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Evaluating the Subject-Performed Task effect in healthy older adults: Relationship with neuropsychological tests

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ABSTRACT

Background: An enhancement in recall of simple instructions is found when actions are performed in comparison to when they are verbally presented – the Subject-Performed Task (SPT) effect. This enhancement has also been found with older adults (Bäckman & Nilsson, 1984). However, the reason why older adults, known to present a deficit in episodic memory, have a better performance for this type of information remains unclear. In this article we aim to contribute to explain this by comparing the performance in SPT with the performance in other cognitive tasks, in order to understand the underlying mechanisms that may explain this effect.

Objective: We analyzed the performance of older adults in terms of episodic memory measures of the SPT effect. We hypothesized that both young and older adults groups should show a higher recall in SPT compared with the verbal learning condition, and that the differences between age groups decrease significantly in the SPT condition. We also aimed to explore the correlations between these tasks and known neuropsychological tests and we measured source memory for the encoding condition.

Design: A mixed design was created to test the SPT paradigm with thirty healthy older adults, comparing their performance with thirty healthy younger adults. Each participant was asked to perform sixteen simple instructions (SPT condition) and to only read other sixteen instructions (Verbal condition – VT). The test phase included a free recall task. Participants were also tested with a set of neuropsychological measures (speed of processing, working memory and verbal episodic memory).

Results: The SPT effect was found for both age groups; but even for SPT materials, group differences in recall persisted. Source memory was found to be preserved for the two groups. Simple correlations suggested differences in correlates of SPT performance between the two groups. However, when controlling for age, the SPT and VT tasks correlate with each other, and a measure of episodic memory correlated with both SPT and VT performance.

Conclusion: A strong effect of SPT was observed but one which still displayed the expected aging deficit. The correlations and source memory data suggest that the SPT and VT possibly share the same underlying episodic processes, thus SPT contributing only for an enhancement of the episodic memory trace, by the multimodality it provides.

Keywords: aging, subject performed task, memory for actions, episodic memory.

INTRODUCTION

In the early 1980s, Engelkamp and Krumnacker (1980) and Cohen (1981) introduced a new paradigm in the study of memory, the SPT paradigm (subject-performed task). From this paradigm they proposed fundamental differences between episodic memory for verbal information and episodic memories concerning the prior execution of actions, in terms of the quality of the individuals' performance when confronted with these tasks, and also in terms of the mechanisms underlying this kind of information processing (Zimmer & Cohen, 2001). Many studies subsequently have replicated the basic effect that memory is enhanced when the subject enacts to-be-remembered materials. Various proposals have been made as to why there is a difference between verbal information and the execution of actions. Some researchers stress the role of the motor and multimodal information that strengthens the memory trace and explains the better performance in SPT (Engelkamp et al., 1980, 1983, 1985), whereas other researchers highlight the processing of actions as being a more automatic process (non-intentional), which is thus easier to retain and to recall than verbal information (Cohen, 1983).

The focus of this article is healthy aging, where there is a well-documented deficit in episodic memory, such that older adults show reduced recall and particular difficulty in tasks that require intentional effort (Naveh-Banjamin, 2000; Earles, 2002). Perhaps the clearest manifestation of this deficit is the "associative-deficit hypothesis" of cognitive aging. This paradigm suggests that older adults have difficulty in integrating the multiple, related and unrelated features of an episode (Naveh-Benjamin, 2000; Naveh-Benjamin, Hussain, Guez, & Bar-On, 2003). Many researchers, employing a variety of different stimulus–stimulus pairings, have shown that older adults demonstrate relatively intact recognition for individual items while presenting impaired recognition of the association between them (Castel & Craik, 2003; Naveh- Benjamin, 2000; Naveh-Benjamin, Kilb, & Reedy, 2004; Naveh-Benjamin et al., 2003).

In this article, we aim to analyze the presence of the SPT effect, already evident in younger adults, in healthy aging, as it was concluded primarily by Backman and Nilsson

(1984;1985). The novelty of this article is to use correlational measures to examine the basis of this probable effect in older adults. A clarification about the older adults' ability to recall actions has a heuristic and practical value that is unquestionable. On one hand, it is important to understand to what extent the knowledge drawn from investigations of age-related differences in memory performance, based on verbal and visual tasks, is generalized to tasks related to memory for actions (Norris & West, 1993). On the other hand, if we have a strong SPT effect in healthy aging, the knowledge we have in terms of the neuropsychological characteristics of this population (working memory deficits, verbal episodic memory relatively impaired, procedural memory preserved, etc.) may help us to understand better the nature of the effect.

A critical issue in the SPT effect is automaticity. Cohen (1983) suggested that the processing involved in SPT is automatic, therefore, not requiring effort or strategy. They observed other concomitant peculiarities of SPT effect, such as the absence of a primacy effect in the serial position curve (a point also noted by Helstrup (1986)), the lack of effect of the elaboration of the items (e.g., no differences in the recall of sentences with more than one object, or with more than one action included) and the presence of a similar effect regardless of the list size (data confirmed later by Nilsson and Cohen (1988)). These phenomena are clearly different from those observed in tasks of verbal learning and led to the conclusion that processing in tasks of memory for actions is governed by memory processes different from those in verbal and visual episodic memory. Cohen developed this idea to suggest that this non-strategic process underlying the SPT effect would diminish the executive load related to the task, thus being easier for people with some executive impairment, such as older adults. However, this researcher (see Engelkamp & Cohen, 1991) also agreed that this nonstrategic theory is an argument that has already been questioned by other researchers, for example, Kausler (1989) that showed that the more cognitive demanding the task was, the more age differences were found in the SPT tasks, which accounts against the theory of automaticity.

Defending another perspective, Engelkamp and colleagues (1980, 1983, 1985) have focused on the exploitation of the role of the motor component in performance, indicating that the motor execution of the verbal instructions is responsible for the SPT effect. In support of this theory, Engelkamp and Zimmer (1989) observed the performance of participants in the SPT condition, an imagination condition and also an EPT condition (the participant observed the experimenter performing the action). The result was found that both the imagination and the EPT conditions exhibited significantly lower scores than the SPT condition, which led them to conclude that something more than the mental image or the observation of the actions is involved in the effect (Engelkamp, 1995). These researchers propose that the motor activation code (produced by enactment) optimizes the item specific information integrating the object with a specific action (Engelkamp & Zimmer, 1989). Further, Bäckman and Nilsson (1984, 1985) proposed that enactment during encoding produced a richer multimodal storage, which joined the characteristics of objects or events (color, texture, shape, size, etc.). Thus the semantic, perceptual and motor information encoded which is not present in the verbal (control) condition, would explain the significant and robust superiority of the SPT (Steffens, 2007). However, has happened for the nonstrategic theory, the multimodality argument was also questioned by the conclusion of Nyberg, Nilsson and Bäckman (1992) that the objects and its sensory richness present in the SPT and absent in the VT were not critical for the SPT effect, but the enactment of the action alone, is efficient to provide good item-specific information with or without the presence of the object (Engelkamp & Cohen, 1991). An approach that help us to understand the effect of enacting in memory is the research conducted into gestures (for a review, see Madan & Signhal, 2012a), where is was found extensively that the mere gesturing enhanced learning and memory in several populations, evidencing again that the presence of the object is not necessary to produce the SPT effect. The same authors (Madan & Signhal, 2012b) added to these considerations that even the motoric properties of the words to be recalled – their movement-related properties – affects memory recall, such that the more manipulable an object or the more movement imagery produced by the words to be recalled, more easy is to the person to recall that information. So the “movement component” of the information is apparently critical to explain the enhancement of memory performance, in agreement with what Engelkamp and colleagues first hypothesized.

A number of studies have also shown an intact SPT effect in healthy older adults, as we will describe bellow, suggesting that performing an action (or the use of an object) can effectively boost memory, and therefore, that some binding of an item and an action occurs in memory when an action is executed (Bäckman and Nilsson, 1984; 1985) even for population with binding deficits.

Bäckman and Nilsson (1984) were the first to use the SPT paradigm with older adults. Eight lists of twelve simple instructions each were presented to a sample of 36 young adults and 36 older adults, with half of the lists presented in the SPT condition (the participants performed the simple instructions) and the remaining lists presented in the control condition in which participants only had to read the instructions. For both age groups, superior free recall was found in the SPT condition than in the control condition. Furthermore, it was found that the difference between groups, although not eliminated, decreased significantly in the SPT condition. These results led to the idea that older adults benefit particularly from this type of tasks (Rönnlund, Nyberg, Bäckman, & Nilsson, 2003). Rönnlund et al. proposed that the presence of multimodal cues eliminates older adults' difficulties in auto-initiated processes of remembering (see also Steffens, 2007).

Brooks and Gardiner (1994) repeated Bäckman and Nilsson's (1984) study but included two lists of sixteen sentences each, and in each list, half of the sentences concerned to familiar activities and the other half included less common actions. The results confirmed the findings by Bäckman and Nilsson (1984), in that there was a significant decrease in the difference between young and old adults (almost to the residual level) in the SPT condition, regardless of the familiarity of the actions (Nilsson, 2005). Nyberg, Nilsson and Bäckman (1992) attempted to examine to what extent this effect of superior performance under the SPT condition is increased in older adults, if, in the recall phase, the participants were prompted to perform, again, the actions they could remember. However, they found that this method did not significantly improve the performance of both groups in SPT condition.

Norris and West (1993) analyzed the SPT condition in a sample of 80 young adults and 80 older adults, where two lists were presented, each with 16 statements. In one of the lists, items could be organized into semantic categories, while in the other there was no semantic grouping of items. It was found that differences between groups were maintained for verbal and SPT conditions, despite there being superior performance in the SPT condition for both groups. Additionally, it was observed that the group of older adults benefited more from the organized list than the group of the young, even in the SPT condition. This finding led to the reflection that the characteristics of the list as well as its organization may influence the existence of differences between the groups, consequently meaning that there is no pure SPT processing, e.g., there is no independent cognitive processes involved in coding actions (Norris & West, 1993). Additionally, Earles, Kersten, Mas and Miccio (2004) also concluded that when there is a time limit to perform the SPT task, older adults performance is diminished suggesting that in these cases the presence of the object and consequently the overload of the visual system affects their performance.

Earles (1996) studied the SPT effect on a sample of 101 young adults and 101 older adults, analyzing the memory for brief sentences enacted (four lists of twelve subject - performed tasks) and for non-enacted items (four lists with twelve specific names). In this within-subjects design, the SPT effect was observed for both groups in memory of enacted sentences, although the recall for the group of young adults was significantly higher than for the group of older adults. Also McDonald - Miszczak, Hubley and Hultsch (1996) concluded that, although the enactment of information improves recall, regardless of age, this benefit is not enough to reduce the differences between the groups. The theoretical issue of whether the age difference is reduced or removed in older adults pertains to the basis of the effect. If older adults show a deficit on one task, but not on the other, the neuropsychological rationale might be that the two processes are independent.

Rönnlund and collaborators (2003) analyzed the memory performance in an action memory task, using a sample of 1000 subjects aged between 35 and 80 years of age, divided in ten-year age groups. The participants had to study two lists of 16 simple instructions. The results of free recall showed a main effect of age and condition. Additionally, there was a decrease in differences between the age groups in the SPT condition, although a more thorough analysis, suggested that there was a possible floor effect in verbal learning for older age groups, which may explain this pattern of results.

Mangels and Heinberg (2006) studied the SPT paradigm in older adults from the point of view of its potential as a promoter of a broader episodic integration. For this purpose, they observed the performance of 30 young adults and 30 older adults in a memory for actions task which included four lists with 20 instructions each. Two types of lists were created, lists with action - object pairs semantically related (e.g., *put the phone to the ear*) and lists with unrelated object - action pairs (e.g., *Shake the phone*). The aim of manipulating the semantic association intra - items was examining whether the associative potential underlying the SPT effect would be independent of the semantic information of items. The results from this within subject design showed the superiority of SPT encoding compared to verbal encoding, for both groups, verifying, however, a superior performance for the group of young adults in comparison with older adults. In the SPT task there were no differences in performance for the lists in any of the groups, which indicates that this type of effect overcomes any semantic contribution. Taken together, these results led the researchers to conclude that the execution of sentences provides a benefit in memory of associations, even for a group (the older adults) that usually have difficulties in associating information, even if this effect cannot completely eliminate the performance differences between this group and young adults (Mangels & Heinberg, 2006).

In sum, there is overwhelming evidence that older adults show, at the least, a SPT effect which is parallel to that seen in younger adults (for a review see Feyereisen, 2009). Furthermore, studies with clinical populations have been conducted, showing that this benefit even extends to people with degenerative diseases such as Mild Cognitive Impairment (Karantzoulis, Rich, & Mangels, 2006) or Alzheimer's disease (Dick, Kean, & Sands, 1989; Farfield & Mammarella, 2009; Lekeu, Van der Linden, Moonen, & Salmon, 2002; Mack, Eberle, Frolich, & Knopf, 2005), transient global amnesia (Hainselin, et al., 2014) and other neurological conditions (Knopf, Mack, Lenel, & Ferrante, 2005) (for a review see Hainselin, Quinette & Eustache, 2013). However, there is fewer consensuses about the locus of this effect and the results of studies into older adults are marked by strong differences in the magnitude of the SPT effect. Almost all of the studies presented with non-convergent results about the nature of the SPT effect in aging follow different methodologies, both with regard to the lists characteristics and the experimental design used (Lekeuet al., 2002). The issue of whether the effect reduces or removes the episodic deficit (and therefore whether it might be linked to the same system or derive from a different process in episodic memory) is in question. Thus far, there has been less emphasis on whether older adults know the basis of their improved memory (can they accurately report the source of the to-be-studied as enacted or not) and whether SPT and other forms of episodic memory are related.

The present study had the aim of looking at performance on other memory and cognition tasks to examine correlates of the effect, with a view to making a small but specific contribution to the aging literature. We can possibly begin to disentangle explanations about the underlying cognitive processes involved in memory for actions by seeing if related tasks converge on the same processes. For instance, is intact executive function required to show the SPT effect? Is it those people with better episodic or working memory measures who show more of a benefit in SPT processing? Previous studies have focused on the SPT task compared to a Verbal task, but no information is described about the performance of the individuals in other cognitive domains that could allow us to make some associations of the SPT processing and other cognitive processes. Let us imagine that there is a correlation between SPT performance and a different, standardized episodic memory test, for instance. This would suggest that the effect was in some way driven by, or at least reliant upon a level of episodic memory function. If the effect is automatic, on the other hand, or perhaps driven by motoric processes not captured in measures which classically correlate with episodic memory in aging, it might suggest that the SPT effect bypasses those processes implicated in the episodic memory deficit in older adults: executive function, speed of processing, working memory (for review see Balota, Dolan, & Duchek, 2000). Moreover, measurement of sub components of memory, such as source memory also may help us elucidate the basis of the SPT effect. Source memory is typically impaired in older adults (Glisky, Rubin, & Davidson, 2001) which is typically seen as an extension of the failure to make associations at encoding which are later useful in retrieval, since the older adult just remembers that they have seen the item and not in what context. If SPT instructions enhance the retrieval of source, and indeed if older adults can reliably report how they encountered materials in SPT and verbal conditions, it will point to the fact that the SPT instructions enhance and compliment this facet of episodic memory (memory for source) rather than by-pass it.

Thus, the present study used the SPT paradigm with older adults, and a number of other measures in an exploratory fashion. If the explanations stressed by Cohen and Engelkamp about the possible underlying mechanism of processing actions are true, older adults should show a strong SPT effect, because the processing is effortless (Cohen, 1983) and because the multimodal information provided with enactment (Bäckman & Nilsson, 1985; Engelkamp et al., 1988) strengthens the memory trace. We will compare older adults' performance in SPT with their performance in tasks where they normally show some impairment: working memory, speed processing, source memory, and verbal and visual episodic memory. This will help us to understand if the SPT effect is independent of cognitive domains that are more exposed to disruption through life span, thus being a useful paradigm to introduce in cognitive stimulation of this group.

METHOD

Subjects

Participants were recruited in the community, home care centers and senior universities. A total of 60 people participated: 30 young adults (age range: 35 to 45 years; *M* = 41.43, *SD* = 2.73) and 30 older adults (age range: 70 to 75 years; *M* = 72.30, SD = 1.62), all of whom had normal or corrected vision and hearing, and not exhibiting significant depressive symptoms. The older participants also did not show cognitive decline, according to the Addenbrooke's Cognitive Examination-Revised instrument, a 15-minutes screening test with a range of tasks to detect cognitive deficits (that includes as domains of assessment the following: Orientation and Attention, Memory, Verbal Fluency, Language and Visuo-Constructive Capacity; and that that incorporates the known screening test Mini-Mental State Examination)(MMSE: *M* = 28.53, *SD* = .97; ACE-R: *M* = 84.87, *SD* = 5.67). The groups did not differ in terms of gender, education, premorbid IQ and dwelling area (Table 1). All participants provided informed consent, and all study procedures were approved by the research ethics board of the faculty.

(Table 1 – insert here)

Materials

Memory for Actions Test

A **Memory for Actions Task** was created for this study based on the SPT paradigm (Cohen, 1981; 1983; Engelkamp & Krumnaker, 1981). This task comprised 34 sentences (32 plus 2 for training trials) related to simple and familiar actions (e.g., “throw the dice”), with each sentence written in black on a white card; and 34 familiar objects (32 plus 2 for training trials). Two lists with 16 sentences each (plus 1 for training) were created. While showing each pair (sentence and object) to the participant, the experimenter read the sentence out loud. For one of the lists the participants only read the sentences (VT-verbal condition) after hearing the experimenter, and for the other list the participants were asked to perform the action depicted in the presented sentence (SPT condition). Each pair was shown for 12 seconds after which the object and sentence were hidden from the participant’s view. Participants were told that later in the session they would be asked to recall the sentences. After a brief distractor task (counting backwards for 40 seconds), the participants recalled the sentences presented under both encoding conditions, for 5 minutes.

To assess source memory, a task usually described to show a poor performance by older adults (Glisky et al., 2001), all sentences were randomized and read by the experimenter and the participant had to answer verbally if each sentence had been enacted or not. Proficient source memory is shown by being able to correctly report which condition the sentence had been encountered in.

This experiment followed a within-participants design. The sentence coding was in two blocks of 16 sentences each, according to the sequence VT-SPT or SPT-VT. The order of each sequence was counterbalanced (half participants did the VT-SPT sequence and the other half did the SPT-VT sequence) and each sentence was coded the same number of times in both conditions.

Complementary neuropsychological measures

We aimed to contribute some explanations about the underlying cognitive processes involved in the SPT effect. For this reason we constructed a set of neuropsychological tests, which was administered to all participants, including measures of speed processing, attention, working memory and verbal episodic memory. The assessment included measures that are known to show a relative decline in cognitive aging as we intended to understand the singularity of the SPT effect in aging compared to these cognitive domains. A short description of the tests and the cognitive domains assessed by each test is described below:

- *Symbol Search* (Wechsler Adult Intelligence Scale-III; WAIS-III; Wechsler, 1997, 2008) is a task that analyses the speed processing and also the attention capacity (both sustained and selective).
- *Digit Symbol-Coding* (WAIS-III; Wechsler, 1997, 2008) is a task that tests speed processing and incidental memory.
- *Portuguese version of WMS Verbal Paired Associates subtest* (Wechsler Memory Scale – III, 2008), with additional specificities, testing episodic memory of items, 5 semantically related – like “Boat-River” – and 5 not related semantically – like “Offer-Speed”. Data from immediate recall and long delay recall can be obtained from this test.
- *Visual Patterns Test* (Della Sala, Gray, Baddeley, & Wilson, 1997) is a task that examines visual working memory performance and visual short term memory. As extended literature suggests this task is predicted by visuo-espacial executive function capacity (Barroulillet & Camos, 2010; Brown, Brockmole, Gow, & Deary, 2012; Fournier-Vicente, Larigauderie, & Gaonac’h, 2008; Miyake, Friedman, Rettinger, Shah, & Hegarty, 2001), for the purpose of interpreting the results we considered this task a measure of executive functioning.
- *Letter-Number Sequencing* (WMS-III; Wechsler, 1997, 2008) is a test used to assess verbal working memory performance, sequential processing and memory

span. Because this task involves complex item manipulation, is also interpreted in this study, in agreement with literature, as a measure of executive function (Emery, Myerson & Hale, 2007; Salthouse, 2005). Based in the multi-componets model of Badelley & Hitch (1974) and Badelley (2000), working memory includes a central component described as “central executive” which justifies also why we consider these measures as testing executive function.

RESULTS

The results section is organized as follows: firstly, we will present data from the SPT Task, both the total recall and the source memory measures; secondly, we will present data from the complementary neuropsychological measures for both groups; and finally, we will present the correlations for the two age groups between the Memory for Actions task conditions and the neuropsychological measures.

Memory for actions task

Total recall

The correct recall of the complete sentences (correct action-object pair) was analyzed in both age groups, in the VT and the SPT conditions.. As it was a within-subjects design, a mixed ANOVA with repeated measures in the condition of processing (VT and SPT) was performed to analyze the differences between the two age groups. From this analysis, the expected main effects of group [$F(1, 58) = 41.24$, $p < .001$, $\eta^2_p = .416$] and condition were found [$F(1, 58) = 470.39$, $p < .001$, $\eta^2_p = .890$]. Moreover, with these participants and with this design an interaction effect between the group and the processing condition was found [$F(1, 58) = 9.61$, $p = .003$, $\eta^2_p = .142$], where the differences in total recall between groups diminished in the SPT condition (in this condition the performance of both groups was higher, e.g., young adults *M* = .57, *SD* = .13; older adults *M* = .47, *SD* = .08, than in the verbal condition, e.g., young adults *M* = .35, *SD* = .09; older adults *M* = .17, *SD* = .08). However, when going further into this analysis, a paired samples t-test for each group between the SPT and VT found significant differences (Younger Adults: *t*(1,

29) = -11.80, $p < .001$; $d = 2.17$; Older Adults: $t(1, 29) = -20.11$, $p < .001$; $d = 3.67$). Likewise, we found significant differences when we analyze the group differences in SPT and VT separately, in a independent sample t-test (SPT: $t(1, 58) = 3.81$, $p < .001$; $d = 3.79$; VT: $t(1, 58) = 8.02$, $p < .001$; $d = 8.08$), thus suggesting that although the SPT increases memory performance in the older adults, significant differences remain between the young and old, which is patent by the large effect size of these analysis.

Source memory test

All 32 sentences were re-presented to the participants, and they reported in which condition they had encoded the materials. A one-way ANOVA showed no differences between groups in source recognition: $F(1, 58) = 1.98$, $p = .164$. Interestingly, both the younger adults group ($M = 30.90$; $SD = .92$) and the older adults group ($M = 30.50$; $SD = 1.25$) correctly recognized the source for almost all the sentences (Max = 32). However, because of the evident ceiling effect with this task, we must be cautious regarding the apparent lack of differences between groups in source memory for the Memory for Actions Test.

When looking at the errors (very few as we can see by the recognition scores) committed by participants, we separated the errors committed for sentences coded in the SPT condition and in the VT condition, and we performed a repeated measures ANOVA for these errors within conditions and between age groups. In sum, an interaction effect was found between group and the type of errors [$F(1, 58) = 9.079$, $p = .004$], suggesting that the groups differ less in errors for sentences coded under enactment (Younger Adults $M = .33$, $SD = .547$; Older Adults $M = .17$; $SD = .461$) than for sentences coded under the verbal condition (Younger Adults M = .77, SD = .728; Older Adults M = 1.33 ; SD = .17), although the effect size for this interaction is considered weak ($\eta^2 = .135$).

Complementary cognitive measures

Table 3 shows the expected pattern of deficits in older adults on our cognitive task measures, with only the difference in digit symbol coding (incidental learning) showing a non-significant difference between groups. Thus far we can therefore characterize our older adult group as a group who show broad deficits in long term memory and executive function, and who equally have a deficit in the verbal and SPT components of our experimental measures. Nonetheless our older adult group has shown a strong SPT effect, and therefore we have replicated the known patterns of data in this domain. Of interest, when asking older adults about their memory function, they show a near-perfect source memory for their actions. In this dichotomised decision, older adults, as their young counterparts, can reliably report how they encountered materials in a later recognition task, even if they have not been able to previously recall the sentence including the object and action. The final section of this methods section considers a set of individual differences analyses to explore correlates of SPT performance.

(Table 2 - insert here)

Relation of the performance in the Memory for Actions Task and the neuropsychological measures

First we present the simple correlations between the two conditions of the Memory for Action task (VT and SPT conditions) and the neurocognitive measures for each group separately (see Table 3). To control for the number of correlations conducted we performed the Benjamin and Hochberg False Discovery Tate correction (1995) as a multiple comparison procedure to correct the significance scores. In the young group, for the VT condition, we find positive and strong associations with the immediate task of the WMS Paired Associates test [$r_s(30) = .735$, $p = .01$], and also with the Letter-Number Sequencing [$r_s(30) = .780$, $p = .01$]. Additionally we found a positive, moderate association between the VT condition and the Symbol Search test [$r(28) = .469$, $p = .04$]. For the SPT condition in the young group, a different pattern of associations was observed; positive, but weak to moderate associations with most of the tests, *except* the episodic memory test: Letter-Number Sequencing [$r(28) = 0.416$, $p = .08$]; Visual Patterns Test [$r(28) = 0.473$, $p = .04$]; Digit Symbol Coding [$r(28) = 0.376$, p= ..11]; Symbol Search [$r(28) = 0.571$, p= .02]. Analyzing the correlation matrix for the older adults group, we firstly see fewer significant correlations. In the VT condition, we identified positive and weak to moderate associations (some not significant) with the

WMS Paired Associates test immediate [$r_s(30) = .446$, $p = .05$], and delayed [$r_s(30) = .407$, p = ..13], with the Letter-Number Sequencing [$r_s(30) = .410$, p = ..13], and with the Digit Symbol Coding [$r_s(30) = .486$, $p = .04$]. In the SPT condition, we found no statistically significant associations with any of the neurocognitive tests used.

(Table 3 – Insert here)

If there is some pattern in these correlations, it is that the verbal condition of our experimental task seems to show a moderate to strong association with our test of episodic memory, the Paired Associates Test. This pattern is more clear in the immediate test in the younger and older adults. On the other hand, the paired associates' measure does not correlate significantly with the SPT task in either group..

To elucidate further the role of our other cognitive measures on the SPT we considered an analysis combining the groups but controlling for age with partial correlations. Like this, we aimed to examine if there were any common factors which influenced the SPT. That is, we had group differences in SPT and most of our neuropsychological measures, so it is difficult to know what neuropsychological measures influence directly the SPT and which may just be part of a common aging deficit. In particular we were interested in further examining the above trend that whereas tests of episodic memory (and a few others beside) are associated performance in the verbal condition, there is a different set of correlations for the SPT task - in particular a lack of the relationship with the paired associates task.

(Table 4 – insert here)

In these partial correlations controlling for age (see Table 4) we observed moderate relations between our neuropsychological measures and experimental tasks, with all but one of our measures (visual pattern test) correlating with both SPT and VT measures.

Thus, once having controlled for age, there appears to be no difference in neuropsychological correlates (at least the broad spread that we have chosen) for SPT and VT. Perhaps this pattern is best summarized with the fact that SPT and VT tasks themselves correlate very strongly when controlling for age: those people who do well on one test, do well on the other, (r=.57, *p* = .01). As this pattern in partial correlations was not enough clear to understand the relationship between SPT and the other measures, we decided to analyze the groups as a hole, not controlling for age and our results were that all complementary neuropsychological measures correlated with both the VT and the SPT, and a stronger correlation between the VT and the SPT (r = .67, p = .01). The episodic memory test (WMS Verbal Paired Associates) correlated more strongly with the VT (Immediate r = .70, p = .01; Delayed r =.75, p = .01) that with the SPT (Immediate r = .51, p =.01; Delayed r =.45, p = .01) but all correlations where significant, thus we can therefore conclude that the SPT task has a relationship with the general episodic memory system, despite it is not entirely driven by it. The two tasks used to measure executive function also correlated positively and strongly for both the VT (Visual Patterns Test r = .62, p = .01; Letters-Numbers Sequencing r =.81, p = .01) and the SPT (Visual Patterns Test r = .56, p = .01; Letters-Numbers Sequencing r = .55, p = .01), with a similar pattern of correlations strength as for the episodic memory measures, indicating again the existence of a role of executive functioning in the SPT, despite that not completely explaining the effect. Finally, for the attention and speed processing measures, we find the same results, with similar correlations for both VT and SPT with these measures, but stronger for the VT task (Digit-Symbol Coding r = .74, p = .01; Symbol Search r = .61; p = .01) that for the SPT ((Digit-Symbol Coding r = .56, p = .01; Symbol Search r = .46; p = .01).

Our final analysis considered using a regression to predict the SPT and VT scores. When carrying out the regressions without splitting the age groups, both VT recall and SPT recall are significantly predicted by the combined model of all the other tests together , [VT, R^2 = .76, *adjusted* R^2 = .73, F(6, 53) = 27.99, p < .001; SPT, = .46, *adjusted* R^2 = .40, F(6, 53) = 7.61, p < .001 (but alone, no one test explained a significant proportion of the variance of the results in both conditions). However, when separating the analysis by age groups, one interesting finding raised, because VT recall and SPT recall are predicted by the combined model of complementary neuropsychological measures only for the younger adults [VT, R^2 = .73, *adjusted* R^2 = .67, $F(6, 23) = 10.70$, $p < .001$; SPT, R^2 = .65, *adjusted* R^2 = .55, $F(6, 23) = 6.96$, $p < .001$], whereas for the older adults, both VT results and SPT results are not predicted by the model of complementary tests, neither by any of these tests alone [VT, R^2 = .28, *adjusted* R^2 = .09, $F(6, 23) = 1.50$, $p = .223$; SPT, R^2 = .30, *adjusted* R^2 = .12, $F(6, 53) = 1.68$, $p = .172$]. Perhaps the significant differences in most cognitive measures used in this study between older and younger adults justify this pattern, which we will analyze in more detail later in the discussion section.

DISCUSSION

This study builds on a succession of studies examining the SPT in older adults. Like those before us, we found two clear effects: a deficit in memory in older adults, but a significant SPT effect. If anything, our older adults showed more of an SPT effect than the younger adults, as shown by a significant interaction, but nonetheless, follow up t-tests showed that significant age differences remained in SPT performance. A similar pattern was obtained by Bäckman and Nilsson (1984), Brooks and Gardiner (1994), and West & Norris (1993), Earles (1996) and Mangels and Heinberg (2006), who used a sample and methods with similar characteristics to the present study.

Based on original studies of SPT paradigm with older people, we were interested in the possibility that differences between the two age groups were not eliminated in the SPT condition. Additionally, the fact that the VT and the SPT condition correlated with each other in the correlation matrix suggests that performance in these two tasks is related, so probably activating the same substrate of episodic memory, at least partially (because the correlation is moderate - $r = .67$ – and not strong). This is also relatively supported by the correlations performed not controlling for age, where the SPT task correlated moderately with the episodic memory measures, thus meaning that there is an involvement of the episodic memory brain areas in the performance of SPT tasks. Thus we have found that a powerful SPT effect exists in older adults, but not one which reduces age differences to non significant levels.

The novelty of the experiment was also to consider the SPT task alongside a report of source: are people aware of how they studied the material, given that they benefit from performing the action, or is it more implicit than that? Secondly, we considered whether a number of standard neuropsychological measures would point to the basis of the SPT effect. We were most interested in whether SPT and VT conditions had different correlates, and in whether episodic memory performance *per se*, measured on another task, correlated with either VT or SPT or both.

First, considering source memory, previous studies have suggested a dissociation between item memory and source memory, verifying the benefit of the SPT condition only in memory for what was study and not in which condition, but this study included no older adults, only young adults, undergraduates (Hornstein & Mulligan, 2004). In our study, we analyzed the source memory in older adults as this age group usually shows deficits in this type of task of recognizing the source of the information (McDaniel Einstein & Jacoby, 2008). Here the results obtained by the two age groups for the source recognition showed no differences, and almost all the items learned in both conditions were recognized. As we can observe a ceiling effect for this task, we maintain caution regarding the interpretations from this task results. However, on the whole, the results point to older adults to be able to report the source of the items studied, and when looking at the errors committed in source recognition, both the young and the older adults evidenced more recognition errors for sentences coded under the verbal condition (VT) than for sentences coded under the Subject Performed Task condition (SPT). Despite the effect size of this difference is relatively weak, we can suggest that older adults, who present more difficulty in this task normally, are more reliable to report the source of the items when they where coded by enactment, and this effect apparently helps them to be more aware of the source for all the test, thus knowing later how they encoded the information, they become more accurate than expected for this age group.

As another main purpose of this study was to contribute with possible underlying cognitive processes involved in the SPT effect in aging, we added to the study a set of neuropsychological measures and we analyzed the correlation matrix for the two age groups, relatively to the VT and the SPT conditions of the Memory for Actions Task. For the most part, we found strongest correlations in the young group, and for the VT task. However, when considering the group as a whole, it is clear that VT and SPT tasks correlate with each other moderately, and that they also correlate with our other neuropsychological tests. A number of more fine-grained analyses of the simple correlations split by group do point to some interesting patterns which we suggest are interpreted with caution, but which may well be interesting in future studies. In the first matrix, for instance, we found that, while the older adults' SPT performance showed no significant correlation with the neurocognitive measures (with moderate correlations for the VT condition), for the group of younger adults, the neuropsychological tests have positive and moderate relationships with the VT and SPT tasks. The crucial test was, moreover, the correlations without controlling by age groups, where the SPT showed positive, moderate and significant correlations with all the neuropsychological measures used in this study (episodic memory, executive function and attention/speed processing), which, despite evidencing lower correlation strength compared to the VT task (that showed strong and positive correlations with all the cognitive measures), indicates that the SPT effect is not an separated type of memory, having influence, as the general episodic memory, of both executive functions and attention domain. As the correlations are, as mentioned, only moderated in comparation to the concurrent task (VT), we miss some deeper understanding of what more than these domains tested is involved in the SPT effect. It will be important to get a better elucidation of the domains that can influence the performance of episodic memory for actions, possibly by enlarging the set of neuropsychological tests administered and to use more pure tests that assess a more specific kind of cognitive domains; thus allowing us to understand the more true connections between the action memory processing and the other cognitive processes known to be relatively impaired in aging (Craik & Salthouse, 2000).

The regression analysis performed separating the age groups are also not very clear by means to help us to understand what could explain the SPT effect, because, when for younger adults all the tests used explain their performance in both the VT and the SPT, for older adults, no test alone neither the set of test taken together explained their performance both in VT and in SPT task. This can account for the fact that all the measures used to complement the Memory for Actions study where expected to show a deficit in older adults performance, thus not predicting their performance in the SPT condition where they showed a better performance. However the fact that the same happens for the VT condition may raise other questions, as their performance in this task was lower than for younger adults similarly to what happens with an equivalent task (WMS Paired Associates) but the performance seems to not be explained by it. This may be related with the visual and sensorial component present in the VT condition that is not assessed by the verbal episodic memory test WMS Paired Associates, and that could be some explanation for this finding. A limitation from this set of neuropsychological instruments used in this study is the lack of an episodic visual task where we could more clearly compare the visual episodic system involved in the Memory for Actions test with another parallel instrument.

The results of this investigation, taken together, and although some unclear findings, help to establish hypothetical lines to some of the theoretical explanations given to justify the SPT effect. Knowing the difficulty to associate information in a single episode inherent to the cognitive aging process (Chalfonte & Johnson, 1996; Naveh - Benjamin, 2000; Naveh - Benjamin et al., 2003), one should expect that the is the rule for all types of associations. However, the presence of an SPT effect for sentences that associate an object and an action, as a consequence of the implementation of that action (the enactment) unifies and strengthens the episodic action - object associations. This evidence converges with the explanation conveyed by Kormi-Nouri (1995; Kormi - Nouri & Nilsson, 1998) which refers to the potential of the SPT paradigm to increase episodic integration. The SPT condition could transform the episode as a whole unit, enhancing the associative memory processing even in a population (older adults) in which this processing is generally deficient. Moreover, the comparison of this task with the WMS Paired Associates Test reinforces the evidence that binding deficits are, in fact, present in the group of older adults, and are significantly reduced in the Memory for Actions Task (SPT condition). This idea is supported by the intact source memory and the lower number of recognition errors committed under the SPT condition: older adults have declarative access to bindings made at study, and this is helped by enactment.

Other studies with the SPT paradigm, in which this pattern of results was obtained, were explained by Zimmer, Helstrup and Engelkamp (2000) as being a reflection of the fact that the laws governing episodic memory for actions are different to the ones governing verbal episodic memory, defending the possibility of being behind the SPT effect an automatic type of processing (Cohen, 1981, 1989; Cohen & Nilsson, 1988). We do not find any evidence of this here. If there is some immediate, automatic benefit, it operates also on episodic memory, in that SPT is related to tests of episodic memory, and at a later point, older adults know how they studied the information. Since we know that older people have a deficit in using strategies to encode information, (e.g. Naveh-Benjamin, Brev & Levy, 2007) it remains possible that a form of automatic and effortless encoding of information occurs at encoding, even though subsequently, standard episodic processes are those which repeat, retrieve and benefit from, this information.

Our results lend support to theories of the SPT benefit which interact with known episodic memory functions, such as the idea that there is a greater support from the semantic, sensory, and motor encoding of the object and the enacted action; the theory of multimodal coding (Bäckman & Nilsson, 1984, 1985; Engelkamp, Zimmer & Kurbjuweit, 1995). This would be consistent with our finding that the SPT effect is related to episodic memory function, and the idea that participants can consciously report how they encoded the information. In the SPT condition information is encoded in motor, visual and verbal codes, which appears to increase the item specificity information and also the relation to its context (Engelkamp & Zimmer, 1989; Engelkamp & Seiler, 2003), thus contributing to increased performance on this task either for the group of young adults or for the group of older adults. Consider the source task in this study: it is easier to report the source of an item if you have carried it out, since it merely gives one more piece of information about the item. In the VT condition, presumably, verbal and semantic information brings to bear on retrieval. To these cues, in the SPT condition, we can add, proprioceptive, motoric and other visuo-spatial cues not available in the VT task.

Additionally this study suggests that the SPT effect is related with more that only episodic memory, regarding the correlation values between the SPT task and the executive function measures, as well as the attention and speed processing test, which may explain why the age differences are not eliminated in this task, despite they are reduced (by the argument of multimodality described above, in our view). These domains, executive function, attention and speed processing are domains that show a decreased performance for older adults as this study confirms, so it seems that these functions are important to show a strong SPT effect. We stress, however, that the measures used here, as standardized instruments, where not pure measures of any of these domains, thus remaining the need for using more pure tasks of each cognitive domains to understand in deep their connection with the SPT effect.

In conclusion, this study finds the standard SPT effect in the context of a memory deficit in older adults. Older adults are able to report the source of items in a subsequent recognition test, showing that they retain episodic information about how they previously encountered the stimuli. Thus, we imagine that the SPT encoding, even if 'special' in some way, enters into the episodic system, and is later available for conscious report. This is born out in our correlations. The general pattern is that people with high VT scores have high SPT scores, and episodic memory measures correlate with SPT scores. Thus, the SPT effect seems to act in concert with, and in line with the episodic system, and not separately from it. We continue to stress the use of this kind of rich multimodal encoding where the episodic memory is particularly impaired (Zimmer, 2001).

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Tables

Table 1. Demographic and general cognitive characteristics of participants

***N* = 60**	**Younger Adults** ***N* = 30**	**Older Adults** ***N* = 30**
Age	*M* = 41.43 (*DP* = 2.72; *A* = 35-45)	*M* = 72.30 (*DP* = 1.62; *A* = 70-75)
Gender	Female = 23 (76.7%) Male = 7 (23.3%)	Female = 24 (80%) Male = 6 (20%)
Education	4 years = 20 (66.7%) 6 years = 10 (33.3%)	4 years = 23 (76.6%) 6 years = 7 (23.3%)
Dwelling area	Urban = 2 (6.7%) Rural = 28(93.3%)	Urban = 5 (16.7%) Rural = 25 (83.3%)
Vocabulary (estimated IQ measure)	*M* = 31.00 (*DP* = 5.68)	*M* = 33.13 (*DP* = 7.39)
***MMSE* (0-30)**		*M* = 28.53 (*DP* = .97)

***ACE-R* (0-100)**		*M* = 84.87 (*DP* = 5.67)
***GDS* (0-30)**		*M*= 6.40 (*DP* = 2.896)
***BDI* (0-63)**	*M*= 5.33 (*DP* = 2.26)	

Table 2. Means and statistic tests for the two groups, in the neuropsychological measures

	Younger Adults		**Older Adults**				
	Mean	***SD***	***Mean***	***SD***	*t*	*Sig.*	*Cohen's d*

Symbol Search (WAIS-III)	17.37	3.94	11.40	3.49	6.206	.000*	1.60
Digit symbol Coding – codification	48.77	8.42	25.13	4.73	13.398	.000*	3,46
Digit symbol Coding – incidental learning	11.03	3.62	10.20	4.30	0.812	.420	0.20
Coding – free memory task (WAIS-III)	7.93	0.98	7.37	0.85	2.392	.020	0.61
Coding – Copy (WAIS-III)	78.53	20.79	52.87	13.64	5.653	.000*	1.46
Letter-Number Sequencing (WMS-III)	10.60	1.87	7.03	1.33	8.528	.000*	2.20
Visual Patterns Test	5.04	0.69	3.74	0.41	8.918	.000*	2.29
WMS Paired Associates Test – immediate	13.50	4.62	10.00	3.52	3.299	.002*	0.85
WMS Paired Associates Test – delayed	6.10	1.49	4.17	1.21	5.516	.000*	1.42

*sig < .001

Table 3. Correlation matrix between VT and SPT Conditions and the Neuropsychological tests, for the younger adults groups

		WMS Paired Associates Test – Immediate	*WMS Paired Associates Test - Delayed*	*Letter-Number Sequencing*	*Visual Patterns Test*	*Digit Symbol Coding - codification*	*Symbol Search*
Younger Adults	**VT Condition – Memory for Actions**	.735 *p* =.01	.304 *p* = .17	.780 *p* = .02	.311 *p* = .17	.292 *p* = .18	.469 *p* = .04
	SPT Condition – Memory for Actions	.335 *p* = .14	-.066 *p* = .86	.416 *p* = .08	.473 *p* = .04	.376 *p* = .11	.571 *p* = .02
Older Adults	**VT Condition – Memory for Actions**	.446 *p* = .05	.407 *p* = .13	.410 *p* = .13	-.047 *p* = .86	.486 *p* = .04	.028 *p* = .89
	SPT condition – Memory for Actions	.236 *p* = .25	.135 *p* = 0.61	.041 *p* = .86	.045 *p* = .86	.212 *p* = .35	-.333 *p* = .14

Table 4. Partial correlations between VT and SPT Conditions and the Neuropsychological tests, controlled for age groups

	WMS Paired Associates Test - immediate	*WMS Paired Associates Test - delayed*	*Letter-Number Sequencing*	*Visual Patterns Test*	*Digit Symbol Coding - codification*	*Symbol Search*
VT Condition – Memory for Actions	.649 *P*=.01	.581 *P*=.01	.588 *P*=.01	.151 *p*= .26	.325 *p*= .02	.280 *p*= .05
SPT Condition – Memory for Actions	.404 *p*= .01	.267 *p*= .05	.355 *p*= .02	.371 *p*= .01	.385 *p*= .01	.260 *p*= .06