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Perceptual and motor inhibitory abilities in normal aging and Alzheimer disease (AD): A preliminary study

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ABSTRACT

Deficits in inhibitory abilities are frequently observed in normal aging and AD. However, few studies have explored the generality of these deficits in a single group of participants. A battery of tasks assessing perceptual and motor inhibitory functioning was administered to young and older healthy participants (Study 1), as well as to mild Alzheimer patients (Study 2). Results did not agree with a selective impairment of motor or perceptual inhibition in either AD or normal aging but rather suggest that a decrease in cognitive resources available in working memory could explain inhibitory performance both in normal aging and AD.

1. Introduction

Inhibition is a basic aspect of cognitive and emotional functioning involved in the performance of numerous tasks and processes and whose correct functioning is necessary to maintain an adequate level of adjustment to environmental demands (e.g., Nigg, 2000). Inhibition is generally defined as the set of processes that allow the suppression of previously activated cognitive contents, the clearing of irrelevant actions or of attentional focus from consciousness, and the resistance to interference from potentially attention-capturing stimuli (Bjorklund and Harnishfeger, 1995). Deficits in inhibitory abilities are proposed as one of the causes of the diminished daily functioning characterizing normal aging and AD (e.g., Harnishfeger and Bjorklund, 1993; Harnishfeger, 1995; Collette and Van der Linden, 2002; Amieva et al., 2004).

Recently, several theoretical frameworks have been proposed to explain the inhibitory effects reported in the literature in various normal and pathological populations. For instance, inhibition was specifically related to working memory by Hasher, Zacks, and May (Hasher et al., 1999, 2001), who described three general inhibitory functions that operate at different times in the information processing sequence: the access function, preventing access to irrelevant information; the deletion function, suppressing information that either is or becomes irrelevant; and the restraint function, which operates when strong responses are triggered by a familiar cue but do not have to be produced. Other authors viewed inhibition as a general process operating in various cognitive domains. In that context, Dempster and Corkill (1999a,b) have suggested making a distinction between perceptual, motor and verbal inhibition. Inhibitory tasks were also classified according to the following three dimensions: (1) intentional vs. unintentional, (2) behavioral vs. cognitive, and (3) inhibition vs. interference (Harnishfeger, 1995). More generally, Nigg (2000) suggested dissociating effortful inhibitory processes (for example, cognitive inhibition, behavioral inhibition and oculo-motor inhibition) from automatic inhibition of attention (concerning inhibition of irrelevant spatial locations or of recently inspected stimuli). Finally, Kipp Harnishfeger (Harnishfeger and Bjorklund, 1993; Harnishfeger, 1995; Wilson and Harnishfeger, 1998), proposed a distinction between the concepts of inhibition and interference. In that theoretical framework, inhibitory control corresponds to a voluntary suppression of the information, and interference resolution represents a gating mechanism preventing the processing of distracting information. More precisely, Kipp Harnishfeger proposed that interference resolution consists of an automatic/unintentional process occurring prior to conscious awareness while inhibition results when a stimulus is classified as irrelevant for the ongoing task and is then consciously/intentionally suppressed. By reference to daily life activities, intentional

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inhibition would correspond to avoiding black chocolate ice cream that you do not like, while unintentional inhibition might correspond to ‘‘automatically’’ taking vanilla ice cream, while you might have enjoyed white chocolate ice cream. Perceptual inhibition would correspond to avoiding any brown ice cream because you do not like black chocolate, while motor suppression would result from your neighbor telling you not to take his ice cream.

A large number of studies exploring inhibition in normal aging and AD demonstrated impaired abilities using various tasks and procedures. For example, difficulties in inhibiting prepotent responses were observed in these populations on Stroop[1] (e.g., Spieler et al., 1996; Balota and Faust, 2001), negative priming[2] (McDowd and Oseas-Kreger, 1991; Kane et al., 1994) and Hayling tasks[3] (Collette et al., 1999; Andres and Van der Linden, 2000), as well as on the stop-signal[4] (Kramer et al., 1994; May and Hasher, 1998), go/no-go[5] (Nielson et al., 2002) and anti-saccade[6] (Butler et al., 1999) tasks. However, a negative effect of normal aging and AD on suppression abilities has not been systematically observed. In older participants, some studies demonstrated no evidence of impairment for the Stroop task (Kieley and Hartley, 1997), as well as for negative priming (Gamboz et al., 2002; Buchner and Mayr, 2004) and inhibition of return[7] tasks (Hartley and Kieley, 1995). In a similar way, normal inhibition-of-return effects are observed in AD patients (Faust and Balota, 1997; Langley et al., 2001) and little evidence of dysfunction has been found in tasks assessing motor response inhibition (Amieva et al., 2002; Collette et al., 2007).

Additionally, studies in which batteries of tasks were used also showed that some aspects of inhibition can be preserved in normal aging and AD. For instance, dissociation between impaired intentional inhibitory abilities and preserved unintentional ones was reported in two studies. Collette et al. (2009a) compared the performances of normal elderly and young participants on tasks involving either intentional or unintentional inhibitory control of memory content. Their results suggested that normal aging is associated with a specific dysfunction affecting intentional inhibitory control of memory contents. In addition, Andrès et al. showed that older subjects' performances were impaired in the Stroop test and in the stop-signal task (that can be considered as effortful or intentional) while automatic inhibition, as assessed by a negative priming task, was spared (Andres et al., 2008). With regard to AD, Amieva et al. (2002) observed impaired performance on the negative priming and Stroop tasks, but not on the go/no-go task, and only limited impairment was observed on the stop-signal task, suggesting that motor response inhibition could be relatively spared in that group of patients (for similar data on the Stroop and go/no-go task, see also Collette et al., 2007).

As a whole, results of these studies indicate that not all aspects of inhibitory functioning are impaired in normal and pathological aging, and that not exactly the same processes could be altered in these two populations. However, very few of these studies tried to relate the performance of elderly participants and AD patients to a theoretical framework of inhibition. In that context and according to the proposal of Dempster and Corkill that there exists an earlier development of motor than perceptual inhibition during childhood (Dempster and Corkill, 1999a,b), the existence of a specific impairment of perceptual vs. motor inhibitory functioning appears particularly interesting to investigate in these populations. Two studies (Germain and Collette, 2008; Jennings et al., 2011) explored this question in normal aging using a task assessing separately resistance to perceptual and motor interference within the context of very similar stimulus and response demands (Nassauer and Halperin, 2003). The two studies showed both decreased perceptual and motor inhibitory abilities in older participants. With regard to AD, some preliminary evidences tend to demonstrate that motor inhibition could be relatively spared in the early stages of the illness (Amieva et al., 2002; Collette et al., 2007).

However, at this time, no study explored perceptual and motor inhibitory functioning simultaneously in a large range of tasks in healthy older participants and AD patients to determine if aging (and more particularly AD) is associated to a (relative) preservation of motor inhibition that would correspond to the reverse of the developmental course proposed by Dempster and Corkill (1999a,b). Consequently, in the present study, seven inhibitory tasks were administered to four groups of participants: a group of young and a group of older participants (Study 1) as well as a group of mild AD patients and a group of matched healthy participants (Study 2). The tasks included in our battery were selected according to two main criteria. They are generally considered in the literature as involving mainly perceptual or motor inhibitory processes (Amieva et al., 2004) and they were administered to aging populations in previous studies (with the exception of the Simon task for AD patients). Other task characteristics such as the un(intentional) aspect of inhibition, the working memory load or the verbal/visual component were not taken into account since it was not possible to equate these aspects between motor vs. perceptual inhibition tasks. The three tasks assessing perceptual inhibition were a variant of the Stroop test (Stroop, 1935) used to assess both the classical Stroop interference and the negative priming effects (Tipper, 1985), the perceptual condition of the Simon task previously proposed by Nassauer and Halperin (2003) and the Eriksen's flanker task (Eriksen and Eriksen, 1974). The four motor inhibitory tasks were an anti-saccade task (Roberts et al., 1994), a go/no-go task (Zimmerman and Fimm, 1994), the motor condition of the Simon task (Nassauer and Halperin, 2003) and a stop-signal task (Logan et al., 1984; Logan, 1994). The novel aspect of this study is the administration of several tasks assessing motor and perceptual inhibition to the same group of participants. Such a procedure allows ascertaining that the presence of specific perceptual or motor inhibitory deficits cannot be explained by confounding factors related to the characteristics of the participants (as this is the case when results from different studies/populations are compared).

[1] The interference Stroop effect refers to the increased latency time to name the color of the ink with which an item is printed when the item is the name of another color (e.g. the word ‘‘red’’ printed in green) in comparison to neutral stimuli (e.g. the item ‘‘XXX’’ also printed in green).

[2] In the negative priming procedure, subjects are simultaneously shown two items (e.g., letters), one red (target) and the other green (distractor). Subjects are instructed to process the red item as quickly as possible and to ignore the green one. The negative priming effect corresponds to response time increase when the item serving as the distractor in one trial (prime) is used as the target in the very next trial (probe). The explanation for this effect is that the distractor is actively inhibited in the prime trial.

[3] In the Hayling task, subjects are asked to complete sentences in which the final word is omitted, either with an appropriate word (‘‘initiation’’ condition) or with a word that makes no sense at all in the context of the sentence (‘‘suppression’’ condition). In comparison to the first condition, the second condition requires inhibiting the automatically activated word in order to provide a word unrelated to the context of the sentence.

[4] In the stop/signal task, participants have to categorize items (i.e. living/no-living) as quickly as possible but to suppress the production of the response following the appearance of a warning signal in a short delay after the presentation of some items.

[5] The go/no-go task requires pressing a response key as quickly as possible when target items are presented but to withhold that motor response following the presentation of distracters items.

[6] The anti-saccade task necessitates inhibiting automatic ocular saccades from the location where a non-relevant item is presented.

[7] The phenomenon of Inhibition of return consists *of* a slowing down in the processing of items appearing at a spatial location where attention was focalized shortly before the presentation of these items.