of intrusions. This interaction suggests that the ability to suppress irrelevant information differs depending on the age of the participants. Although, this interaction was present in both the percentage of recall and the number of intrusions, the obtained pattern differed slightly depending on the variable considered. The analysis of the recall data indicated that the different levels of suppression affected only the youngest children (8-year-olds), whereas the other two groups recalled practically the same number of items irrespective of the number of to-be-suppressed items. In contrast, analyses performed on intrusion errors indicated that there were differences between the high and low suppression conditions for both younger and older children, whereas this difference was not significant for the adult participants. These differences in the pattern of results may be related to the differential sensibility of the two dependent variables to the difficulty of the suppression process, but they also suggest developmental trends in the ability to inhibit information so that younger children are less efficient than older children and these in turn less efficient than young adults.

In agreement with the results obtained in other studies that have used the updating task (i.e., De Beni & Palladino, 2004; Palladino et al., 2001), the WM load affected both the
percentage of recall and the number of intrusion errors. These results suggest that maintenance processes are affected by the quantity of information which should be kept in WM and may reflect the limits of this system. Interestingly, there were no developmental differences in the effect of this variable; the amount of items to be retained (WM load) affected all age groups equally. The absence of interaction between memory load, level of suppression and age indicates that the difficulty of children in avoiding intrusions was not due to the increase in the amount of information to be held in memory nor to the greater effort needed in recalling a larger number of studied items.

3. Experiment 2

In Experiment 1, we reported age differences in the ability to inhibit intentionally information which is no longer relevant to the task. This result confirms the findings of other studies that have shown developmental differences in inhibitory tasks (for example, Chiappe et al., 2000; De Beni & Palladino, 2000; Hasher & Zacks, 1988; Palladino & De Beni, 1999). However, as we discussed in the introduction, there are other studies that have shown no age-related differences in tasks which require non-intentional inhibition.

A task which allows us to explore the existence of possible differences in unintentional inhibitory processes is a retrieval practice. This task, designed by Anderson et al. (1994), involves generally three phases: a study phase, a retrieval-practice phase and a final recall test. In the first phase the participants study, for example, a series of pairs of words where one is the name of a category (for example, Fruit) and the other a member of this category (for example, Orange). After the study stage, the participants carry out a recall test of half the exemplars of half the categories used (hereinafter referred to as Rp+ items). Retrieval practice is induced by presenting the name of the category along with the first two letters of the exemplar (for example, Fruit Or_____). During this phase, the set of practised exemplars is presented various times in order to maximise the facilitating effect of this practice. After a retention interval (of 5–20 min), and without warning, the participants carry out a final recall test, in which the names of the categories studied in the first phase are presented in a random order, and they are asked to recall as many exemplars as they can for each one. The impact of previous retrieval on subsequent recall is observed by comparing the performance of the participants in two different types of exemplars: those which were not practised but belong to categories which were practised (hereinafter referred to as Rp− items) are recalled significantly less than the examples of categories which were not practised at all (hereinafter referred to as Nrp items). This effect is known as retrieval-induced forgetting effect: RIF.

The RIF effect is normally attributed to inhibition (e.g., Anderson, 2003; Anderson & Bell, 2001; Anderson & McCulloch, 1999; Blaxton & Neely, 1983; Carr & Dagenbach, 1990; Gómez-Ariza, Lechuga, Pelegrina, & Bajo, in press). Basically, the idea is that inhibition works in recall in a similar way to how it works in other areas such as language processing or selective attention (i.e., Neill, Valdes, & Terry, 1995; Posner & Deheane, 1994). Anderson and his colleagues suggest that an attentional mechanism may be responsible for inhibiting the “internal distraction” caused by different competitors during recall in the practice phase. In this way, the higher probability of forgetting in a subsequent recall task would be due to the suppression of the representations rather than to the interference of the practised items. Indeed, several findings support this inhibitory account (see Anderson, 2003, for a review).
Ford et al. (2004) adapted this procedure for use with 7-year-old children. Their results showed RIF effects of similar magnitude in children and adults in cue recall and in recognition indicating that there are no developmental differences in inhibition when the retrieval-practice procedure is used. Similarly, Zellner and Bäuml (2005) have found intact inhibition in second and fourth graders as captured by the retrieval-practice paradigm. Hence, there are recent indications that the type of inhibition tapped by this procedure may develop early in time and remain intact for the most part of the life span. However, while the generality of the effect in the adult population has been largely demonstrated by showing it with a wide variety of materials and tasks (see Anderson, 2003, for a review of the adult findings), to our knowledge only these two studies have been conducted with children.

Therefore, the aim of the experiment was to replicate these findings and to extend them to a different type of materials (propositional) and ages (8 and 12 years old). While Ford et al. (2004) used picture exemplars from semantic categories, and Zellner and Bäuml (2005) used the more standard category and word-exemplar lists, in Experiment 2 we used sentences as the experimental materials. It was possible that this somewhat more complex material might capture developmental differences in unintentional inhibition.

3.1. Method

3.1.1. Participants

A total of 87 children and university students participated in this study, distributed in three different groups according to their age. The first group comprised 27 children (12 boys and 15 girls), aged between 8 and 9 years (average age 8 years 9 months), and a second group of 30 children (10 boys and 20 girls), aged between 11 and 12 years (average age 11 years 6 months). The children attended various medium-class schools in the city of Jaén. The third group was formed by 30 university students (10 men and 21 women) with an average age of 19 years 3 months, from the Faculty of Humanities and Education Sciences at the University of Jaén. All three groups were selected randomly. The children were given a milkshake when they finished the task, and the university students were awarded credits towards one of their degree courses.

3.1.2. Design

The within-subject dependent variable considered was the status with respect to the practice of the sentences which made up the test material. Thus, there were practised sentences associated to practised characters (Rp+), not-practised sentences associated to practised characters (Rp−), and not-practised sentences associated to not-practised characters (Nrp). As is usual in this type of task, we recorded the percentage of correctly recorded facts in each condition in the final recall test.

3.1.3. Materials

Forty sentences were constructed to be used as the stimuli to be recalled. All sentences contained a single proposition and had names of professions as grammatical subjects (the characters). The 10 professions were selected from Goikoetxea’s (2000) norms. All the sentences contained six words. The predicates of the sentences were created in such a way that all the actions were familiar and believable (e.g., the plumber has washed his clothes, gone up in the lift, eaten a salad, drawn with a pencil). Each character was randomly assigned to
four predicates. Given that one of the tasks involved providing the first letters of the verb as a cue to recall, it was crucial that there was no repetition of the initial letters. Hence, all the verbs in the sentences had different initial letters. Assignment of the characters to the predicates was random. Four of the eight characters were assigned to the practice condition, while the other four characters were assigned to the control conditions. In addition, two random versions of this material were generated so that the sentences assigned to the Rp+, Rp— and Nrp were different for each of them.

3.1.4. Order of study

The set of sentences to be studied was made up of 32 experimental sentences and eight filler sentences, which were presented individually on the computer screen. In order to avoid the adjacent presentation of sentences with the same grammatical subject, we constructed blocks of four sentences. Each block contained propositions related to different characters. The sentences in each block were randomised for each participant and assignment of the sentences to the blocks was also random. In addition, to avoid any possible primacy or recency effects, the filler sentences were shown at the beginning and at the end of the series.

3.1.5. Retrieval practice

The practice phase consisted of 42 trials. Only half of the eight characters used as experimental sentences were presented in this phase. In turn, two of the four sentences associated to each character were presented (Rp+). In this way, only half of the total number of sentences was practised. Thus, eight sentences comprised the Rp+ condition, eight sentences comprised the Rp— condition and 16 sentences comprised the Nrp control condition. Both the characters and the sentences were randomly selected. In addition, the two filler characters were included in the practice set. As indicated, two different versions of the material were made, so that in each of the versions the characters and sentences assigned to the Rp+, Rp— and Nrp differ. Approximately half of the participants were assigned to each of these versions.

Similarly to the study phase, we constructed blocks made up of sentences involving different characters. Each block was composed of sentences from each of the to-be-practised characters, so that the sentences related to the same character never appeared sequentially. We also used the filler sentences at the beginning and end of the series in order to reduce primacy and recency effects. Filler sentences were also used to separate blocks of experimental sentences.

In the practice phase of the grammatical subject, the first three letters of the main verb and the first two letters of the complement were presented (i.e., “The policeman has arr____ at the ci____” for “The policeman has arrived at the cinema.”) and participants were asked to recall the complete sentence. The set of eight experimental sentences were presented three times, each time in a different order.

3.1.6. Final recall

We prepared small notebooks composed of nine pages. On each page was written the name of one of the characters used. In all the notebooks, the first page contained the name of one of the characters used as fillers. The other filler character was not included in the notebook. The order of presentation of the eight experimental characters was randomised for each of the participants.
3.1.7. Distractor task

During the lapse of time between the end of the recall practice and the final test, the adult participants carried out a reasoning task, the D-70 test. The children were asked to do drawings of objects unrelated to the test material.

For the presentation of stimuli during the study and practice stages, we created a program using ERTS language (experimental run time system, Beringer, 1997). The sentences were presented on a screen in front of the participants, using a multimedia projector connected to the computer.

3.2. Procedure

The experiment was composed of four different stages: study, retrieval practice, distractor task and free recall. Participants carried out the tasks in individual sessions. The specific instructions for each task were given just before the task began. In the study phase, the participants were told to pay as much attention as possible to the set of sentences which they were about to see, as they would be asked about them later. Each of the sentences was presented on the computer screen for 10 s, after a fixation point of 1200 ms. The time between each sentence was 2 s. Before beginning the study phase, it was emphasised to the participants that it was important to memorise the sentences so that the action could be recalled if they were given the name of the character. Two filler examples were shown on paper.

Before beginning the practice phase, and after the study phase, the participants were told that they would carry out a recall task of the sentences they had seen. In this phase, the incomplete sentences from the Rp+ condition (e.g., El policía ha lle___ al ci___ “The policeman has arr____ at the ci___”) were presented one by one for 7 s. As in the study phase, the time lapse between the sentences was 2000 ms, and also, the sentences were preceded by a fixation point. The participants were informed that the sentences would appear more than once during the task. In addition, insistence was placed on the need to try to recall the complete sentence, before it disappeared from the screen. Two filler examples were shown on paper. The participants wrote their responses in a specially provided notebook. When they finished, the participants carried out the distractor task for 15 min.

The final recall test was carried out by giving each participant the notebook with nine pages and the names of the nine characters. While the instructions were given, the notebooks were kept face down. The participants were told that when instructed, they should turn over the notebooks, and that they would have 40–50 s to write all the actions they could remember about the character on the top of the page. This time was selected because the results of previous studies with similar procedures and materials showed that 50 s was enough for the 8-year-old children to complete the recall phase. As an example, participants were given the name of a filler character not included in the notebook.

3.3. Results

Statistical analyses were carried out on the percentages of experimental sentences which were correctly recalled for each of the conditions. Two types of analyses of data were used with the aim of isolating two different phenomena: the facilitating effect of the Rp+ condition and its possible disruptive effect on recall of the Rp− items.
In general, performance during the practice phase was moderately high in the three age groups (88%, 74% and 66%, respectively for the group of adults, 11–12-year-old children and 8–9-year-old children).

### 3.3.1. Facilitation effect

Comparison between the conditions Rp+ and Nrp allows us to determine the possible beneficial effect of practice (see Table 6). With the aim of determining whether this effect was present and whether it varied as a function of age, we carried out an ANOVA 3 (age) × 2 (status: Rp+ vs. Nrp).

The statistical analysis showed that the main effects of the age and status were significant. Thus, the adults recalled more propositions (48%) than the 11–12 years old children (41%), who in turn recalled more than the younger children (34%), \(F(2, 84) = 3.8, \text{MSE} = 655.95, p < .05, \eta^2 = .08\). In addition, we observed better performance for the Rp+ sentences (\(M = 53\%\)) than for the Nrp sentences (\(M = 29\%\)), \(F(1, 84) = 84.94, \text{MSE} = 280.17, p < .05, \eta^2 = .50\), indicating that there was a facilitation effect due to retrieval practice.

The interaction between age and practice status was also significant, \(F(2, 84) = 4.45, \text{MSE} = 280.17, p = .05, \eta^2 = .10\), revealing larger effects for the younger participants. Whereas the recall levels in the Rp+ condition were equivalent in the three groups (\(F < 1\)), this was not so for the Nrp sentences. The proportion of recalled items in this condition (Nrp) was directly proportional to the age of the participants \(F(2, 84) = 9.70, \text{MSE} = 371.1, p < .05, \eta^2 = .19\). The facilitation effect was 33% for the youngest children, 22% for the older children and 15% for the adults.

### 3.3.2. Retrieval-induced forgetting

To assess the negative effect of retrieval practice on un-practised items of practised characters we compared the Rp− items with the Nrp items (see Table 6). Although the sentences belonging to these two conditions were not practised, they differ in their relationship with those that have been previously practised (Rp+), because the Rp− sentences were linked to the same characters and, therefore, they had a competitive relation with the Rp+ sentences, whereas the Nrp sentences were linked to other characters and, therefore, they served as controls. Thus, an unequal percentage of recall in the final test could be attributed to their status compared to the practised sentences. As in the previous section, we carried out an ANOVA 3 (age) × 2 (status: Rp− and Nrp).

The analyses showed that the main effects of age and status were significant. First, the adults recalled more sentences (34%) than the older children (25%), who in turn recalled more sentences than the younger children (14%), \(F(2, 84) = 9.50, \text{MSE} = 603.80, p < .05, \eta^2 = .19\). In addition, significantly fewer sentences were recalled from the Rp− condition (\(M = 20\%\)) than from the Nrp condition (\(M = 29\%\)), \(F(1, 84) = 19.81, \text{MSE} = 184.41, p < .05\).

<table>
<thead>
<tr>
<th>Retrieval-practice status</th>
<th>Rp+</th>
<th>Rp−</th>
<th>Nrp</th>
</tr>
</thead>
<tbody>
<tr>
<td>8 Years</td>
<td>50.9 (23.7)</td>
<td>10.6 (12.4)</td>
<td>17.1 (12.3)</td>
</tr>
<tr>
<td>11 Years</td>
<td>51.3 (22.8)</td>
<td>20.4 (20.9)</td>
<td>30.2 (19.4)</td>
</tr>
<tr>
<td>19 Years</td>
<td>55.0 (24.7)</td>
<td>28.3 (25.0)</td>
<td>39.6 (23.7)</td>
</tr>
</tbody>
</table>
\( \eta^2 = .19 \), showing an overall effect of retrieval-induced forgetting. More importantly, this effect did not depend on the age of the participants, since the interaction between age and status was not significant, \( F(2, 84) = 0.45, \text{MS}e = 184.41, p = .65, \eta^2 = .01 \). Therefore, retrieval-induced forgetting was observed for all the age groups demonstrating the general nature of inhibition in retrieval-induced forgetting.

However, it could be argued that the detrimental effect of retrieval practice on the Rp—sentences was not due to the inhibition of the Rp—memory representations, but to output interference. If stronger Rp+ items were recalled first, they could interfere and block the recall of the Rp—items, and therefore, the obtained effect would be only due to this interfering effect during the final recall task and not to the inhibition of the Rp—items during the retrieval-practice phase. In order to make sure that the RIF effect was due to inhibition and not to output interference additional analyses were carried out. First, we calculated the probability that the Rp—items were recalled before or after the Rp+ items. The results of this calculation indicated that the probability of recalling the Rp—items after the Rp+ items (.35, .30, .35 for the 8, 11 and adult groups, respectively) was equal to the probability of recalling them before the Rp+ items (.30, .34, .32 for each of the age groups). In addition, we selected those participants that recalled more than one Rp—item, and introduced output order (Rp—before or after the Rp+) in the analyses. Although the results of this analysis have to be taken with caution because of the low number of observations, they indicated that the magnitude of the RIF effect did not vary as a function of the order of recall (\( p > .05 \)) and the interaction of age, output order and practice status was non-significant (\( p > .05 \)). Hence, output interference does not seem to be the factor underlying the low level of recall of the Rp—items.

### 3.4. Discussion

The results of this experiment indicated that retrieval practice facilitated the recall of the practice sentences for all age groups, although this effect was especially large for the youngest children and decreased as age increased. The larger effect for younger children is probably related to their overall poorer recall, and their greater difficulties in encoding the sentences in the first place. More importantly for our objectives are the results related to the retrieval-induced forgetting effect. First, they replicate previous results by showing retrieval-induced forgetting with propositional materials (Anderson & Bell, 2001; Gómez-Ariza et al., in press; Macrae & MacLeod, 1999). Thus, the sentences which were not practised but which were associated with practised characters (Rp—) were recalled significantly less than those which were not practised and were linked to non-practised characters (Nrp). Thus, recalling some of the actions associated with one character led to a decrease in the recall of the other propositions related to that character relative to the un-practised control condition. This detrimental effect on the Rp—items seems not to be due to output interference since the probability of recalling the Rp+ items before the Rp—items was equal to the probability of recalling them after the Rp—items.

Second, the results of this experiment clearly confirm the general nature of retrieval-induced forgetting in children of different ages. In fact, children and adults had effects of similar magnitude. The only difference between the age groups was their overall recall levels. As is usually found in developmental studies, the adults had higher levels of recall than the children. However, the difference in recall between the propositions in the Rp—condition and those in the Nrp condition (the measurement of retrieval-induced forgetting) was similar in children and adults.
These results are similar to those found by Ford et al. (2004) and Zellner and Bäuml (2005), who did not observe developmental differences in memory inhibition. However, while they used picture exemplars and word exemplars, we used sentences as the experimental materials. Therefore, our results extend their findings to a new type of materials, supporting the generality of their conclusion: the inhibitory mechanism underlying retrieval-induced forgetting does not change between the ages of 7–8 years and early adulthood. If, as various studies suggest, the factor responsible for the effect of retrieval-induced forgetting is inhibition of competing memories, then children in their 3rd year of primary education are as effective as children in their 2nd year of secondary education and as adults in terms of their ability to avoid the interference produced by competing memories.

4. General discussion

In this study, we aimed to explore the hypothesis that part of the cognitive deficits that are associated to age (children and elderly individuals) are related to less efficient inhibitory processes. According to this hypothesis young children and elderly people are less effective both at suppressing memory contents which have become irrelevant and at inhibiting retrieval of irrelevant information (e.g., Bjorklund & Harsnishfeger, 1990; Harnishfeger & Bjorklund, 1993; Hasher et al., 1991; Hasher & Zacks, 1988; Hasher et al., 1999). In this context, we were interested in assessing whether this deficit was limited to situations which required voluntary suppression of irrelevant contents in working memory, or whether the deficit also affected less-intentional inhibitory processes involved in retrieving long-term memory traces. With this purpose, we asked children and adults to perform two types of memory tasks: a WM updating task which required intentional inhibition of irrelevant information, and a retrieval-induced forgetting task which involved unintentional inhibitory mechanism.

The results of the updating task indicated that there is an improvement in the effectiveness of inhibitory processes as age increases. That is, young children were less effective at suppressing irrelevant information than older children, who in turn were less effective than adults. These results are in agreement with those of other studies which have used the updating task to detect individual differences. Differences both in recall and in intrusions have been found between young and elderly people (De Beni & Palladino, 2004), between individuals with high and low levels of text comprehension (Palladino et al., 2001) or between people with high and low working memory capacity (Soriano, Macizo, & Bajo, 2004). Therefore, the results of the updating task provide evidence of the existence of developmental changes during childhood in the ability to inhibit information in WM. These results also indicated that there is certain independence between maintenance and inhibition. The difficulty encountered by younger children in suppressing irrelevant information was related to the quantity of information that had to be suppressed, but not to the amount of information to be recalled (memory load).

In contrast, results of Experiment 2 showed no developmental differences in retrieval-induced forgetting, since these effects were of similar magnitude for all the age groups. Our results indicate that the factor responsible for inhibition during retrieval operates as effectively in 8-year-old children as in 20-year-old young adults, which suggests that between these ages there is no development of the processes which forestall competition during retrieval. The absence of developmental differences in Experiment 2 replicates results obtained in other studies which also did not find differences between children and adults in
inhibition tasks (Ford et al., 2004; Pritchard & Neumann, 2004; Zellner & Bäuml, 2005). In addition, Moulin et al. (2002) found that elderly people (with and without Alzheimer’s disease) showed similar retrieval-induced forgetting effects. According to these authors, this pattern suggests that the inhibitory dysfunctions found in other studies with Alzheimer patients are due to a different mechanism from that which underlies retrieval-induced forgetting. Given the systematic absence of interaction with age in this task, it could be concluded that the (inhibitory) mechanism responsible for the effect seems to be intact in the developmental periods which are considered the most critical in terms of cognitive effectiveness: childhood and old-age (Demster, 1992, 1993; Harsnishfeger, 1995; McDowd et al., 1995).

The differential pattern of results obtained in the two experiments supports the position that inhibition is not a unitary mechanism. However, it might be argued that the paradigms used in both experiments differ in many other factors that could be responsible for the observed differences. Thus, Experiment 1 tapped inhibition in a WM setting and involved single words, while Experiment 2 clearly required retrieval from long-term memory and involved sentences. Although we recognise that this may limit our conclusions, the results of other experiments involving different procedures (directed forgetting, negative priming, etc.) and manipulations (e.g. memory load) seem to suggest similar conclusions. While directed forgetting (intentional inhibition) is diminished or abolished by introducing a working memory load (Conway et al., 2000; Racsmany, Conway, & Tisljar, 2005), inhibition in the retrieval-practice paradigm (unintentional inhibition) remains unaffected (Racsmany et al., 2005; Soriano, Román, & Bajo, in preparation), indicating that inhibition paradigms that differ in the degree of intention are also differentially affected by variables related to memory control.

Although initially the general nature and unity of inhibitory mechanisms was advocated, current theorising seems to favour the differentiation of distinct types of inhibition. For example, Harsnishfeger (1995) considers that two types of inhibitory processes should be distinguished. First, there is a type of inhibition which is intentional and useful for freeing space in working memory. Examples of tasks which could involve this type of suppression mechanism are directed forgetting and updating of WM. In contrast, Harsnishfeger (1995) considers that there is another type of inhibition (or suppression) mechanisms which functions automatically and with no control or awareness on the part of the individual. This unintentional inhibition occurs when irrelevant information is activated together with relevant information, but is then suppressed in favour of the relevant information. The paradigms of resolution of lexical ambiguity (e.g., Swinney & Prather, 1989), Stroop (e.g., Tipper, 1985) or retrieval practice (e.g., Anderson et al., 1994) could be examples in which this type of suppression mechanism is involved.

Similarly, Nigg (2000), after an extensive review of the literature, proposed a taxonomy which seeks to include very different phenomena which are supposedly of an inhibitory nature. This many-sided conception includes three interrelated categories: automatic inhibition of attention, executive inhibition and motivational inhibition; these categories are in turn divided into subcategories. The inhibitory processes dealt within our experiments fit into the category of executive inhibition that, according to Nigg’s proposal, it is responsible for protecting WM from irrelevant contents, and also for preventing interference. Within this category Nigg distinguishes between intentional and unintentional inhibitions. These two types of inhibitions could be affected by different factors, depending on different neuronal systems and, as our experiments suggest, follow different developmental patterns.
According to this proposal, the developmental pattern observed in many school related activities such as reading comprehension or mathematical tasks could be related to the development of this type of intentional inhibition. The role of unintentional inhibition in the development of cognitive efficiency is less clear. Our results, as well as those from other studies (Ford et al., 2004; Pritchard & Neumann, 2004) suggest that this type of inhibition remains constant across the life span of the individual.

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References


