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RESEARCH

# The use of a T-maze to measure cognitive–motor function in cats (*Felis catus*)

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**Abstract** Few tests have been developed to evaluate the cognitive and motor capabilities of domestic cats, despite the suitability of cats for specific studies of neuroanatomy, infectious diseases, development, aging, and behavior. The present study evaluated a T-maze apparatus as a sensitive and reliable measure of cognition and motor function in cats. Eighteen purpose-bred, specific pathogen-free, male, neutered domestic short-haired cats (*Felis catus*), 1-2 years of age, were trained and tested to a T-maze protocol using food rewards. The test protocol consisted of positional discrimination training (left arm or right arm) to reach a predetermined criterion, followed by 2 discrimination reversal tests. The 2 reversal tests documented the ability of the subjects to respond to a new reward location by switching arms of the T-maze. Data were collected on side preference, number of correct responses, and latency of the responses by the subjects. Aided by a customized computer program (CanCog Technologies), data were recorded electronically as each cat progressed from the start box to the reward arm. The protocol facilitated rapid training to a high and consistent level of performance during the discrimination training. This learning was associated with a decrease in the latency to traverse the maze to a mean of 4.80 ± 0.87 seconds, indicating strong motivation and consistent performance. When the rewarded side was reversed in the test phase, the cats required more trials to reach the criterion, as expected, but again showed reliable learning. The latency to the reward in the first session of reversal increased 86% from the first to the last trial, indicating that it may provide a useful index of cognitive processing. Latencies subsequently decreased as the new reversal paradigm was learned. This paradigm provides a relatively rapid and reliable test of cognitive–motor performance that can be used in various settings for the evaluation of feline cognitive and motor function.
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## Introduction

There is a paucity of quantitative information available on cognitive and motor function in domestic cats, despite their domestication over millennia and their ubiquity as pets. Although the use of cats in neurobiological studies is well documented, their use in cognitive–motor assessment paradigms is widely viewed as challenging. Sensitive and reliable measures of cognition (Dore et al., 1996) and motor function in cats could provide valid and sensitive end points for studies of feline aging (Levine et al., 1987), diet, and disease states. We have been particularly interested in using cognitive and motor tests to distinguish behavioral effects of feline immunodeficiency virus (FIV), aiding in our understanding of the pathophysiology and pharmacologic management of the disease (Meeker, 2007). For example, FIV serves as an important animal model for human immunodeficiency virus, with neurologic dysfunction observed in both diseases. Despite progress in the development of retroviral treatment agents, cognitive decline remains a persistent and debilitating problem among HIV-infected individuals (Sacktor et al., 2002; Robertson et al., 2007; Moore et al., 2011). However, although of critical importance, early subtle behavioral effects of the disease in cats have not been fully addressed, limiting the ability to investigate early interventional therapies.

Several recent studies have attempted to reveal cognitive and motor abilities of cats, with mixed success. For example, a hole-board test was developed as a spatial memory test for cognitive ability to distinguish FIV-infected from uninfected cats (Steigerwald et al., 1999). A simplified version of the test has also been applied to aging studies but may not be sensitive enough to identify the effects of aging on cognitive function in cats, if these effects exist (McCune et al., 2008). Cats failed to "show causal understanding" in a string-pulling task (Whitt, 2009) or to distinguish 2 from 3 dots in a quantity discrimination test, although alternative explanations were suggested (Pisa and Agrillo, 2009). Feline motor function has been evaluated using a plank-walking test (Steigerwald et al., 1999). This test revealed motor differences between cats infected as kittens with FIV and uninfected controls but did not identify aging effects on motor function in cats (McCune et al., 2008), leading to uncertainty about the sensitivity of the test. More recent tests have used increasingly sensitive measures of cognitive and motor function in FIV-infected cats. Increases in gait width, greater errors in a stepping task, and increased maze completion times in a modified T-maze were found to correlate with inflammatory markers and FIV burden in the central nervous system (Malingat et al., 2009). These studies reveal the potential of behavioral studies to assess neural function in cats but also highlight the need for more sensitive and standardized approaches.

The goal of these studies was to develop a simple, yet sensitive, test that could be used for the assessment of disease-associated cognitive–motor decline as well as the efficacy of novel therapeutic agents. The T-maze has been used as a standard tool for the assessment of cognitive processes (Haley and Raber, 2011), such as spatial memory and associative learning, as well as motor function in many species (from mollusks [Painter et al., 1998] to rats [Carillo-Mora et al., 2009] to primates [Easton et al., 2003]). Levine et al., (1987) used the T-maze to examine the effects of aging in cats. The T-maze has also been used in feline ablation studies to document limitations to sensory discrimination and spatial learning (Norrsell, 1983; Burgess et al., 1986). The objective of the present study was to develop a reliable and sensitive T-maze protocol that could be used to quantify cognitive and motor function in cats.

## Materials and methods

### Subjects

The subjects were 18 specific pathogen-free, purpose-bred, neutered male domestic short-haired cats (*Felis catus*) aged 1-2 years. The cats were maintained in individual pens (188 cm high, 147 cm deep, 91 cm wide) in a laboratory animal facility on a 12/12-hour light–dark cycle, fed a measured balanced feline dry ration after testing each day, and maintained at body weights consistent with initial body weights and low-to-normal (3/9-4/9) body condition score, as referenced on a standard score chart (Purina Body Condition Score Index, http://www.purina.com/cat/weight-control/bodycondition.aspx). At the time of initial training, all cats were naive to cognitive testing. Housing and test protocols were approved by the North Carolina State University Institutional Animal Care and Use Committee.

### Apparatus

Constructed of plywood sealed with polyurethane to conform to laboratory standards, the feline-adapted T-maze was designed by CanCog Technologies (Toronto, ON, Canada) to provide a simple test of cognitive and motor ability (Figures 1 and 2). The outside dimensions of the T-maze were 183 cm × 99 cm, with a height of 77 cm. The maze components included a start box that opened to a runway at the end of which was a decision point, and a left and right reward arm, each leading to a reward area with a reward well where a food reward could be placed. Doors, positioned in each reward arm, were closed to prevent path reversal after the arm choice was made. These doors had magnetic latches that kept the doors open and could be remotely closed by the tester using a switch that released the magnet once the cat had passed. Doors out of and into the start box were guillotine style, operated manually by the tester. Partial wooden panels obscured the view of the reward well until the cat had committed to entering a reward

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