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Aging and performance on laboratory and naturalistic prospective memory tasks: The mediating role of executive flexibility and retrospective memory

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ABSTRACT

The current study investigates whether individual differences in retrospective memory and executive flexibility tasks mediate the relation between age and performance on laboratory and naturalistic prospective memory tasks. One hundred and ninety-seven people aged 61 to 95 years performed four laboratory prospective memory tasks, two naturalistic prospective memory tasks, an executive flexibility task and a retrospective memory task. The results of confirmatory factor analysis indicate that the best measurement model for prospective memory tasks is a unidimensional model. Likewise, a bi-factor model consisting in a general "memory/speed" factor and an uncorrelated specific "executive flexibility" factor is the best measurement model for retrospective memory and executive flexibility tasks. The latent variable mediation analysis conducted in the SEM framework shows that "executive flexibility" mainly operates as a mediator in the negative relationship between age and prospective memory. Additionally the negative effect of age on prospective memory via "executive flexibility" increases significantly with the age of the participants.

1. Introduction

Prospective memory refers to the ability to remember to initiate or to execute at the right time an action one has planned to do. This ability is critical for human adaptation to the environment and people rely on this type of memory every day. One must remember an appointment at a particular time, or must remember to take a medicine daily just before having dinner. Prospective memory is thus crucial for maintaining autonomy in the elderly. This is one of the many reasons why for more than two decades a great number of studies have been investigating the effect of aging on those mental processes that are brought into play when a person is to remember that s/he has to take a certain action at a particular time in the future.

Few studies have examined prospective memory from an individual differences approach and it is still poorly understood which cognitive abilities best predict prospective memory in older adults. In one of the first studies on this issue, Maylor (1996) showed that prospective memory significantly correlated with age, $r(113) = -.539$ and that vocabulary, fluid intelligence and speed taken together accounted for about 30% of the variance in prospective memory when age independently accounted for an additional 17% of explained variance. The role of intelligence in the relationship between age and prospective memory can also be incriminated in some results showing little or no age-related declines in prospective memory performance (e.g., Cherry & LeCompte, 1999), on the hypothesis that this finding could be partially attributable to confounding age with verbal intelligence when comparing intelligent older adults with lesser intelligent younger adults (Uttl, 2006, 2008). These pieces of information suggest that while prospective memory performance is related to retrospective memory (e.g., Huppert, Johnson, & Nickson, 2000; Reese & Cherry, 2002) it is also, and maybe above all, related to cognitive resources such as processing speed, working memory capacity, fluid intelligence and a number of executive functions (e.g., Salthouse, Berish, & Siedlecki, 2004; Schnitzspahn, Stahl, Zeintl, Kaller, & Kliegel, 2013; Zeintl, Kliegel, & Hofer, 2007). The well-established effects of age on cognitive resources thus could explain why prospective memory may be particularly impaired in older people.

Prospective memory is generally assessed within two broad categories of situations, corresponding to two types of tasks that are classically opposed in the literature: laboratory prospective memory tasks vs. naturalistic prospective memory tasks. Laboratory prospective memory tasks are computer-based tasks more often than not inspired from Einstein and McDaniel's (1990) paradigm, a paradigm whereby participants are placed in a dual task situation in order to simulate the carrying out of a prospective memory task in everyday life. The ongoing (i.e., the secondary) task may consist in memorizing words, naming famous

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people upon presentation of their picture, or answering questions bearing on a text. At the same time, participants must remember to take an action (e.g., press a certain keyboard key, deliver a message), either (a) at a particular time (e.g., at 10:30) or at a particular pace (e.g., every 3 min), in time-based tasks, or (b) when an exogenous cue is presented (e.g., when a word from a given superordinate category is presented), in event-based tasks. Naturalistic prospective memory tasks are performed by the participants in their everyday home environment as part of their daily activities, without any control from an experimenter. Unlike laboratory prospective memory tasks, which last only minutes, naturalistic prospective memory tasks frequently span many days (Bailey, Henry, Rendell, Phillips, & Kliegel, 2010). Although the distinction between time-based and event-based prospective memory tasks is one that was initially made for laboratory prospective memory tasks, and though the naturalistic prospective memory tasks that have been generally used are time-based prospective memory tasks, the distinction between time-based and event-based prospective memory tasks also applies to the naturalistic prospective memory tasks. For instance, participants must remember to post a letter to the experimenter once a week during many weeks (Meacham & Singer, 1977) or to phone the experimenter at a precise time every day during five days (e.g., Maylor, 1990) in time-based tasks, or to phone the experimenter as soon as they see on television the weather map during the evening weather forecast, in event-based tasks (Niedźwieńska & Barzykowski, 2012). The many different prospective memory tasks can thus be summed up as resulting from crossing a situation type (i.e., laboratory vs. natural setting) with a type of retrieval mechanism for the intention to act (i.e., self-initiated retrieval, in time-based tasks vs. retrieval based on an external cue, in event-based tasks).

The comparison of the performance of old and young people on different prospective memory tasks led to two contradictory results, a configuration that has been dubbed "age prospective memory-paradox" (Rendell & Craik, 2000; Rendell & Thomson, 1999; see the meta-analysis by Henry, MacLeod, Phillips, & Crawford, 2004; for a review, see Phillips, Henry, & Martin, 2008). The first set of results of the age prospective memory–paradox configuration is in keeping with the effects of aging on cognitive functioning (e.g., Craik & Salthouse, 2008): older people generally perform less well than younger people on laboratory prospective memory tasks (e.g., Henry et al., 2004; Martin, Kliegel, & McDaniel, 2003; Maylor, 1993; Maylor, Smith, Sala, & Logie, 2002; Phillips et al., 2008; Rendell & Thomson, 1999; Salthouse et al., 2004). The second set of results is at odds with the first one, as older people generally perform better than younger people on naturalistic prospective memory tasks (Bailey et al., 2010; Rendell & Thomson, 1999; Schnitzspahn, Ihle, Henry, Rendell, & Kliegel, 2011). It should be noted that size effects found in studies that compared prospective memory between young and old participants are overall acceptable, and are almost identical for laboratory and naturalistic tasks (e.g., $R^2 = .12$, Schnitzspahn et al., 2011). A different lifestyle (Henry et al., 2004), a higher motivational level (Aberle, Rendell, Rose, McDaniel, & Kliegel, 2010; Niedźwieńska & Barzykowski, 2012; Schnitzspahn et al., 2011), or the fact that older people have more frequent recourse to external memory aids and to compensation strategies (Masumoto, Nishimura, Tabuchi, & Fujita, 2011) could explain the better results of older people on the naturalistic prospective memory tasks.

The better performances of older people on naturalistic prospective memory tasks seem however to hinge on the type of comparison considered. Generally the comparison is that between the mean performance of a group of older people and the mean performance of a group of young adults. Importantly, a better performance on naturalistic prospective memory tasks in older people is not obtained in those studies that compare the performance of old–old participants (i.e., people aged 75 or more) to that of young–old participants (i.e., people in their 60s and early 70s). For instance, Rendell and his collaborators showed that young–old participants have a performance similar to or better than that of old–old participants on naturalistic prospective memory tasks (Rendell & Craik, 2000; Rendell & Thomson, 1999). More recently, similar results were reported by Kvavilashvili, Cockburn, and Kornbrot (2012) in a study comparing performance on event-based laboratory and naturalistic prospective memory tasks in three age groups: young (18–30 years), young–old (61–70 years) and old–old (71–80 years) people. The results of their study showed that younger participants outperformed old–old participants in two laboratory event-based tasks, but no effect of age was found in their naturalistic event-based task.

While a comparison between groups of people of different ages may allow for detecting average trends of age-related changes, this approach implicitly considers that performance is homogeneous for all people in an age group (Zeintl et al., 2007). Such a view does not take into account the age-related increase in inter-individual variability and in intra-individual variability between tasks (e.g., Christensen et al., 1999; Hultsch, MacDonald, & Dixon, 2002; Morse, 1993; West, Murphy, Armilio, Craik, & Stuss, 2002). An inter-individual differences approach focusing on a wider age range in the old participants (Huppert et al., 2000; Zeintl et al., 2007) seems thus a useful complementary approach to the classical old–young comparison that is generally used to study the effect of age on the performance on laboratory and naturalistic prospective memory tasks.

Additionally, this kind of approach makes it possible to explore the evolution with age of the age-related prospective memory decline. Yet only a few studies with contradictory results have examined this evolution across a wide adult age range. Indeed, in some studies, the age-related decline in prospective memory performance appeared to be linear (e.g., Huppert et al., 2000; Zeintl et al., 2007) while other studies showed an increase of the age-related decline of prospective memory in older people (Kliegel, Mackinlay, & Jäger, 2008; Salthouse et al., 2004). Moreover, the results of these studies concern only laboratory event-based prospective memory task. The knowledge in this research domain is thus still incomplete.

The existence of age-related effects that may be different or even opposite between laboratory and naturalistic prospective memory tasks raises the question of the construct validity of these different measures. Only a few studies provided empirical evidence for the convergent validity of prospective memory tasks (Salthouse et al., 2004; Schnitzspahn et al., 2013; Zeintl et al., 2007). Furthermore, these results were confined solely to event-based laboratory prospective memory tasks. To the best of our knowledge, there are no studies that have investigated the convergent validity of prospective memory tasks of different kinds (i.e., time-based vs. event-based) and carried out in different settings (i.e., naturalistic vs. laboratory). Currently, it appears that the question of the structural validity and more broadly that of the construct validity of prospective memory remains unresolved.

It has been proposed that two types of memory processes underlie prospective memory task performance (e.g., Ellis, 1996; Jones, Livner, & Bäckman, 2006; Smith, 2003). A first set of processes, purely prospective, are involved in the detection of the right time for initiating and executing an intended action. The other processes are retrospective memory processes, which are retrieval processes that are necessary in order to remember the intention to act. Many experimental results support this theoretical distinction. Indeed, performance on retrospective memory tasks (i.e., free recall, recognition) is a predictor of the performance on laboratory event-based prospective memory tasks (Huppert et al., 2000; Reese & Cherry, 2002). It was also shown that retrospective memory (namely, free recall) partially mediates the effect of age on event-based prospective memory task performance (Gonneaud et al., 2011). However, other studies did not find any evidence of a relation between retrospective memory and performance on laboratory event-based prospective memory tasks (Maylor et al., 2002) or on laboratory time-based prospective memory tasks (Gonneaud et al., 2011) — a too low memory load for the retrospective component of the prospective memory tasks has been suggested to explain these latter results (Huppert et al., 2000). Finally, it seems that there is no relation between the efficiency of retrospective memory and the performance on