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Automated touch screen device for recording complex rodent behaviors

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HIGHLIGHTS

- A new hardware/software system was developed to monitor rodent behaviors.
- Touch screen technology is able to record all movements with high sensitivity.
- Amphetamine caused increased locomotor activity and velocity of stepping activity.
- The device can be used for light–dark box tests as a measure of anxiety.
- This novel device can accurately and rapidly characterize mouse behaviors.

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ABSTRACT

Background: Monitoring mouse behavior is a critical step in the development of modern pharmacotherapies.
New method: Here we describe the application of a novel method that utilizes a touch display computer (tablet) and software to detect, record, and report fine motor behaviors. A consumer-grade tablet device is placed in the bottom of a specially made acrylic cage allowing the animal to walk on the device (MouseTrapp). We describe its application in open field (for general locomotor studies) which measures step lengths and velocity. The device can perform light–dark (anxiety) tests by illuminating half of the screen and keeping the other half darkened. A divider is built into the lid of the device allowing the animal free access to either side.
Results: Treating mice with amphetamine and the delta opioid peptide receptor agonist SNC80 stimulated locomotor activity on the device. Amphetamine increased step velocity but not step length during its peak effect (40–70 min after treatment), thus indicating detection of subtle amphetamine-induced effects. Animals showed a preference (74% of time spent) for the darkened half compared to the illuminated side.
Comparison with existing method: Animals were videotaped within the chamber to compare quadrant crosses to detect motion on the device. The slope, duration and magnitude of quadrant crosses tightly correlated with overall locomotor activity as detected by MouseTrapp.
Conclusions: We suggest that modern touch display devices such as MouseTrapp will be an important step toward automation of behavioral analyses for characterizing phenotypes and drug effects.

1. Introduction

Much of the knowledge gained in the neurosciences has been extrapolated from measurements of animal behaviors responding to surgical, pharmacological and environment/cue-related manipulations. The development of novel neurological and psychiatric pharmacotherapies depends heavily upon how animals respond to these agents in a preclinical setting. Therefore, it is critical to

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develop methods to quantify animal behaviors in greater detail to characterize potential treatments. In particular, the mouse has become the preferred neuroscience research subject because of the large number of genetic variants that have been developed by laboratories worldwide. Indeed a number of mouse models have been developed for diseases such as Parkinson's disease (PD), Alzheimer's disease, depression/anxiety, and others in order to mimic the genetic, motor and cognitive components of these diseases (Zimprich et al., 2004; Westerman et al., 2002; Cryan and Mombereau, 2004). Therefore, investigating behavioral phenotypes remains an important aspect to characterizing the effects of pharmacological and genetic manipulations.

Behavioral studies have been particularly valuable for the development of novel targets for movement disorders like PD. In PD, a loss of dopamine tone in the brain causes a cascade of neurochemical deficits resulting in a loss of movement. In addition to a generalized loss of movement (akinesia), postural and gait disturbances are also observed clinically. In rodents, gait and postural deficits are more challenging to quantify than generalized locomotion since individual steps must be observed from underneath the animal's body. One way to do these types of experiments is to apply paint to the bottom of the animal's paws and then measure distances and geometries between steps (Fernagut et al., 2002). Other more sophisticated techniques have been used such as the CatWalk XT™ system from Noldus Information Technology. Although these techniques are very useful, each has some drawbacks. Applying paint to animal paws for step measurements do not allow the animal to normally habituate to an environment since paint must be continually reapplied which can cause stress. On the other hand, cost is a significant factor when using commercially available digital imaging analysis systems.

Modern computer and touch display technologies may be useful for exploring new experimental rodent behavior paradigms. Capacitance touch screens work by coating glass with a transparent conductor such as indium tin oxide. The conductance generated by the touch of a human finger or an animal's paw will distort the electric field on the screen and generate a change in capacitance. When coupled to a computing device (i.e. a tablet) a number of applications can be devised. This technology is particularly amenable to animal behavioral studies since it requires no direct pressure to generate a digital signal. In addition, the broad availability of such devices like iPad™ or Android™ tablets use this type of technology allowing for extremely sensitive and accessible touch detection systems.

Here we describe a method in which a consumer grade tablet device is transformed into a complete rodent behavior tracking apparatus. The device (MouseTrapp) is capable of directly recording and scoring animal movements made on the device through a novel software interface. This allows users to then more readily capture behavioral phenotypes in an automated environment with less user input. Although the device has been used for studying a number of parameters such as novel object recognition (cognition) and gait analysis, the current article describes its application in open field (locomotor activity) and light–dark (anxiety) tests.

2. Materials and methods

2.1. Hardware

An acrylic chamber was designed with a slot to house a tablet device, leaving only the touch screen portion of the tablet exposed (Fig. 1). Dimensions of the apparatus are 21 cm (l) × 14 cm (w) × 15 cm (h). A clear lid was used when performing general locomotor assays while a lid with an opaque top and separation wall

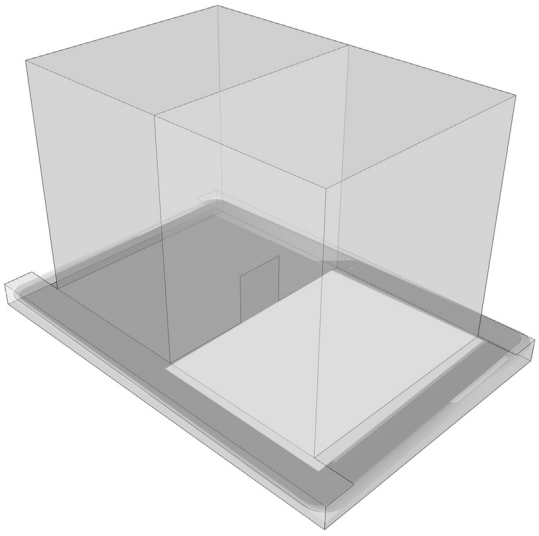

Fig. 1. A schematic showing MouseTrapp which includes an acrylic enclosure and a slot at the bottom to introduce a tablet device. The configuration shown has a divider, which is attached to the lid, with a small cutout at the bottom allowing free access between sides of the apparatus. The display on the tablet shows lightened and darkened halves which provide the illumination and darkness required for the light–dark test.

is placed within the enclosure for the light–dark test. This separating wall has a 32 mm^2 cutout at the bottom to allow a mouse to pass back and forth between each side of the tablet device (Fig. 1). An Android (Google, Moutainview, CA) Samsung Galaxy Tab II 10.1 (Samsung, Suwon, South Korea) running a copy of the MouseTrapp software (Neurolytical, Ann Arbor, MI) slides into the opening at the bottom of the chamber. This tablet has a 10.1″ diagonal screen which leaves enough room for an adult mouse to ambulate comfortably.

2.2. Software

MouseTrapp software was especially designed to detect all "touches" on the screen at any given point and to report these values through a simplified interface. Each mouse paw touching the tablet is therefore registered in the software as an X–Y coordinate. The calculated center of the mouse depends on how many paws are touching the screen. It is assumed that there will be at least two, but no more than four touches at a given time. If there are two or four touches on the screen, a simple average of the points is given as the center position. If there are three touches on the screen, a simple triangular logarithm calculates the precise center of these points, generating a unique X–Y coordinate. These coordinates are continually recorded to track the animal's movement over time. In addition, a more comprehensive data set is generated detailing all steps made. Therefore, the distances between all steps can be tallied over time as well as the calculated duration of these steps. Velocity of steps is then calculated as length of step/duration of the step. The software then reports all of these data in a .csv (comma separated values) file which can then be transferred to Microsoft Excel™ software for further analyses. It must be noted that mice did not ordinarily drag their tails on the tablet screen during this study, however, when there were occasional touches of the screen by the tail, a touch point was rarely registered. This may be due to the fact that the tails are coated by a thin layer of hair which may prevent the capacitive interaction with the screen that normally occurs with the animal's paw pads.