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Age-associated cognitive deficits in humans and dogs: A comparative neuropsychological approach

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Abstract

We compared performance of younger and older human participants to that of younger and older dogs on tasks that evaluate object discrimination, egocentric spatial ability, object recognition, spatial memory, and cognitive flexibility. Our goal was to determine whether (i) tasks sensitive to advanced age in dogs are also age-sensitive in humans; (ii) the pattern of task difficulty observed in dogs mirrors that observed in humans; (iii) dogs and humans use similar strategies to solve equivalent tasks. Dogs performed more poorly than humans on reversal tasks that evaluate cognitive flexibility. We suggest that dogs, most notably older dogs, use different strategies than healthy humans when solving these tasks. Humans appear to test a priori hypotheses to solve the task at hand. As a consequence, expectations about the complexity of the task being tested can impair human performance. By contrast, dogs appear to rely more heavily on either simpler hypotheses, or associative trial and error learning, which probably accounts for their difficulty in learning non-matching tasks. Dogs also show perseverative responding, which hinders the acquisition of reversal tasks.

Keywords: Aging; Delayed non-matching; Discrimination; Reversal; Species differences

1. Introduction

Human aging is associated with significant changes in cognitive functions, including impairments in the ability to remember specific events (Levine et al., 2002; Spencer and Raz, 1995), to acquire new information (Small et al., 1999), and to deploy executive functions (Albert, 1993). Investigating the relationship between neural changes and behavioral impairments in humans is limited by the inability to collect combined behavioral and anatomical data within a short period of time. To overcome this limitation, researchers are increasingly relying on animal models. These models have been particularly valuable for studying the relationship between neural changes and age-associated behavioral impairments as well as for exploring interventions that can arrest these impairments. However, results obtained using animals cannot always be extended to humans because the tasks employed differ in their ability to evaluate cognitive functions such as perceptual discrimination, storage, retrieval, and cognitive flexibility.

A recent line of research, termed comparative neuropsychology, uses a modified version of the Wisconsin General Test Apparatus (WGTA) developed for use with

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Abbreviations: DNMP, delayed non-matching to position; DNMS, delayed non-matching to sample; EDL, egocentric discrimination learning; EDR, egocentric discrimination reversal; M, mean; MMSE, mini-mental status examination; OA, older adults; ODL, object discrimination learning; ODR, object discrimination reversal; SE, standard error; SD, standard deviation; WGTA, Wisconsin General Test Apparatus; YA, younger adults.

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primates to evaluate cognition in humans (Freedman and Oscar-Berman, 1986, 1987, 1989; Oscar-Berman and Zola-Morgan, 1980). This approach allows researchers to compare humans and animals on the same tasks. Because the tasks are non-verbal, individuals with severely limited cognitive abilities can be evaluated. Moreover, researchers can make inferences about neuropathology because the neural substrates underlying the ability to perform these tasks have been delineated. Animal-based tasks have been successfully employed in a variety of populations including infants (Overman, 1990; Overman et al., 1992, 1993, 1996) and patients with Down syndrome (Nelson et al., unpublished data), Alzheimer disease (Irle et al., 1987), Parkinson disease (Freedman and Oscar-Berman, 1986, 1987, 1989; Sahakian et al., 1988), and Korsakoff syndrome (Oscar-Berman and Zola-Morgan, 1980). However, animal models do not always display the same behavioral impairments on a given task as humans with comparable brain damage (Kessler et al., 1986), suggesting that different psychological constructs may be triggered when animals and humans perform these tasks.

In the present study, we obtained data from a sample of younger and older human participants on tasks for which data had previously been collected with dogs. Our goals were threefold. First, we compared the effect of age in humans on tasks that are sensitive to advanced age in dogs. In particular, older dogs have been shown to have more difficulties than younger dogs in tasks that evaluate object recognition (Milgram et al., 1994) and spatial memory (Head et al., 1995; Adams et al., 2000a). There is also some evidence that older dogs need more trials to acquire reversed stimulus–reward associations than the original association (Milgram et al., 1994; Tapp et al., 2003). Second, we examined whether the pattern of task difficulty found in dogs is comparable to humans. Previous research has shown that in dogs, more extensive training is required to acquire memory tasks that involve delayed responses and reversal tasks that involve switching a previously learned stimulus–reward contingency than simple discrimination tasks (Adams et al., 2000a; Milgram et al., 1994). Finally, we examined whether dogs and humans employ similar strategies when solving equivalent tasks. In dogs, aging seems to affect the type of strategy employed to solve discrimination learning and reversal tasks with older dogs relying more heavily on associative learning than younger dogs, and younger dogs relying more heavily on concept learning than older dogs (Milgram, 2004; Tapp et al., 2003).

2. Method

2.1. Human participants

Seventeen older adults (11 females, 6 males) and 30 younger adults (22 females, 8 males) were tested in this study. All participants provided informed consent. Older adults had a mean age of 73 years (range 58 to 83). They were recruited from a registry of volunteers at the Baycrest Centre for Geriatric Care, Toronto, Canada. Participants suffering from mood disorders, psychosis, obsessive compulsive disorder, panic disorder, severe systemic disease, poor vision or hearing, inadequate English, or neurological disorders were excluded. The Mini-Mental State Examination (MMSE) was used to provide an independent measure of cognitive status. One older male participant obtained a score of 24 on the MMSE. Considering that this participant displayed motivational problems throughout the study, we felt that this low score was not indicative of a cognitive deficit and excluded the data from the analysis.

Younger adults had a mean age of 21 (range 19 to 24). They were recruited from the student population at the University of Toronto at Scarborough. All younger participants obtained a score of 27 or more on the MMSE (M: 29.34; SD: 0.86) except for one participant who obtained 26, which is the cut-off score for mild cognitive impairment in older adults. We consequently excluded this participant's data from the analyses.

2.2. Apparatus

Human participants were tested using a modified version of the WGTA similar to the apparatus devised by Oscar-Berman and Zola-Morgan (1980) (Fig. 1). The apparatus consists of a vertical panel and a horizontal box with a sliding tray. The tray contains three reinforcement wells. The bottom of the vertical panel consists of hinged door that can be opened and closed to allow the investigator to move the tray towards and away from the participant. When the door is closed, the participant cannot see the tray or the investigator. The vertical panel has a one-way mirror

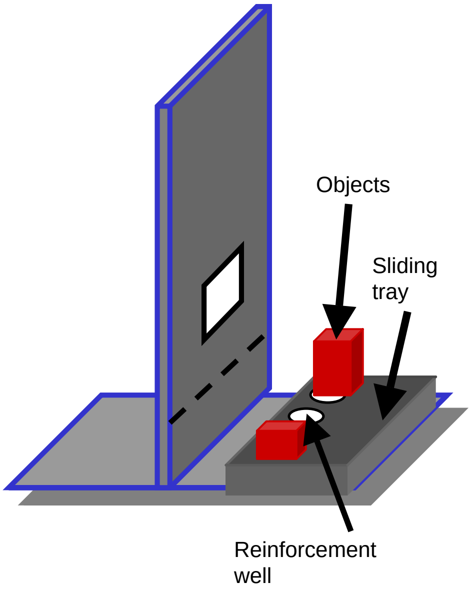

Fig. 1. A schematic illustration of the apparatus used in this study.