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(54) **Title**: USE OF RASAGILINE FOR THE TREATMENT OF OLFACTORY DYSFUNCTION

(57) **Abstract**: Disclosed are methods of treating olfactory dysfunction by periodically administering a therapeutically effective amount of rasagiline or a pharmaceutically acceptable salt of rasagiline to a subject.

USE OF RASAGILINE FOR THE TREATMENT OF OLFACTORY DYSFUNCTION

This application claims priority of U.S. Provisional Applications Nos. 61/437,212, filed January 28, 2011 and 61/400,464, filed July 27, 2010, the contents of each of which are hereby incorporated by reference.

Throughout this application various publications, published patent applications, and patents are referenced. The disclosures of these documents in their entireties are hereby incorporated by reference into this application in order to more fully describe the state of the art to which this invention pertains.

Background of the Invention

Olfactory dysfunction can arise from a variety of causes and can profoundly influence a patient's quality of life. Studies have shown that olfactory dysfunction affects at least 1 % of the population under the age of 65 years, and well over 50% of the population older than 65 years. The sense of smell contributes to the flavor of foods and beverages and also serves as an early warning system for the detection of environmental hazards, such as spoiled food, leaking natural gas, smoke, or airborne pollutants. The losses or distortions of smell sensation can adversely influence food preference, food intake and appetite (1), which in turn will adversely affect the health of patients.

Three specialized neural systems are present within the nasal cavities in humans. They are 1) the main olfactory system (cranial nerve I), 2) trigeminal somatosensory system (cranial nerve V), 3) the nervus terminalis (cranial nerve 0). CN I mediates odor sensation. It is responsible for determining flavors. CN V mediates somatosensory sensations, including burning, cooling, irritation, and tickling. CN 0 is a ganglionated neural plexus. It spans much of the nasal mucosa before coursing through the cribriform plate to enter the forebrain medial to the olfactory tract. The exact function of the nervus terminalis is unknown in humans (1).

The olfactory neuroepithelium is a pseudostratified columnar epithelium. The specialized olfactory epithelial cells are the only group of neurons capable of regeneration. The olfactory

epithelium is situated in the superior aspect of each nostril, including cribriform plate, superior turbinate, superior septum, and sections of the middle turbinate. It harbors sensory receptors of the main olfactory system and some CN V free nerve endings. The olfactory epithelium loses its general homogeneity postnatally, and as early as the first few weeks of life metaplastic islands of respiratory-like epithelium appear. The metaplasia increases in extent throughout life. It is presumed that this process is the result of insults from the environment, such as viruses, bacteria, and toxins (1).

There are 6 distinct cells types in the olfactory neuroepithelium: 1) bipolar sensory receptor neurons, 2) microvillar cells, 3) supporting cells, 4) globose basal cells, 5) horizontal basal cells, 6) cells lining the Bowman's glands. There are approximately 6,000,000 bipolar neurons in the adult olfactory neuroepithelium. They are thin dendritic cells with rods containing cilia at one end and long central processes at the other end forming olfactory fila. The olfactory receptors are located on the ciliated dendritic ends. The unmyelinated axons coalesce into 40 bundles, termed olfactory fila, which are ensheathed by Schwann-like cells. The fila transverses the cribriform plate to enter the anterior cranial fossa and constitute CN I. Microvillar cells are near the surface of the neuroepithelium, but the exact functions of these cells are unknown. Supporting cells are also at the surface of the epithelium. They join tightly with neurons and microvillar cells. They also project microvilli into the mucus. Their functions include insulating receptor cells from one another, regulating the composition of the mucus, deactivating odorants, and protecting the epithelium from foreign agents. The basal cells are located near the basement membrane, and are the progenitor cells from which the other cell types arise. The Bowman's glands are a major source of mucus within the region of the olfactory epithelium (1).

The odorant receptors are located on the cilia of the receptor cells. Each receptor cell expresses a single odorant receptor gene. There are approximately 1,000 classes of receptors at present. The olfactory receptors are linked to the stimulatory guanine nucleotide binding protein Golf. When stimulated, it can activate adenylate cyclase to produce the second messenger cAMP, and subsequent events lead to depolarization of the cell membrane and signal propagation. Although each receptor cell only expresses one type of receptor, each cell is electrophysiologically responsive to a wide but circumscribed range of stimuli. This implies that a single receptor accepts a range of molecular entities (1).

The olfactory bulb is located on top of the cribriform plate at the base of the frontal lobe in the anterior cranial fossa. It receives thousands of primary axons from olfactory receptor neurons. Within the olfactory bulb, these axons synapse with a much smaller number of second order neurons which form the olfactory tract and project to olfactory cortex. The olfactory cortex includes the frontal and temporal lobes, thalamus, and hypothalamus (1).

Olfactory disorders can be classified as follows: 1) anosmia: inability to detect qualitative olfactory sensations (i.e., absence of smell function), 2) partial anosmia: ability to perceive some, but not all, odorants, 3) hyposmia or microsmia: decreased sensitivity to odorants, 4) hyperosmia: abnormally acute smell function, 5) dysosmia (cacosmia or parosmia): distorted or perverted smell perception or odorant stimulation, 6) phantosmia: dysosmic sensation perceived in the absence of an odor stimulus (a.k.a. olfactory hallucination), 7) olfactory agnosia: inability to recognize an odor sensation (1).

It is also useful to classify olfactory dysfunction into three general classes: 1) conductive or transport impairments from obstruction of nasal passages (e.g. chronic nasal inflammation, polyposis, etc.), 2) sensorineural impairments from damage to neuroepithelium (e.g. viral infection, airborne toxins, etc.), 3) central olfactory neural impairment from central nervous system damage (e.g. tumors, masses impacting on olfactory tract, neurodegenerative disorders, etc.). These categories are not mutually exclusive. For example: viruses can cause damage to the olfactory neuroepithelium and they may also be transported into the central nervous system via the olfactory nerve causing damage to the central elements of the olfactory system (1).

The etiology of most cases of olfactory dysfunction can be ascertained from carefully questioning the patient about the nature, timing, onset, duration, and pattern of their symptoms. It is important to determine the degree of olfactory ability prior to the loss. And any historical determination of antecedent events, such as head trauma, upper respiratory infection, or toxic exposure, should be sought. Fluctuations in function and transient improvement with topical vasoconstriction usually indicate obstructive, rather then neural, causes. Medical conditions frequently associated with olfactory dysfunction should be identified, such as epilepsy, multiple sclerosis, Parkinson's disease, and Alzheimer's disease. Also any history of sinonasal disease and allergic symptoms, including any previous surgical

therapy for sinonasal disease should be investigated. In addition, patients who complain of taste loss, upon quantitative olfactory testing usually reveal an olfactory disorder (1).

Disclosed herein is that rasagiline effectively treats olfactory dysfunction. Rasagiline, R(+)-N-propargyl-1-aminoindan, is a potent second generation monoamine oxidase (MAO) B inhibitor (Finberg et al., Pharmacological properties of the anti-Parkinson drug rasagiline; modification of endogenous brain amines, reserpine reversal, serotonergic and dopaminergic behaviours, *Neuropharmacology* (2002) 43(7):1110-8). Rasagiline Mesylate in a 1 mg tablet is commercially available for the treatment of idiopathic Parkinson's disease as Azilect® from Teva Pharmaceuticals Industries, Ltd. (Petach Tikva, Israel) and H. Lundbeck A/S (Copenhagen, Denmark).

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Any description of prior art documents herein is not an admission that the documents form part of the common general knowledge of the relevant art in Australia.

Throughout this specification the word "comprise", or variations such as "comprises" or "comprising" will be understood to imply the inclusion of a stated element, integer or step, or group of elements, integers or steps, but not the exclusion of any other element, integer or step, or group of elements, integers or steps.

Summary of the Invention

The subject invention relates to a method of treating a symptom of olfactory dysfunction in a subject afflicted by olfactory dysfunction, the method comprising:

a) identifying the subject as afflicted by olfactory dysfunction, and

b) periodically administering to the subject so identified an amount of R(+)-N-propargyl-1-aminoindan or a pharmaceutically acceptable salt thereof, effective to treat the subject.

The subject invention also relates to a method of reducing the rate of progression of olfactory dysfunction in a non-Parkinson's disease subject afflicted by olfactory dysfunction, the method comprising periodically administering to the subject an amount of R(+)-N-propargyl-1-aminoindan or a pharmaceutically acceptable salt thereof effective to reduce the rate of progression of olfactory dysfunction in the non-Parkinson's disease subject.

The subject invention further relates to a method of inhibiting loss of olfactory function in a non-Parkinson's disease subject, the method comprising periodically administering to the subject an amount of R(+)-N-propargyl-1-aminoindan or a pharmaceutically acceptable salt thereof effective to inhibit loss of olfactory function in the non-Parkinson's disease subject.

The subject invention relates to a method of treating a symptom of olfactory dysfunction in a subject afflicted by olfactory dysfunction, the method comprising:

a) identifying the subject as afflicted by olfactory dysfunction, and

b) periodically administering to the subject so identified an amount of R(+)-N-propargyl-1-aminoindan or a pharmaceutically acceptable salt thereof, effective to treat the subject, wherein the subject is a non-Parkinson's disease subject.

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The subject invention also relates to a method of reducing the rate of progression of olfactory dysfunction in a non-Parkinson's disease subject afflicted by olfactory dysfunction, the method comprising periodically administering to the subject an amount of R(+)-N-propargyl-1-aminoindan or a pharmaceutically acceptable salt thereof, effective to reduce the rate of progression of olfactory dysfunction in the non-Parkinson's disease subject.

The subject invention further relates to a method of inhibiting loss of olfactory function in a non-Parkinson's disease subject, the method comprising periodically administering to the subject an amount of R(+)-N-propargyl-1-aminoindan or a pharmaceutically acceptable salt thereof, effective to inhibit loss of olfactory function in the non-Parkinson's disease subject.

The subject invention relates to use of R(+)-N-propargyl-1-aminoindan or a pharmaceutically acceptable salt thereof, in the preparation of a medicament for treating a symptom of olfactory dysfunction in a subject afflicted by olfactory dysfunction, wherein:

a) the subject is identified to be afflicted by olfactory dysfunction, and

b) the medicament is adapted to be periodically administered to the subject in an amount effective to treat the subject,

wherein the subject is a non-Parkinson's disease subject.

The subject invention also relates to use of R(+)-N-propargyl-1-aminoindan or a pharmaceutically acceptable salt thereof, in the preparation of a medicament for reducing the rate of progression of olfactory dysfunction in a non-Parkinson's disease subject afflicted by olfactory dysfunction, wherein the medicament is adapted to be periodically administered to the subject in an amount effective to reduce the rate of progression of olfactory dysfunction in the non-Parkinson's disease subject.

The subject invention further relates to use of R(+)-N-propargyl-1-aminoindan or a pharmaceutically acceptable salt thereof, in the preparation of a medicament for inhibiting loss of olfactory function in a non-Parkinson's disease subject, wherein the medicament is adapted to be periodically administered to the subject in an amount effective to inhibit loss of olfactory function in the non-Parkinson's disease subject.

The subject invention relates to use of R(+)-N-propargyl-1-aminoindan or a pharmaceutically acceptable salt thereof, in treating a symptom of olfactory dysfunction in a subject afflicted by olfactory dysfunction, the use comprising:

a) identifying the subject as afflicted by olfactory dysfunction, and

b) periodically administering to the subject so identified an amount of the R(+)-N-propargyl-1-aminoindan or the pharmaceutically acceptable salt thereof, effective to treat the subject,

wherein the subject is a non-Parkinson's disease subject.

The subject invention also relates to use of R(+)-N-propargyl-1-aminoindan or a pharmaceutically acceptable salt thereof, in reducing the rate of progression of olfactory dysfunction in a non-Parkinson's disease subject afflicted by olfactory dysfunction, the use comprising periodically administering to the subject an amount of the R(+)-N-propargyl-1-aminoindan or the pharmaceutically acceptable salt thereof, effective to reduce the rate of progression of olfactory dysfunction in the non-Parkinson's disease subject.

The subject invention further relates to use of R(+)-N-propargyl-1-aminoindan or a pharmaceutically acceptable salt thereof, in inhibiting loss of olfactory function in a non-Parkinson's disease subject, the use comprising periodically administering to the subject an amount of the R(+)-N-propargyl-1-aminoindan or the pharmaceutically acceptable salt thereof, effective to inhibit loss of olfactory function in the non-Parkinson's disease subject.

Brief Description of the Figures

Figure 1: Effect of rasagiline on odor detection threshold of wild type (WT) and mutant mice.

Figure 2: Effect of rasagiline on short-term olfactory memory.

Figure 3: Effect of rasagiline on the ability of WT and mutant mice to discriminate between familiar and novel social odors.

Figure 4: Effect of rasagiline on the ability of WT and mutant mice to discriminate between two close non-social odors.

Figure 5: Odor preference test in WT and mutant mice untreated or treated with rasagiline

Figure 6: Effect of rasagiline on object exploration of WT and mutant mice untreated or treated with rasagiline.

Figure 7: Effect of rasagiline on object/odor discrimination of WT and mutant mice untreated or treated with rasagiline.

Detailed Description of the Invention

The subject invention provides a method of treating a symptom of olfactory dysfunction in a subject afflicted by olfactory dysfunction, the method comprising:

a) identifying the subject as afflicted by olfactory dysfunction, and

b) periodically administering to the subject so identified an amount of R(+)-N-propargyl-1-aminoindan or a pharmaceutically acceptable salt thereof, effective to treat the subject.

In an embodiment of the method, the subject is a non-Parkinson's disease subject.

The subject invention also provides a method of reducing the rate of progression of olfactory dysfunction in a non-Parkinson's disease subject afflicted by olfactory dysfunction, the method comprising periodically administering to the subject an amount of R(+)-N-propargyl-1-aminoindan or a pharmaceutically acceptable salt thereof effective to reduce the rate of progression of olfactory dysfunction in the non-Parkinson's disease subject.

The subject invention further provides a method of inhibiting loss of olfactory function in a non-Parkinson's disease subject, the method comprising periodically administering to the subject an amount of R(+)-N-propargyl-1-aminoindan or a pharmaceutically acceptable salt thereof effective to inhibit loss of olfactory function in the non-Parkinson's disease subject.

In an embodiment of the method, the amount of R(+)-N-propargyl-1-aminoindan or of the pharmaceutically acceptable salt thereof is from 0.01 mg to 5 mg per day.

In another embodiment of the method, the amount of R(+)-N-propargyl-1-aminoindan or of the pharmaceutically acceptable salt thereof is 0.5 mg per day.

In yet another embodiment of the method, the amount of R(+)-N-propargyl-1-aminoindan or of the pharmaceutically acceptable salt thereof is 2 mg per day.

In yet another embodiment of the method, the amount of R(+)-N-propargyl-1-aminoindan or of the pharmaceutically acceptable salt thereof is 1 mg per day.

In yet another embodiment of the method, R(+)-N-propargyl-1-aminoindan is administered in the form of free base.

In yet another embodiment of the method, the pharmaceutically acceptable salt of R(+)-N-propargyl-1-aminoindan is esylate, mesylate, sulphate, citrate or tartrate.

In yet another embodiment of the method, the pharmaceutically acceptable salt is a mesylate salt.

In yet another embodiment of the method, the pharmaceutically acceptable salt is a citrate salt.

In yet another embodiment of the method, the olfactory dysfunction is selected from the group consisting of anosmia, partial anosmia, hyposmia, hyperosmia, dysosmia, phantosmia, and olfactory agnosia.

In yet another embodiment of the method, the olfactory dysfunction is caused by a condition selected from the group consisting of head trauma, upper respiratory infection, toxic exposure, epilepsy, multiple sclerosis, Parkinson's disease,Alzheimer's disease, sinonasal disease, Addison's disease, Turner's syndrome, Cushing's syndrome, hypothyroidism, pseudohypoparathyroidism, Kallmann's syndrome and neoplasm.

In yet another embodiment of the method, the amount of R(+)-N-propargyl-1-aminoindan or a pharmaceutically acceptable salt thereof is formulated in oral, parenteral, rectal, or transdermal formulation.

By any range disclosed herein, it is meant that all hundredth, tenth and integer unit amounts within the range are specifically disclosed as part of the invention. Thus, for example, 0.01 mg to 50 mg means that 0.02, 0.03 ... 0.09; 0.1, 0.2 ... 0.9; and 1, 2 ... 49 mg unit amounts are included as embodiments of this invention.

As used herein, a Parkinson's disease (PD) patient is a patient who has been disgnosed with any of the following five PD stages described by Hoehn and Yahr (Hoehn MM, Yahr MD, Parkinsonism: onset, progression and mortality. *Neurology* 1967, **17**:427–42).

Stage I: (mild or early disease): Symptoms affect only one side of the body.
Stage II: Both sides of the body are affected, but posture remains normal.
Stage III: (moderate disease): Both sides of the body are affected, and there is mild imbalance during standing or walking. However, the person remains independent.
Stage IV: (advanced disease): Both sides of the body are affected, and there is disabling instability while standing or walking. The person in this stage requires substantial help.
Stage V: Severe, fully developed disease is present. The person is restricted to a bed or chair.

As used herein, a "non-Parkinson's disease" patient is a patient who has not been diagnosed with any of the five PD stages described by Hoehn and Yahr.

As used herein, a "symptom of olfactory dysfunction" is one or more of the following:

a) decreased odor detection threshold;
b) decreased short-term olfactory memory;
c) decreased discriminating ability of a social odor;
d) decreased discriminating ability of a non-social odor.

As used herein, "functional decline" means the worsening of a symptom of olfactory dysfunction in a patient suffering from olfactory dysfunction over time.

As used herein, "reducing the rate of progression of olfactory dysfunction" means reducing the rate of progression of functional decline experienced by a patient suffering from olfactory dysfunction, as compared to the rate experienced by a patient suffering olfactory dysfunction and not receiving rasagiline over a period of time.

As used herein, a "pharmaceutically acceptable salt" of rasagiline includes citrate, tannate, malate, mesylate, maleate, fumarate, tartrate, esylate, p-toluenesulfonate, benzoate, acetate, phosphate and sulfate salts. For the preparation of pharmaceutically acceptable acid addition salts of the compounds of the invention, the free base can be reacted with the desired acids in the presence of a suitable solvent by conventional methods.

As used herein, an example of an immediate release formulation of rasagiline is an AZILECT® Tablet containing rasagiline mesylate.

Rasagiline can also be used in its free base form. A process of manufacture of the rasagiline base is described in PCT publication WO 2008/076348, the contents of which are hereby incorporated by reference.

As used herein, a "pharmaceutically acceptable" carrier or excipient is one that is suitable for use with humans and/or animals without undue adverse side effects (such as toxicity, irritation, and allergic response) commensurate with a reasonable benefit/risk ratio.

Specific examples of pharmaceutically acceptable carriers and excipients that may be used to formulate oral dosage forms of the present invention are described, e.g., in U.S. Patent No. 6,126,968 to Peskin et al., issued Oct. 3, 2000. Techniques and compositions for making dosage forms useful in the present invention are described, for example, in the following references: 7 Modern Pharmaceutics, Chapters 9 and 10 (Banker & Rhodes, Editors, 1979); Pharmaceutical Dosage Forms: Tablets (Lieberman et al., 1981); Ansel, Introduction to Pharmaceutical Dosage Forms 2nd Edition (1976); Remington's Pharmaceutical Sciences, 17th ed. (Mack Publishing Company, Easton, Pa., 1985); Advances in Pharmaceutical Sciences (David Ganderton, Trevor Jones, Eds., 1992); Advances in Pharmaceutical Sciences Vol 7. (David Ganderton, Trevor Jones, James McGinity, Eds., 1995); Aqueous Polymeric Coatings for Pharmaceutical Dosage Forms (Drugs and the Pharmaceutical Sciences, Series 36 (James McGinity, Ed., 1989); Pharmaceutical Particulate Carriers: Therapeutic Applications: Drugs and the Pharmaceutical Sciences, Vol 61 (Alain Rolland, Ed., 1993); Drug Delivery to the Gastrointestinal Tract (Ellis Horwood Books in the Biological Sciences. Series in Pharmaceutical Technology; J. G. Hardy, S. S. Davis, Clive G. Wilson, Eds.); Modern Pharmaceutics Drugs and the Pharmaceutical Sciences, Vol 40 (Gilbert S. Banker, Christopher T. Rhodes, Eds.).

The pharmaceutical dosage forms may be prepared as medicaments to be administered orally, parenterally, rectally or transdermally. Suitable forms for oral administration include tablets, compressed or coated pills, dragees, sachets, hard or soft gelatin capsules, sublingual tablets, syrups and suspensions; for parenteral administration the invention provides ampoules or vials that include an aqueous or non-aqueous solution or emulsion; for rectal administration the invention provides suppositories with hydrophilic or hydrophobic vehicles; for topical

application as ointments; and for transdermal delivery the invention provides suitable delivery systems as known in the art.

Tablets may contain suitable binders, lubricants, disintegrating agents, coloring agents, flavoring agents, flow-inducing agents, melting agents, stabilizing agents, solubilizing agents, antioxidants, buffering agent, chelating agents, fillers and plasticizers. For instance, for oral administration in the dosage unit form of a tablet or capsule, the active drug component can be combined with an oral, non-toxic, pharmaceutically acceptable, inert carrier such as gelatin, agar, starch, methyl cellulose, dicalcium phosphate, calcium sulfate, mannitol, sorbitol, microcrystalline cellulose and the like. Suitable binders include starch, gelatin, natural sugars such as corn starch, natural and synthetic gums such as acacia, tragacanth, or sodium alginate, povidone, carboxymethylcellulose, polyethylene glycol, waxes, and the like. Antioxidants include ascorbic acid, fumaric acid, citric acid, malic acid, gallic acid and its salts and esters, butylated hydroxyanisole, editic acid. Lubricants used in these dosage forms include sodium oleate, sodium stearate, sodium benzoate, sodium acetate, stearic acid, sodium stearyl fumarate, talc and the like. Disintegrators include, without limitation, starch, methyl cellulose, agar, bentonite, xanthan gum, croscarmellose sodium, sodium starch glycolate and the like, suitable plasticizers include triacetin, triethyl citrate, dibutyl sebacate, polyethylene glycol and the like.

One type of oral dosage forms of the present invention relates to delayed release formulations. Such formulations may be comprised of an acid resistant excipient which prevents the dosage form or parts thereof from contacting the acidic environment of the stomach. The acid resistant excipient may coat the rasagiline in the form of an enteric coated tablet, capsule, or gelatin capsule. Enteric coating, in the context of this invention, is a coating which prevents the dissolution of an active ingredient in the stomach. Specific examples of pharmaceutically acceptable carriers and excipients that may be used to formulate such delayed release formulations are described, e.g., in International Application Publication No. WO 06/014973, hereby incorporated by reference in its entirety.

Another type of oral dosage forms of the present invention relates to fast disintegrating formulations which provide a means to avoid the absorption of rasagiline in the stomach, and to eliminate the need for swallowing tablets, by absorption of rasagiline into the body before

reaching the stomach. Such absorption of rasagiline can be accomplished by contact with the buccal, sublingual, pharyngeal and/or esophageal mucous membranes. To accomplish this, the fast disintegrating formulations were designed to rapidly disperse within the mouth to allow maximum contact of rasagiline with the buccal, sublingual, pharyngeal and/or esophageal mucous membranes. Specific examples of pharmaceutically acceptable carriers and excipients that may be used to formulate such fast disintegrating formulations are described, e.g., in International Application Publication No. WO 03/051338, hereby incorporated by reference in its entirety.

Other pharmaceutical compositions of the present invention include transdermal patches. Transdermal patches are medicated adhesive patches placed on the skin to deliver a time-released dose of medication through the skin and into the bloodstream. A wide variety of pharmaceuticals can be delivered through transdermal patches. Some pharmaceuticals must be combined with other substances, for example alcohol, to increase their ability to penetrate the skin. Transdermal patches have several important components, including a liner to protect the patch during storage, the drug, adhesive, a membrane (to control release of the drug from the reservoir), and a backing to protect the patch from the outer environment. The two most common types of transdermal patches are matrix and reservoir types. (Wikipedia; and Remington, The Science and Practice of Pharmacy, 20th Edition, 2000)

In reservoir type patches, a drug is combined with a non-volatile, inert liquid, such as mineral oil, whereas in matrix type patches a drug is dispersed in a lipophilic or hydrophilic polymer matrix such as acrylic or vinylic polymers. Adhesive polymers, such as polyisobutylene, are used to hold the patch in place on the skin. (Stanley Scheindlin, (2004) "Transdermal Drug Delivery: PAST, PRESENT, FUTURE," Molecular Interventions, 4:308-312)

The major limitation to transdermal drug-delivery is the intrinsic barrier property of the skin. Penetration enhancers are often added to transdermal drug formulations in order to disrupt the skin surface and cause faster drug delivery. Typical penetration enhancers include high-boiling alcohols, diols, fatty acid esters, oleic acid and glyceride-based solvents, and are commonly added at a concentration of one to 20 percent (w/w). (Melinda Hopp, "Developing Custom Adhesive Systems for Transdermal Drug Delivery Products," Drug Delivery)

This invention will be better understood from the experimental details which follow. However, one skilled in the art will readily appreciate that the specific methods and results discussed are merely illustrative of the invention as described more fully in the claims which follow thereafter.

5

Experimental Details

Study Design

Wild type (WT) and alpha-synuclein over-expressing (mutants) 11 months' males were treated with 3mg/kg of rasagiline in the drinking water for eight weeks. Olfaction tests started four weeks after the beginning of the rasagiline treatment. The number of mice in each treatment group is summarized in table below.

Treatment / Mice	Water	Rasagiline
Control	21	18
Mutant	19	20

Alpha-Synuclein Over-Expressing Mice

Transgenic mice overexpressing alpha-synuclein under the Thy1 promoter (Thy1-aSyn) have high levels of alpha-synuclein expression throughout the brain but no loss of nigrostriatal dopamine neurons up to 8 months. Thus, such mice are useful to model pre-clinical stages of PD, in particular, olfactory dysfunction which often precedes the onset of the cardinal motor symptoms of PD by several years and includes deficits in odor detection, discrimination and identification. Overexpression of alpha-synuclein is sufficient to cause olfactory deficits in mice similar to that observed in patients with PD (2).

The following olfaction tests were performed during the study:

1. Social odor discrimination test
2. Non-social odor discrimination test
3. Odor detection test
4. Short term olfactory memory test

The following control tests were performed during the study:

1. Object exploration test
2. Object/odor discrimination test
3. Odor preference

Example 1: Odor Detection Threshold Determination

This experiment was designed to determine whether rasagiline had positive effect on odor detection threshold of olfactory challenged animals (Figure 1A). Odor detection threshold is the lowest concentration (dilution 10^{-8}; 10^{-6}; 10^{-4} in the water) at which mice are able to detect a novel odor. Upon detection of a novel odor, mice will spend more time sniffing it. The detection threshold was measured as percentage of time sniffing novel odor out of total time of sniffing.

Results:

The results of the experiment are summarized in tables 1a-1d. The analysis was performed by 2-way ANOVA followed by Bonferroni post-hoc test (*p<0.05, **p<0.01, ***p<0.001).

Table 1a: Odor detection threshold of WT untreated mice

Treatment Group (n=10)			**% time sniffing odor at concentration:**		
Mice	**Genotype**	**Treatment**	**10^{-8}**	**10^{-6}**	**10^{-4}**
2	WT	Water	48.3	51.4	61.4
6	WT	Water	48.1	74.5	74.6
13	WT	Water	51.3	63.2	66.2
17	WT	Water	35.8	77.7	68.1
20	WT	Water	59.0	60.8	65.5
24	WT	Water	45.7	67.8	54.6
26	WT	Water	52.2	68.7	68.5
27	WT	Water	59.5	53.3	41.2
31	WT	Water	49.7	60.1	67.4
35	WT	Water	53.5	71.9	55.0
Mean			**50.3**	**64.9**	**62.2**
SEM			**2.2**	**2.8**	**3.0**

Table 1b: Odor detection threshold of WT mice receiving rasagiline

Treatment Group (n=9)			**% time sniffing odor at concentration:**		
Mice	**Genotype**	**Treatment**	**10^{-8}**	**10^{-6}**	**10^{-4}**
1	WT	Ras	38.4	44.4	70.2
5	WT	Ras	49.3	61.0	74.5
9	WT	Ras	48.3	56.1	74.4
12	WT	Ras	45.9	51.9	41.9
14	WT	Ras	52.7	83.5	86.4
18	WT	Ras	43.3	61.1	68.7
23	WT	Ras	39.1	82.5	56.0
33	WT	Ras	46.6	46.2	57.4
38	WT	Ras	40.4	64.9	
Mean			**44.9**	**61.3**	**66.2**
SEM			**1.7**	**4.7**	**4.9**

Table 1c: Odor detection threshold of untreated α-syn mutants

Treatment Group (n=10)			**% time sniffing odor at concentration:**		
Mice	**Genotype**	**Treatment**	**10^{-8}**	**10^{-6}**	**10^{-4}**
3	Mutant	Water	46.0	58.0	72.5
7	Mutant	Water	47.9	48.1	66.9
10	Mutant	Water	53.7	39.5	64.8
11	Mutant	Water	33.3	48.1	50.3
16	Mutant	Water	49.9	40.9	55.7
19	Mutant	Water	47.6	56.2	65.7
22	Mutant	Water	57.2	41.3	61.9
29	Mutant	Water	58.4	40.8	67.0
32	Mutant	Water	44.9	68.1	55.8
36	Mutant	Water	50.9	51.7	72.0
Mean			**49.0**	**49.3**	**63.2**
SEM			**2.3**	**3.0**	**2.3**

Table 1d: Odor detection threshold of α-syn mutants receiving rasagiline

Treatment Group (n=9)			**% time sniffing odor at concentration:**		
Mice	**Genotype**	**Treatment**	**10^{-8}**	**10^{-6}**	**10^{-4}**
4	Mutant	Ras	43.7	60.2	73.6
8	Mutant	Ras	50.1	74.8	86.6
15	Mutant	Ras	40.9	50.0	62.2
21	Mutant	Ras	41.4	50.8	66.6
25	Mutant	Ras	64.4	54.1	57.7
28	Mutant	Ras	58.3	56.9	67.4
30	Mutant	Ras	50.5	60.2	60.7
34	Mutant	Ras	38.8	80.6	55.7
37	Mutant	Ras	49.8	62.8	62.7
Mean			**48.7**	**61.1**	**65.9**
SEM			**2.8**	**3.5**	**3.2**

Discussion:

The results above demonstrate that rasagiline improved the odor threshold of α-syn mutants from 10^{-4} to 10^{-6} (Figure 1B). The data in Figure 1B were analyzed by 2-way ANOVA with Effect of the concentration $p<0.001$; No effect of the group $p>0.05$; No interaction conc *group $p>0.05$; and Bonferroni post-hoc (*$p<0.05$, **$p<0.01$ and ***$p<0.001$). Figure 1B shows that mutants need a higher concentration (10^{-4}) to detect the odor compared to controls (10^{-6}) and that rasagiline improves the odor detection threshold of mutants.

The results above also demonstrate that at the concentration of 10^{-6}, rasagiline improved the odor detection ability of α-syn mutants (Figure 1C). The data in Figure 1C were analyzed by 2-way ANOVA with Bonferroni post-hoc, *$p<0.05$, **$p<0.01$; At 10^{-8}: No effect of genotype and treatment, No interaction genotype*treat; At 10^{-6}: No effect treatment, Effect of genotype and interaction genotype*treat $p<0.05$; and At 10^{-4}: No effect of genotype and treatment, No interaction genotype*treat. Figure 1C shows that at the concentration 10^{-6}, untreated mutants don't detect the odor and rasagiline improves the odor detection ability of mutants.

Example 2: Short-term olfactory memory

This experiment was designed to assess the effect of rasagiline on the capability of the mutant animals to remember a novel odor during a short time interval of 1 min, 1 min 30s or 2 min (Figure 2A). The underlying principle was that if mice would spend less time sniffing the odor at T2 (second exposure to the odor) their short term olfactory memory is intact. The testing parameter was percentage of time of sniffing at T2, calculated as time of sniffing at T2 out of total time of sniffing at T1 (first exposure) & T2.

Results:

The results of the experiment are summarized in tables 2a-2d. The analysis was performed by 2-way ANOVA followed by Bonferroni post-hoc, or by a non parametric test, Kruskal-Wallis, when the normal distribution failed.

Table 2a: Short-term olfactory memory of WT untreated mice

Treatment Group (n=10)			**% time sniffing during T2 after interval:**		
Mice	**Genotype**	**Treatment**	**1 min**	**1.5 min**	**2 min**
2-2	WT	Water	35.4	25.9	37.1
2-6	WT	Water	36.6	20.1	19.6
2-13	WT	Water	46.7	53.5	19.6
2-17	WT	Water	12.9	28.6	37.2
2-20	WT	Water	8.8	39.1	34.8
2-24	WT	Water	46.8	42.7	33.8
2-26	WT	Water	41.0	33.6	36.1
2-27	WT	Water	11.2	35.6	27.0
2-31	WT	Water	8.0	26.5	39.7
2-35	WT	Water	24.0	19.3	35.5
Mean			**27.1**	**32.5**	**32.0**
SEM			**5.0**	**3.4**	**2.3**

Table 2b: Short-term olfactory memory of WT mice receiving rasagiline

Treatment Group (n=9)			**% time sniffing during T2 after interval:**		
Mice	**Genotype**	**Treatment**	**1 min**	**1.5 min**	**2 min**
2-1	WT	Ras	18.8	8.6	19.9
2-5	WT	Ras	44.9	23.4	59.2
2-9	WT	Ras	47.6	20.4	25.5
2-12	WT	Ras	2.3	34.4	27.9
2-14	WT	Ras	7.6	19.4	33.3
2-18	WT	Ras	3.3	29.8	58.3
2-23	WT	Ras	28.0	32.5	31.6
2-33	WT	Ras	13.2	41.4	41.0
2-38	WT	Ras	12.7	10.4	36.0
Mean			19.8	24.5	37.0
SEM			**5.6**	**3.7**	**4.6**

Table 2c: Short-term olfactory memory of untreated α-syn mutants

Treatment Group 2 (n=10)			**% time sniffing during T2 after interval:**		
Mice	**Genotype**	**Treatment**	**1 min**	**1.5 min**	**2 min**
2-3	Mutant	Water	2.6	36.8	30.6
2-7	Mutant	Water	13.7	23.3	48.9
2-10	Mutant	Water	18.3	23.2	55.6
2-11	Mutant	Water	24.0	23.1	67.1
2-16	Mutant	Water	38.1	36.8	57.4
2-19	Mutant	Water	46.0	31.0	45.9
2-22	Mutant	Water	18.6	29.0	50.3
2-29	Mutant	Water	21.4	75.6	32.6
2-32	Mutant	Water	27.5	33.9	30.1
2-36	Mutant	Water	19.5	44.3	34.0
Mean			23.0	35.7	45.2
SEM			**3.9**	**5.0**	**4.1**

Table 2d: Short-term olfactory memory of α-syn mutants receiving rasagiline

Treatment Group 2 (n=9)			**% time sniffing during T2 after interval:**		
Mice	**Genotype**	**Treatment**	**1 min**	**1.5 min**	**2 min**
2-4	Mutant	Ras	19.1	28.6	52.8
2-8	Mutant	Ras	22.9	40.9	44.1
2-15	Mutant	Ras	20.1	27.7	25.7
2-21	Mutant	Ras	30.1	19.2	51.8
2-25	Mutant	Ras	26.4	25.2	22.7
2-28	Mutant	Ras	37.8	23.3	38.1
2-30	Mutant	Ras	16.7	26.6	67.2
2-34	Mutant	Ras	13.4	20.2	56.8
2-37	Mutant	Ras	17.9	27.5	44.4
Mean			**22.7**	**26.6**	**44.8**
SEM			**2.5**	**2.1**	**4.8**

Discussion:

The results above demonstrate that rasagiline has positive effect on short term olfactory memory of WT and of α-syn mutants mice, in particular at the 1.5 min interval (Figures 2B&C).

The data in Figure 2B were analyzed by 2-way ANOVA with Effect of ITI $p<0.001$; No effect of the group $p>0.05$; No interaction ITI*group $p>0.05$; and Bonferroni post-hoc (*$p<0.05$, **$p<0.01$, ***$p<0.001$). Figure 2B shows that that at ITI of 2 min, mutants and WT-Ras showed a reduced short-term olfactory memory compared to WT-water.

The data in Figure 2C were analyzed by 2-way ANOVA followed by Bonferroni post-hoc, *$p>0.05$ at 1 min and 2 min and by a non parametric test, Kruskal-Wallis, at 1.5 min ; At 1 min: No effect of genotype and treatment, No interaction genotype*treat; At 1.5 min: no statistical difference between groups, $p>0.05$, Effect of treatment $p<0.05$, No effect of genotype and no interaction genotype*treat; and At 2 min: Effect of genotype $p<0.05$, No effect of genotype and no interaction genotype*treat. Figure 2C shows that at 1.5 min, rasagiline had a positive effect on short term olfactory memory for both WT and mutants.

Example 3: Social Odor discrimination

This experiment was designed to assess effect of rasagiline on the capability of the mice to discriminate between a familiar social odor (F) and a novel social odor (N) (Figure 3A). Mice capable of discriminating between the odors would spend more time sniffing the new odor. The experiment was further subdivided into two levels of odor intensity:

Light intensity: two days of odor impregnation

Strong intensity: seven days of odor impregnation

The testing parameter was percentage of time of sniffing novel odor out of total time of sniffing.

Results:

1. Discrimination of light social odors:

The results of the experiment are summarized in tables 3a-3d. The analysis was performed a non parametric test, Kruskal-Wallis, and Mann-Whitney test was used as post-hoc (***$p<0.001$).

Table 3a: Discrimination of light social odors by WT untreated mice

Mice (n=21)	Genotype	Treatment	Time Sniffing F	Time Sniffing N	Total time sniffing	% time sniffing N
1-2	**WT**	**Water**	2.9	7.3	10.2	71.4
1-6	**WT**	**Water**	17.6	39.3	56.9	69.1
1-13	**WT**	**Water**	1.7	6.1	7.8	78.2
1-17	**WT**	**Water**	12.0	4.2	16.2	25.7
1-20	**WT**	**Water**	4.3	21.5	25.8	83.5
1-24	**WT**	**Water**	8.0	6.1	14.1	43.3
1-26	**WT**	**Water**	3.9	15.6	19.5	80.0
1-27	**WT**	**Water**	3.5	10.8	14.3	75.3
1-31	**WT**	**Water**	12.4	42.7	55.1	77.6
1-35	**WT**	**Water**	2.4	13.8	16.2	85.3
2-2	**WT**	**Water**	3.8	13.4	17.2	77.9
2-6	**WT**	**Water**	7.1	60.8	67.9	89.5
2-16	**WT**	**Water**	2.2	13.7	15.9	86.2
2-19	**WT**	**Water**	2.6	8.9	11.5	77.3
2-20	**WT**	**Water**	8.4	31.1	39.5	78.8
2-22	**WT**	**Water**	5.3	46.6	51.9	89.8
2-24	**WT**	**Water**	6.3	15.9	22.2	71.6
2-28	**WT**	**Water**	1.4	61.9	63.2	97.8
2-31	**WT**	**Water**	4.8	17.6	22.4	78.5
2-34	**WT**	**Water**	4.0	12.4	16.4	75.6
2-35	**WT**	**Water**	12.5	25.7	38.2	67.3
Mean			**6.0**	**22.6**	**28.7**	**75.2**
SEM			**0.9**	**3.9**	**4.2**	**3.4**

Table 3b: Discrimination of light social odors by WT mice receiving rasagiline

Mice (n=18)	Genotype	Treatment	Time Sniffing F	Time Sniffing N	Total time sniffing	% time sniffing N
1-1	WT	Rasagiline	2.9	4.2	7.1	59.2
1-5	WT	Rasagiline	8.5	10.7	19.1	55.9
1-9	WT	Rasagiline	2.2	60.0	62.2	96.5
1-12	WT	Rasagiline	1.9	7.4	9.3	79.2
1-14	WT	Rasagiline	6.3	3.7	10.0	37.2
1-18	WT	Rasagiline	4.8	6.2	11.0	56.4
1-23	WT	Rasagiline	5.8	21.6	27.4	78.8
1-33	WT	Rasagiline	7.9	7.1	15.0	47.4
1-38	WT	Rasagiline	7.3	21.6	28.9	74.7
2-1	WT	Rasagiline	3.6	36.2	39.8	91.0
2-5	WT	Rasagiline	4.5	16.8	21.3	78.9
2-17	WT	Rasagiline	2.8	7.6	10.4	73.0
2-18	WT	Rasagiline	39.8	56.5	96.3	58.7
2-23	WT	Rasagiline	3.9	17.2	21.1	81.5
2-29	WT	Rasagiline	2.1	18.1	20.2	89.6
2-33	WT	Rasagiline	6.7	2.9	9.6	30.5
2-36	WT	Rasagiline	4.8	36.7	41.5	88.4
2-37	WT	Rasagiline	6.2	7.2	13.4	53.6
Mean			**6.8**	**19.0**	**25.8**	**68.4**
SEM			**2.0**	**4.1**	**5.3**	**4.5**

Table 3c: Discrimination of light social odors by untreated α-syn mutants

Mice (n=19)	Genotype	Treatment	Time Sniffing F	Time Sniffing N	Total time sniffing	% time sniffing N
1-3	Mutant	**Water**	3.6	4.9	8.5	58.0
1-7	Mutant	**Water**	3.8	3.8	7.6	50.3
1-10	Mutant	**Water**	3.0	6.1	9.1	66.8
1-11	Mutant	**Water**	2.2	3.3	5.5	60.6
1-16	Mutant	**Water**	2.6	4.8	7.4	64.7
1-19	Mutant	**Water**	6.3	6.7	12.9	51.5
1-22	Mutant	**Water**	2.6	14.0	16.6	84.3
1-29	Mutant	**Water**	3.2	3.7	6.9	53.4
1-32	Mutant	**Water**	2.4	2.6	5.1	51.9
1-36	Mutant	**Water**	6.3	1.0	7.3	13.6
2-3	Mutant	**Water**	5.0	4.7	9.7	48.2
2-7	Mutant	**Water**	11.6	60.2	71.8	83.9
2-11	Mutant	**Water**	4.6	3.4	8.0	42.6
2-12	Mutant	**Water**	5.0	9.8	14.8	66.2
2-13	Mutant	**Water**	5.3	4.3	9.6	45.0
2-26	Mutant	**Water**	4.2	4.9	9.1	53.9
2-27	Mutant	**Water**	3.0	3.7	6.7	55.1
2-39	Mutant	**Water**	5.3	6.5	11.8	54.9
2-40	Mutant	**Water**	6.1	5.6	11.7	47.9
Mean			**4.5**	**8.1**	**12.6**	**55.4**
SEM			**0.5**	**3.0**	**3.4**	**3.5**

Table 3d: Discrimination of light social odors α-syn mutants receiving rasagiline

Mice (n=20)	Genotype	Treatment	Time Sniffing F	Time Sniffing N	Total time sniffing	% time sniffing N
1-4	Mutant	**Rasagiline**	1.0	6.4	7.4	86.4
1-8	Mutant	**Rasagiline**	3.3	8.3	11.6	71.3
1-15	Mutant	**Rasagiline**	2.8	5.8	8.6	67.8
1-21	Mutant	**Rasagiline**	3.1	5.8	8.9	65.5
1-25	Mutant	**Rasagiline**	3.6	6.6	10.2	64.7
1-28	Mutant	**Rasagiline**	2.4	3.5	5.9	59.6
1-30	Mutant	**Rasagiline**	3.1	6.6	9.7	68.3
1-34	Mutant	**Rasagiline**	2.2	4.9	7.2	68.8
1-37	Mutant	**Rasagiline**	2.7	14.6	17.3	84.3
2-4	Mutant	**Rasagiline**	5.2	9.1	14.3	63.6
2-8	Mutant	**Rasagiline**	2.5	12.9	15.4	83.8
2-9	Mutant	**Rasagiline**	3.4	8.4	11.8	71.1
2-10	Mutant	**Rasagiline**	2.4	12.0	14.4	83.3
2-14	Mutant	**Rasagiline**	2.0	1.6	3.6	44.4
2-15	Mutant	**Rasagiline**	3.2	11.4	14.6	78.0
2-21	Mutant	**Rasagiline**	3.4	6.6	10.0	65.9
2-25	Mutant	**Rasagiline**	5.8	14.5	20.3	71.4
2-30	Mutant	**Rasagiline**	2.1	6.8	8.9	76.5
2-32	Mutant	**Rasagiline**	5.1	10.8	15.9	67.9
2-38	Mutant	**Rasagiline**	2.5	6.9	9.4	73.4
Mean			**3.1**	**8.2**	**11.3**	**70.8**
SEM			**0.3**	**0.8**	**0.9**	**2.2**

2. Discrimination of strong social odors:

The results of the experiment are summarized in tables 3e-3h. The analysis was performed by 2-way ANOVA.

Table 3e: Discrimination of strong social odors by WT untreated mice

Mice (n=21)	Genotype	Treatment	Time Sniffing F	Time Sniffing N	Total time sniffing	% time sniffing N
1-2	WT	Water	4.4	10.1	14.5	69.8
1-6	WT	Water	9.5	16.6	26.0	63.7
1-13	WT	Water	3.2	7.0	10.2	68.9
1-17	WT	Water	7.9	27.2	35.0	77.5
1-20	WT	Water	10.2	27.7	37.9	73.2
1-24	WT	Water	8.7	15.6	24.4	64.2
1-26	WT	Water	13.2	49.8	63.1	79.0
1-27	WT	Water	0.2	76.7	76.9	99.7
1-31	WT	Water	3.9	68.1	72.0	94.6
1-35	WT	Water	3.4	7.4	10.7	68.8
2-2	WT	Water	4.0	21.4	25.4	84.3
2-6	WT	Water	6.8	14.2	21.0	67.6
2-16	WT	Water	3.9	13.6	17.5	77.7
2-19	WT	Water	2.8	12.5	15.3	82.0
2-20	WT	Water	5.4	10.0	15.4	65.1
2-22	WT	Water	6.1	14.6	20.7	70.5
2-24	WT	Water	7.8	8.9	16.7	53.4
2-28	WT	Water	8.2	56.1	64.3	87.2
2-31	WT	Water	11.6	31.2	42.8	72.9
2-34	WT	Water	2.5	10.8	13.3	81.4
2-35	WT	Water	3.5	22.5	26.0	86.6
Mean			**6.0**	**24.9**	**30.9**	**75.6**
SEM			**0.7**	**4.5**	**4.6**	**2.4**

Table 3f: Discrimination of strong social odors by WT mice receiving rasagiline

Mice (n=18)	Genotype	Treatment	Time Sniffing F	Time Sniffing N	Total time sniffing	% time sniffing N
1-1	**WT**	**Rasagiline**	4.0	26.1	30.0	86.8
1-5	**WT**	**Rasagiline**	5.9	36.2	42.2	86.0
1-9	**WT**	**Rasagiline**	1.9	20.8	22.6	91.8
1-12	**WT**	**Rasagiline**	2.1	11.7	13.9	84.7
1-14	**WT**	**Rasagiline**	1.2	45.7	46.8	97.5
1-18	**WT**	**Rasagiline**	4.7	6.0	10.7	56.4
1-23	**WT**	**Rasagiline**	5.3	34.1	39.5	86.5
1-33	**WT**	**Rasagiline**	2.8	60.9	63.7	95.6
1-38	**WT**	**Rasagiline**	8.9	36.6	45.5	80.4
2-1	**WT**	**Rasagiline**	4.7	28.8	33.5	86.0
2-5	**WT**	**Rasagiline**	5.1	14.1	19.2	73.3
2-17	**WT**	**Rasagiline**	4.5	21.0	25.5	82.5
2-18	**WT**	**Rasagiline**	21.4	25.1	46.5	54.0
2-23	**WT**	**Rasagiline**	5.9	37.9	43.8	86.5
2-29	**WT**	**Rasagiline**	3.2	48.7	51.9	93.8
2-33	**WT**	**Rasagiline**	0.9	3.9	4.8	81.1
2-36	**WT**	**Rasagiline**	6.7	60.4	67.1	90.0
2-37	**WT**	**Rasagiline**	1.7	12.1	13.8	87.7
Mean			**5.0**	**29.5**	**34.5**	**83.4**
SEM			**1.1**	**4.0**	**4.3**	**2.8**

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Table 3g: Discrimination of strong social odors by untreated α-syn mutants

Mice (n=19)	Genotype	Treatment	Time Sniffing F	Time Sniffing N	Total time sniffing	% time sniffing N
1-3	Mutant	Water	4.0	1.6	5.6	29.2
1-7	Mutant	Water	2.4	2.7	5.0	53.1
1-10	Mutant	Water	1.5	4.2	5.7	73.6
1-11	Mutant	Water	2.4	3.3	5.6	58.0
1-16	Mutant	Water	2.5	3.7	6.1	60.1
1-19	Mutant	Water	1.8	2.7	4.5	60.5
1-22	Mutant	Water	5.0	10.2	15.2	67.3
1-29	Mutant	Water	2.9	4.0	6.9	58.3
1-32	Mutant	Water	4.6	13.8	18.4	74.9
1-36	Mutant	Water	2.8	3.4	6.3	55.0
2-3	Mutant	Water	5.6	6.7	12.3	54.4
2-7	Mutant	Water	7.5	24.4	31.9	76.5
2-11	Mutant	Water	2.4	9.6	12.0	79.9
2-12	Mutant	Water	2.0	10.3	12.3	83.8
2-13	Mutant	Water	5.8	5.3	11.1	47.7
2-26	Mutant	Water	6.5	2.5	9.0	27.7
2-27	Mutant	Water	4.4	3.4	7.8	43.5
2-39	Mutant	Water	4.7	4.5	9.2	49.1
2-40	Mutant	Water	1.4	2.1	3.5	60.0
Mean			**3.7**	**6.2**	**9.9**	**58.6**
SEM			**0.4**	**1.3**	**1.5**	**3.5**

Table 3h: Discrimination of strong social odors α-syn mutants receiving rasagiline

Mice (n=20)	Genotype	Treatment	Time Sniffing F	Time Sniffing N	Total time sniffing	% time sniffing N
1-4	Mutant	**Rasagiline**	3.66	3.36	7.0	47.9
1-8	Mutant	**Rasagiline**	6.98	6.04	13.0	46.4
1-15	Mutant	**Rasagiline**	2.28	4.87	7.2	68.1
1-21	Mutant	**Rasagiline**	1.62	3.21	4.8	66.5
1-25	Mutant	**Rasagiline**	2.96	6.47	9.4	68.6
1-28	Mutant	**Rasagiline**	2.60	5.92	8.5	69.5
1-30	Mutant	**Rasagiline**	5.02	12.57	17.6	71.5
1-34	Mutant	**Rasagiline**	2.00	5.65	7.7	73.9
1-37	Mutant	**Rasagiline**	3.12	8.64	11.8	73.5
2-4	Mutant	**Rasagiline**	2.1	4.3	6.4	66.7
2-8	Mutant	**Rasagiline**	5.0	36.0	41.0	87.8
2-9	Mutant	**Rasagiline**	2.2	5.3	7.4	70.9
2-10	Mutant	**Rasagiline**	3.0	18.1	21.1	85.8
2-14	Mutant	**Rasagiline**	3.0	5.2	8.2	63.4
2-15	Mutant	**Rasagiline**	1.8	4.0	5.8	69.6
2-21	Mutant	**Rasagiline**	2.4	6.8	9.2	74.0
2-25	Mutant	**Rasagiline**	1.8	5.3	7.0	74.9
2-30	Mutant	**Rasagiline**	3.3	7.1	10.4	68.4
2-32	Mutant	**Rasagiline**	4.5	29.8	34.3	86.9
2-38	Mutant	**Rasagiline**	3.6	7.1	10.7	66.2
Mean			**3.1**	**9.3**	**12.4**	**70.0**
SEM			**0.3**	**2.0**	**2.1**	**2.3**

Discussion:

Discrimination of light social odor intensity:

The results above demonstrate that rasagiline improves discrimination of light social odor in α-syn mutants mice (Figure 3B). The data in Figure 3B were analyzed with Kruskal Wallis ($p<0.001$) and Mann-Whitney post-hoc (***$p<0.001$). Figure 3B shows that mutants are impaired to discriminate "light" social odor and rasagiline improves the discrimination of social odor in mutants.

Discrimination of strong social odor intensity:

The results above also demonstrate that rasagiline improves discrimination of strong social odor in WT and α-syn mutants mice (Figure 3C). The data in Figure 3C were analyzed by 2-way ANOVA with Effect of the genotype $p<0.001$; Effect of the treatment $p<0.001$; No interaction genotype*treatment $p>0.05$; and Bonferroni post-hoc, **$p<0.01$, ***$p<0.001$.

Figure 3C shows that mutants are impaired to discriminate "strong" social odor and rasagiline improves the discrimination of strong social odor in mice.

Example 4: Non-Social Odor Discrimination

This experiment was designed to assess effect of rasagiline on the capability of mice to discriminate between two close non-social odors. In this experiment, lemon odor served as a familiar odor (F), and lime – as a novel odor (N) (Figure 4A). Mice capable of discriminating between the odors will spend more time sniffing the new odor. The testing parameter was percentage of time of sniffing novel odor out of total time of sniffing.

Results:

The results of the experiment are summarized in tables 4a-4d. The analysis was performed by 2-way ANOVA and Bonferroni post-hoc.

Table 4a: Discrimination of non-social odors by WT untreated mice

Mice (n=20)	Genotype	Treatment	Time Sniffing F	Time Sniffing N	Total time sniffing	% time sniffing N
1-2	**WT**	**Water**	1.5	12.6	14.1	89.4
1-6	**WT**	**Water**	3.7	49.9	53.6	93.1
1-16	**WT**	**Water**	12.0	32.8	44.8	73.2
1-19	**WT**	**Water**	14.8	41.6	56.4	73.8
1-20	**WT**	**Water**	6.5	10.9	17.4	62.5
1-22	**WT**	**Water**	11.6	22.8	34.4	66.2
1-24	**WT**	**Water**	3.0	10.8	13.8	78.2
1-28	**WT**	**Water**	5.6	43.0	48.6	88.5
1-31	**WT**	**Water**	10.0	46.6	56.6	82.3
1-35	**WT**	**Water**	7.0	52.2	59.2	88.2
2-2	**WT**	**Water**	19.7	14.0	33.7	41.6
2-6	**WT**	**Water**	3.7	22.3	25.9	85.8
2-13	**WT**	**Water**	3.7	3.6	7.3	49.2
2-17	**WT**	**Water**	10.0	22.7	32.7	69.6
2-20	**WT**	**Water**	4.6	19.1	23.6	80.6
2-24	**WT**	**Water**	2.8	32.5	35.3	92.2
2-26	**WT**	**Water**	5.2	14.4	19.6	73.7
2-27	**WT**	**Water**	1.7	8.2	10.0	82.5
2-31	**WT**	**Water**	13.9	54.0	67.9	79.6
2-35	**WT**	**Water**	4.5	20.6	25.1	81.9
Mean			**7.3**	**26.7**	**34.0**	**76.6**
SEM			**1.1**	**3.6**	**4.1**	**3.0**

Table 4b: Discrimination of non-social odors by WT mice receiving rasagiline

Mice (n=18)	Genotype	Treatment	Time Sniffing F	Time Sniffing N	Total time sniffing	% time sniffing N
1-1	WT	Rasagiline	2.6	25.4	28.0	90.6
1-5	WT	Rasagiline	3.1	11.1	14.2	78.1
1-17	WT	Rasagiline	34.2	24.2	58.4	41.5
1-18	WT	Rasagiline	6.2	37.4	43.6	85.8
1-23	WT	Rasagiline	3.6	59.6	63.2	94.3
1-29	WT	Rasagiline	28.9	52.1	81.0	64.3
1-33	WT	Rasagiline	3.8	4.3	8.1	53.0
1-36	WT	Rasagiline	27.1	44.5	71.6	62.2
1-37	WT	Rasagiline	18.4	31.3	49.7	63.0
2-1	WT	Rasagiline	14.1	24.8	39.0	63.7
2-5	WT	Rasagiline	3.3	19.4	22.8	85.3
2-9	WT	Rasagiline	1.2	6.6	7.8	85.2
2-12	WT	Rasagiline	13.8	10.4	24.2	43.0
2-14	WT	Rasagiline	6.2	30.6	36.8	83.3
2-18	WT	Rasagiline	15.9	33.0	48.9	67.4
2-23	WT	Rasagiline	11.9	40.4	52.3	77.3
2-33	WT	Rasagiline	0.3	65.6	65.9	99.6
2-38	WT	Rasagiline	19.1	29.8	48.9	61.0
Mean			**11.9**	**30.6**	**42.5**	**72.1**
SEM			**2.4**	**4.1**	**5.1**	**4.0**

Table 4c: Discrimination of non-social odors by untreated α-syn mutants

Mice (n=19)	Genotype	Treatment	Time Sniffing F	Time Sniffing N	Total time sniffing	% time sniffing N
1-3	Mutant	**Water**	2.0	1.7	3.7	46.2
1-7	Mutant	**Water**	9.4	14.3	23.7	60.3
1-11	Mutant	**Water**	5.9	6.7	12.6	53.2
1-12	Mutant	**Water**	2.4	2.4	4.8	49.7
1-13	Mutant	**Water**	9.1	5.2	14.3	36.3
1-26	Mutant	**Water**	6.6	6.6	13.2	49.9
1-27	Mutant	**Water**	6.0	5.3	11.3	46.8
1-39	Mutant	**Water**	4.0	3.0	7.0	42.5
1-40	Mutant	**Water**	4.7	5.9	10.6	55.8
2-3	Mutant	**Water**	4.6	2.6	7.1	35.9
2-7	Mutant	**Water**	5.1	4.0	9.1	44.2
2-10	Mutant	**Water**	5.9	2.6	8.4	30.5
2-11	Mutant	**Water**	2.8	2.4	5.2	46.2
2-16	Mutant	**Water**	5.6	1.8	7.4	24.2
2-19	Mutant	**Water**	2.4	6.9	9.3	73.8
2-22	Mutant	**Water**	5.8	4.0	9.7	40.7
2-29	Mutant	**Water**	1.9	3.1	5.0	61.6
2-32	Mutant	**Water**	4.7	5.7	10.4	54.8
2-36	Mutant	**Water**	3.7	2.1	5.9	36.3
Mean			**4.9**	**4.5**	**9.4**	**46.8**
SEM			**0.5**	**0.7**	**1.1**	**2.7**

Table 4d: Discrimination of non-social odors by α-syn mutants receiving rasagiline

Mice (n=20)	Genotype	Treatment	Time Sniffing F	Time Sniffing N	Total time sniffing	% time sniffing N
1-4	Mutant	**Rasagiline**	3.2	6.6	9.8	67.4
1-8	Mutant	**Rasagiline**	6.0	22.2	28.1	78.8
1-9	Mutant	**Rasagiline**	2.1	5.1	7.2	71.1
1-10	Mutant	**Rasagiline**	2.7	13.3	16.0	83.1
1-14	Mutant	**Rasagiline**	5.3	5.8	11.1	52.3
1-15	Mutant	**Rasagiline**	1.6	2.3	3.9	59.1
1-21	Mutant	**Rasagiline**	2.3	11.2	13.5	83.0
1-25	Mutant	**Rasagiline**	4.5	7.8	12.3	63.6
1-30	Mutant	**Rasagiline**	1.8	3.4	5.2	65.1
1-32	Mutant	**Rasagiline**	13.7	70.0	83.7	83.6
1-38	Mutant	**Rasagiline**	2.1	8.2	10.3	79.4
2-4	Mutant	**Rasagiline**	4.9	9.4	14.4	65.7
2-8	Mutant	**Rasagiline**	4.9	4.2	9.1	46.3
2-15	Mutant	**Rasagiline**	3.0	16.6	19.6	84.6
2-21	Mutant	**Rasagiline**	2.8	4.4	7.1	61.3
2-25	Mutant	**Rasagiline**	2.7	6.6	9.3	71.4
2-28	Mutant	**Rasagiline**	0.7	9.2	9.9	92.7
2-30	Mutant	**Rasagiline**	4.4	5.5	9.9	55.6
2-34	Mutant	**Rasagiline**	1.8	3.6	5.3	67.0
2-37	Mutant	**Rasagiline**	3.0	8.4	11.4	73.5
Mean			**3.7**	**11.2**	**14.8**	**70.2**
SEM			**0.6**	**3.3**	**3.8**	**2.7**

Discussion:

The results above demonstrate that rasagiline improves discrimination of two close non-social odors in α-syn mutant mice (Figure 4B). The data in Figure 4B were analyzed by 2-way ANOVA with Effect of the genotype $p<0.001$; Effect of the treatment $p<0.01$; Interaction genotype*treatment $p<0.001$; and Bonferroni post-hoc, ***$p<0.001$. Figure 4B shows that mutants are impaired to discriminate 2 close non social odors and rasagiline improves the discrimination of 2 close non social odors.

Example 5: Odor Preference Test

This experiment was a control test to determine if mice or the rasagiline treatment could interfere on the odor preference between lime and lemon. The time periods that mice spent sniffing lemon and lime were compared. The testing parameters were percentage of time of sniffing lemon out of total time of sniffing and percentage of time of sniffing lime out of total time of sniffing.

Results:

The results are summarized in tables 5a-5d. The analysis was performed by Kruskal-Wallis test to compare % time of sniffing between mouse groups, and a t-test to compare for each group the % of sniffing time of lime and lemon.

Table 5a: Odor preference of WT untreated mice

Treatment Group			Time of sniffing (s)			% Time sniffing	
Mice (n=21)	Genotype	Treatment	Lemon	Lime	Total	Lemon	Lime
1-2	WT	Water	8.5	17.3	25.8	33.0	67.0
1-6	WT	Water	39.9	38.5	78.4	50.9	49.1
1-16	WT	Water	45.3	40.0	85.3	53.1	46.9
1-19	WT	Water	45.4	54.5	99.9	45.4	54.6
1-20	WT	Water	21.2	21.6	42.8	49.5	50.5
1-22	WT	Water	13.1	11.1	24.2	54.1	45.9
1-24	WT	Water	16.6	9.7	26.3	63.2	36.8
1-28	WT	Water	100.7	89.0	189.7	53.1	46.9
1-31	WT	Water	15.6	55.0	70.6	22.1	77.9
1-34	WT	Water	6.8	8.4	15.2	44.7	55.3
1-35	WT	Water	42.9	32.0	74.9	57.3	42.7
2-2	WT	Water	4.1	4.4	8.4	48.3	51.7
2-6	WT	Water	11.8	15.7	27.5	43.0	57.0
2-13	WT	Water	4.7	3.2	7.9	59.5	40.5
2-17	WT	Water	20.4	18.6	39.0	52.3	47.7
2-20	WT	Water	11.7	8.0	19.7	59.5	40.5
2-24	WT	Water	10.0	7.3	17.3	58.1	41.9
2-26	WT	Water	10.1	13.1	23.2	43.4	56.6
2-27	WT	Water	7.5	11.1	18.5	40.3	59.7
2-31	WT	Water	25.7	26.8	52.5	49.0	51.0
2-35	WT	Water	34.2	29.3	63.5	53.8	46.2
Mean			**23.6**	**24.5**	**48.1**	**49.2**	**50.8**
SEM			**4.9**	**4.7**	**9.3**	**2.1**	**2.1**

Table 5b: Odor preference of WT mice receiving rasagiline

Treatment Group			**Time of sniffing (s)**			**% Time sniffing**	
Mice (n=18)	**Genotype**	**Treatment**	**Lemon**	**Lime**	**Total**	**Lemon**	**Lime**
1-1	WT	**Rasagiline**	23.2	14.4	37.6	61.7	38.3
1-5	WT	**Rasagiline**	10.3	6.9	17.2	59.9	40.1
1-17	WT	**Rasagiline**	12.5	14.2	26.7	47.0	53.0
1-18	WT	**Rasagiline**	106.9	33.5	140.4	76.1	23.9
1-23	WT	**Rasagiline**	46.8	80.7	127.5	36.7	63.3
1-29	WT	**Rasagiline**	31.9	15.1	47.0	67.9	32.1
1-33	WT	**Rasagiline**	3.6	4.3	7.9	45.7	54.3
1-36	WT	**Rasagiline**	54.9	96.8	151.7	36.2	63.8
1-37	WT	**Rasagiline**	20.6	13.5	34.1	60.4	39.6
2-1	WT	**Rasagiline**	32.1	10.3	42.4	75.8	24.2
2-5	WT	**Rasagiline**	3.9	7.5	11.4	33.9	66.1
2-9	WT	**Rasagiline**	6.0	6.5	12.4	47.9	52.1
2-12	WT	**Rasagiline**	6.5	8.7	15.2	42.7	57.3
2-14	WT	**Rasagiline**	32.2	37.7	70.0	46.1	53.9
2-18	WT	**Rasagiline**	20.1	13.5	33.6	59.9	40.1
2-23	WT	**Rasagiline**	21.8	15.1	37.0	59.1	40.9
2-33	WT	**Rasagiline**	14.2	10.5	24.7	57.5	42.5
2-38	WT	**Rasagiline**	18.0	30.4	48.4	37.2	62.8
Mean			**25.9**	**23.3**	**49.2**	**52.9**	**47.1**
SEM			**5.8**	**6.1**	**10.5**	**3.1**	**3.1**

Table 5c: Odor preference of untreated α-syn mutants

Treatment Group			**Time of sniffing (s)**			**% Time sniffing**	
Mice (n=19)	**Genotype**	**Treatment**	**Lemon**	**Lime**	**Total**	**Lemon**	**Lime**
1-3	Mutant	**Water**	1.8	2.1	3.9	46.5	53.5
1-7	Mutant	**Water**	3.2	4.1	7.3	43.5	56.5
1-11	Mutant	**Water**	4.0	1.6	5.6	71.6	28.4
1-12	Mutant	**Water**	2.9	3.3	6.2	47.1	52.9
1-13	Mutant	**Water**	4.9	5.4	10.3	47.2	52.8
1-26	Mutant	**Water**	6.9	7.4	14.3	48.1	51.9
1-27	Mutant	**Water**	6.1	6.2	12.3	49.8	50.2
1-39	Mutant	**Water**	10.7	11.1	21.8	49.0	51.0
1-40	Mutant	**Water**	2.2	1.6	3.8	56.9	43.1
2-3	Mutant	**Water**	2.8	3.6	6.4	44.4	55.6
2-7	Mutant	**Water**	4.0	2.7	6.7	60.3	39.7
2-10	Mutant	**Water**	2.5	2.6	5.2	49.0	51.0
2-11	Mutant	**Water**	4.2	5.3	9.6	44.3	55.7
2-16	Mutant	**Water**	5.0	5.6	10.7	47.2	52.8
2-19	Mutant	**Water**	4.3	6.3	10.6	40.9	59.1
2-22	Mutant	**Water**	2.6	2.6	5.2	49.8	50.2
2-29	Mutant	**Water**	7.9	8.4	16.2	48.6	51.4
2-32	Mutant	**Water**	8.4	7.5	15.9	52.9	47.1
2-36	Mutant	**Water**	5.5	6.2	11.7	47.2	52.8
Mean			**4.7**	**4.9**	**9.7**	**49.7**	**50.3**
SEM			**0.5**	**0.6**	**1.1**	**1.6**	**1.6**

Table 5d: Odor preference of α-syn mutants receiving rasagiline

Treatment Group			**Time of sniffing (s)**			**% Time sniffing**	
Mice (n=19)	**Genotype**	**Treatment**	**Lemon**	**Lime**	**Total**	**Lemon**	**Lime**
1-4	Mutant	**Rasagiline**	6.3	3.9	10.2	61.8	38.2
1-8	Mutant	**Rasagiline**	6.4	8.7	15.1	42.4	57.6
1-9	Mutant	**Rasagiline**	4.7	3.7	8.4	55.9	44.1
1-10	Mutant	**Rasagiline**	2.5	4.9	7.4	33.5	66.5
1-14	Mutant	**Rasagiline**	7.9	4.5	12.4	63.7	36.3
1-15	Mutant	**Rasagiline**	2.6	4.6	7.2	36.2	63.8
1-21	Mutant	**Rasagiline**	6.5	7.5	14.0	46.5	53.5
1-25	Mutant	**Rasagiline**	13.0	3.4	16.4	79.3	20.7
1-30	Mutant	**Rasagiline**	5.7	6.0	11.7	48.5	51.5
1-32	Mutant	**Rasagiline**	10.0	63.0	73.0	13.7	86.3
1-38	Mutant	**Rasagiline**	6.2	6.9	13.1	47.3	52.7
2-4	Mutant	**Rasagiline**	6.8	4.2	11.0	62.1	37.9
2-8	Mutant	**Rasagiline**	4.0	5.6	9.6	41.3	58.7
2-15	Mutant	**Rasagiline**	7.8	7.0	14.9	52.7	47.3
2-21	Mutant	**Rasagiline**	5.4	8.4	13.9	39.2	60.8
2-25	Mutant	**Rasagiline**	7.2	7.6	14.8	48.5	51.5
2-28	Mutant	**Rasagiline**	6.9	7.3	14.2	48.6	51.4
2-30	Mutant	**Rasagiline**	2.9	4.9	7.8	37.0	63.0
2-34	Mutant	**Rasagiline**	5.9	8.3	14.2	41.3	58.7
2-37	Mutant	**Rasagiline**	4.2	4.4	8.6	48.8	51.2
Mean			**6.1**	**8.7**	**14.9**	**47.4**	**52.6**
SEM			**0.6**	**2.9**	**3.1**	**3.1**	**3.1**

Discussion:

The results above demonstrate that there was no difference of odor preference between lemon and lime. For each odor, there was no difference in percentage of time sniffing between the groups (Figure 5B). The data in Figure 5B were analyzed for group comparison with Kruskal Wallis $p>0.05$ and lemon/lime comparison for each group with t-test ($p>0.05$). Figure 5B shows that for each group: no difference of odor preference between lemon/lime and for each odor: no difference of % time sniffing between groups.

Example 6: Novel Object Exploration Test

This experiment was a control test to determine if rasagiline has an effect on the level of the exploration of a novel object. The testing parameters were percentage of time exploring the novel object out of total time of the trial.

Results:

The results are summarized in tables 6a-6d. The analysis was performed by Kruskal-Wallis and Mann-Whitney post-hoc.

Table 6a: Novel object exploration of WT untreated mice

Mice (n=10)	Genotype	Treatment	Time of exploration (s)	% Time exploring novel object
2	WT	**Water**	88.0	29.3
6	WT	**Water**	109.6	36.5
16	WT	**Water**	111.8	37.3
19	WT	**Water**	110.5	36.8
20	WT	**Water**	96.7	32.2
22	WT	**Water**	114.8	38.3
24	WT	**Water**	108.7	36.2
28	WT	**Water**	91.1	30.4
31	WT	**Water**	116.1	38.7
35	WT	**Water**	112.4	37.5
Mean			**106.0**	**35.3**
SEM			**3.2**	**1.1**

Table 6b: Novel object exploration of WT mice receiving rasagiline

Mice (n=9)	Genotype	Treatment	Time of exploration (s)	% Time exploring novel object
1	WT	**Rasagiline**	98.0	32.7
5	WT	**Rasagiline**	98.4	32.8
17	WT	**Rasagiline**	105.6	35.2
18	WT	**Rasagiline**	115.1	38.4
23	WT	**Rasagiline**	100.0	33.3
29	WT	**Rasagiline**	113.4	37.8
33	WT	**Rasagiline**	99.8	33.3
36	WT	**Rasagiline**	110.5	36.8
37	WT	**Rasagiline**	109.1	36.4
Mean			**105.5**	**35.2**
SEM			**2.2**	**0.7**

5

Table 6c: Novel object exploration of untreated α-syn mutants

Mice (n=9)	Genotype	Treatment	Time of exploration (s)	% Time exploring novel object
3	Mutant	Water	20.6	6.9
7	Mutant	Water	91.6	30.5
11	Mutant	Water	44.0	14.7
12	Mutant	Water	61.9	20.6
13	Mutant	Water	106.0	35.3
26	Mutant	Water	102.8	34.3
27	Mutant	Water	55.4	18.5
39	Mutant	Water	116.0	38.7
40	Mutant	Water	108.1	36.0
Mean			**78.5**	**26.2**
SEM			**11.3**	**3.8**

Table 6d: Novel object exploration of α-syn mutants receiving rasagiline

Mice (n=11)	Genotype	Treatment	Time of exploration (s)	% Time exploring novel object
4	Mutant	Rasagiline	60.6	20.2
8	Mutant	Rasagiline	103.5	34.5
9	Mutant	Rasagiline	67.6	22.5
10	Mutant	Rasagiline	43.5	14.5
14	Mutant	Rasagiline	73.6	24.5
15	Mutant	Rasagiline	69.4	23.1
21	Mutant	Rasagiline	106.1	35.4
25	Mutant	Rasagiline	85.8	28.6
30	Mutant	Rasagiline	53.1	17.7
32	Mutant	Rasagiline	108.2	36.1
38	Mutant	Rasagiline	101.4	33.8
Mean			**79.3**	**26.4**
SEM			**6.9**	**2.3**

Discussion:

The results above demonstrate that rasagiline has no effect on novel object exploration of the WT and mutant animals (Figure 6B). The data in Figure 6B were analyzed with Kruskal-Wallis ($p<0.05$) and Mann Whitney post-hoc test ($*p<0.05$). Figure 6B shows that mutants are impaired in exploring a novel object compared to WT and rasagiline exhibits no effect on exploring a novel object.

Example 7: Discrimination of a Novel Object/Odor

This experiment was a control test to determine the object/odor discrimination ability of mutant mice and animal treated with rasagiline. The objective was to determine wether the odor discrimination deficit was specific to the olfactory function (Figure7A).

The testing parameters was percentage of time exploring the novel object/odor out of total time of exploration.

Results:

The results are summarized in tables 7a-7d. The analysis was performed by 2-way ANOVA and Bonferroni post-hoc.

Table 7a: Novel object/odor exploration of WT untreated mice

Treatment Group			**Time of Exploration (s)**			**% Time exploring novel object**
Mice (n=10)	**Genotype**	**Treatment**	**Familiar object**	**Novel object**	**Total**	
2	WT	**Water**	2.2	72.0	74.2	97.0
6	WT	**Water**	3.7	81.2	84.8	95.7
13	WT	**Water**	2.5	14.7	17.2	85.7
17	WT	**Water**	1.9	104.6	106.5	98.2
20	WT	**Water**	3.9	18.1	22.0	82.4
24	WT	**Water**	1.4	92.5	93.9	98.5
26	WT	**Water**	6.9	21.6	28.5	75.8
27	WT	**Water**	4.9	48.7	53.6	90.9
31	WT	**Water**	7.2	48.7	55.9	87.1
35	WT	**Water**	1.5	66.8	68.3	97.8
Mean			**3.6**	**56.9**	**60.5**	**90.9**
SEM			**0.7**	**10.1**	**9.7**	**2.5**

Table 7b: Novel object/odor exploration of WT mice receiving rasagiline

Treatment Group			Time of Exploration (s)			% Time exploring novel object
Mice (n=9)	Genotype	Treatment	Familiar object	Novel object	Total	
1	WT	Rasagiline	1.1	108.3	109.4	99.0
5	WT	Rasagiline	2.0	78.6	80.6	97.5
9	WT	Rasagiline	2.8	70.9	73.7	96.3
12	WT	Rasagiline	0.7	92.6	93.3	99.2
14	WT	Rasagiline	11.6	70.2	81.8	85.8
18	WT	Rasagiline	0.4	103.9	104.3	99.7
23	WT	Rasagiline	6.6	65.9	72.6	90.9
33	WT	Rasagiline	1.6	92.9	94.5	98.4
38	WT	Rasagiline	0.4	81.6	82.0	99.5
Mean			**3.0**	**85.0**	**88.0**	**96.2**
SEM			**1.3**	**5.1**	**4.4**	**1.6**

Table 7c: Novel object/odor exploration of untreated α-syn mutants

Treatment Group			Time of Exploration (s)			% Time exploring novel object
Mice (n=10)	Genotype	Treatment	Familiar object	Novel object	Total	
3	Mutant	Water	3.3	13.0	16.3	79.7
7	Mutant	Water	2.8	34.2	37.0	92.4
10	Mutant	Water	2.8	36.6	39.4	92.9
11	Mutant	Water	2.7	8.2	11.0	75.3
16	Mutant	Water	2.3	7.3	9.7	75.8
19	Mutant	Water	1.0	55.7	56.6	98.3
22	Mutant	Water	4.4	18.5	22.9	81.0
29	Mutant	Water	1.9	31.1	33.0	94.2
32	Mutant	Water	2.0	14.2	16.2	87.4
36	Mutant	Water	4.7	16.9	21.6	78.2
Mean			**2.8**	**23.6**	**26.4**	**85.5**
SEM			**0.4**	**4.9**	**4.7**	**2.7**

Table 7d: Novel object/odor exploration of α-syn mutants receiving rasagiline

Treatment Group			**Time of Exploration (s)**			**% Time exploring novel object**
Mice (n=9)	**Genotype**	**Treatment**	**Familiar object**	**Novel object**	**Total**	
4	Mutant	**Rasagiline**	2.8	41.7	44.5	93.7
8	Mutant	**Rasagiline**	3.0	25.8	28.8	89.7
15	Mutant	**Rasagiline**	12.2	75.2	87.5	86.0
21	Mutant	**Rasagiline**	2.7	58.4	61.0	95.6
25	Mutant	**Rasagiline**	0.5	57.2	57.8	99.1
28	Mutant	**Rasagiline**	2.8	67.0	69.8	96.0
30	Mutant	**Rasagiline**	1.8	42.7	44.5	95.9
34	Mutant	**Rasagiline**	4.4	60.3	64.7	93.2
37	Mutant	**Rasagiline**	2.5	10.2	12.7	80.7
Mean			**3.6**	**48.7**	**52.4**	**92.2**
SEM			**1.1**	**6.9**	**7.5**	**1.9**

Discussion:

The results above demonstrated that mutant mice exhibit similar object/odor discrimination ability compared to control meaning that the odor discrimination deficit seems to be specific to olfactory function. The data in Figure 7B were analyzed by 2-way ANOVA with effect of the genotype $p<0.05$; effect of the treatment $p<0.05$; no interaction genotype*treatment; and Bonferroni post-hoc, $*p<0.05$. The data in Figure 7B suggest that discrimination ability of the mutants certainly because of its effect on odor discrimination improvement. Figure 7B shows that mutants are able to discriminate the novel object/odor and that rasagiline treatment improves the discrimination ability of the mutants to substantially WT levels.

Example 8: Study of the Effect of Rasagiline on Olfactory Dysfunction

This experiment is designed to study the effect of rasagiline on olfactory dysfunction following the procedures described in two transgenic mouse models for the study of olfactory loss. (Lane et al., "Development of transgenic mouse models for the study of human olfactory dysfunction", Am J Rhinol., 2005, May-Jun; 19(3):229-35.)

Each model shows that rasagiline is effective in treating the symptoms of olfactory dysfunction in the mice.

The study results also show that rasagiline is effective in reducing the rate of progression of olfactory dysfunction in the mice.

The study results also show that rasagiline is effective in reducing the functional decline in the mice.

References:

1. Grand Rounds Presentation, UTMB, Dept. of Otolaryngology, *"Olfactory Dysfunction and Disorders"*, http://www.utmb.edu/otoref/grnds/Olfactory-2003-1126/Olfactory-2003-1126.htm.

2. Fleming SM, Tetreault NA, Mulligan CK, Hutson CB, Masliah E, Chesselet MF., *"Olfactory deficits in mice overexpressing human wildtype alpha-synuclein"*, Eur J Neurosci. 2008 Jul;28(2):247-56.

What is claimed is:

1. A method of treating a symptom of olfactory dysfunction in a subject afflicted by olfactory dysfunction, the method comprising:
   a) identifying the subject as afflicted by olfactory dysfunction, and
   b) periodically administering to the subject so identified an amount of R(+)-N-propargyl-1-aminoindan or a pharmaceutically acceptable salt thereof, effective to treat the subject,
   wherein the subject is a non-Parkinson's disease subject.

2. A method of reducing the rate of progression of olfactory dysfunction in a non-Parkinson's disease subject afflicted by olfactory dysfunction, the method comprising periodically administering to the subject an amount of R(+)-N-propargyl-1-aminoindan or a pharmaceutically acceptable salt thereof, effective to reduce the rate of progression of olfactory dysfunction in the non-Parkinson's disease subject.

3. A method of inhibiting loss of olfactory function in a non-Parkinson's disease subject, the method comprising periodically administering to the subject an amount of R(+)-N-propargyl-1-aminoindan or a pharmaceutically acceptable salt thereof, effective to inhibit loss of olfactory function in the non-Parkinson's disease subject.

4. The method of claim 1, wherein the amount of R(+)-N-propargyl-1-aminoindan or of the pharmaceutically acceptable salt thereof is from 0.01 mg to 5 mg per day.

5. The method of claim 4, wherein the amount of R(+)-N-propargyl-1-aminoindan or of the pharmaceutically acceptable salt thereof is 0.5 mg per day.

6. The method of claim 4, wherein the amount of R(+)-N-propargyl-1-aminoindan or of the pharmaceutically acceptable salt thereof is 2 mg per day.

7. The method of claim 4, wherein the amount of R(+)-N-propargyl-1-aminoindan or of the pharmaceutically acceptable salt thereof is 1 mg per day.

8. The method of claim 1, wherein R(+)-N-propargyl-1-aminoindan is administered in the form of free base.

9. The method of claim 1, wherein the pharmaceutically acceptable salt of R(+)-N-propargyl-1-aminoindan is esylate, mesylate, sulphate, citrate or tartrate.

10. The method of claim 9, wherein the pharmaceutically acceptable salt is a mesylate salt.

11. The method of claim 9, wherein the pharmaceutically acceptable salt is a citrate salt.

12. The method of claim 1, wherein the olfactory dysfunction is selected from the group consisting of anosmia, partial anosmia, hyposmia, hyperosmia, dysosmia, phantosmia, and olfactory agnosia.

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13. The method of claim 1, wherein the amount of R(+)-N-propargyl-1-aminoindan or a pharmaceutically acceptable salt thereof is formulated in oral, parenteral, rectal, or transdermal formulation.

14. Use of R(+)-N-propargyl-1-aminoindan or a pharmaceutically acceptable salt thereof, in the preparation of a medicament for treating a symptom of olfactory dysfunction in a subject afflicted by olfactory dysfunction, wherein:

a) the subject is identified to be afflicted by olfactory dysfunction, and

b) the medicament is adapted to be periodically administered to the subject in an amount effective to treat the subject,

wherein the subject is a non-Parkinson's disease subject.

15. Use of R(+)-N-propargyl-1-aminoindan or a pharmaceutically acceptable salt thereof, in the preparation of a medicament for reducing the rate of progression of olfactory dysfunction in a non-Parkinson's disease subject afflicted by olfactory dysfunction, wherein the medicament is adapted to be periodically administered to the subject in an amount effective to reduce the rate of progression of olfactory dysfunction in the non-Parkinson's disease subject.

16. Use of R(+)-N-propargyl-1-aminoindan or a pharmaceutically acceptable salt thereof, in the preparation of a medicament for inhibiting loss of olfactory function in a non-Parkinson's disease subject, wherein the medicament is adapted to be periodically administered to the subject in an amount effective to inhibit loss of olfactory function in the non-Parkinson's disease subject.

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17. Use of R(+)-N-propargyl-1-aminoindan or a pharmaceutically acceptable salt thereof, in treating a symptom of olfactory dysfunction in a subject afflicted by olfactory dysfunction, the use comprising:

a) identifying the subject as afflicted by olfactory dysfunction, and

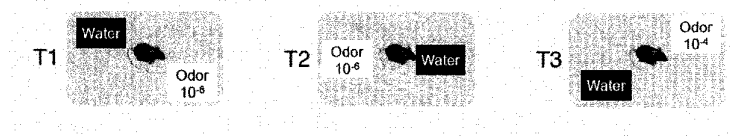
b) periodically administering to the subject so identified an amount of the R(+)-N-propargyl-1-aminoindan or the pharmaceutically acceptable salt thereof, effective to treat the subject,

wherein the subject is a non-Parkinson's disease subject.

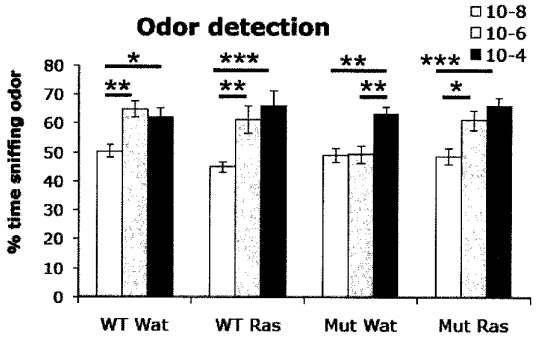
18. Use of R(+)-N-propargyl-1-aminoindan or a pharmaceutically acceptable salt thereof, in reducing the rate of progression of olfactory dysfunction in a non-Parkinson's disease subject afflicted by olfactory dysfunction, the use comprising periodically administering to the subject an amount of the R(+)-N-propargyl-1-aminoindan or the pharmaceutically acceptable salt thereof, effective to reduce the rate of progression of olfactory dysfunction in the non-Parkinson's disease subject.

19. Use of R(+)-N-propargyl-1-aminoindan or a pharmaceutically acceptable salt thereof, in inhibiting loss of olfactory function in a non-Parkinson's disease subject, the use comprising periodically administering to the subject an amount of the R(+)-N-propargyl-1-aminoindan or the pharmaceutically acceptable salt thereof, effective to inhibit loss of olfactory function in the non-Parkinson's disease subject.

A.


T1
Water
Odor
10-8
T2
Odor
10-6
Water
T3
Odor
10-4
Water

B.


Odor detection
10-8
10-6
10-4
% time sniffing odor
80
70
60
50
40
30
20
10
0
*
**
***
**
**
***
*
WT Wat
WT Ras
Mut Wat
Mut Ras

C.

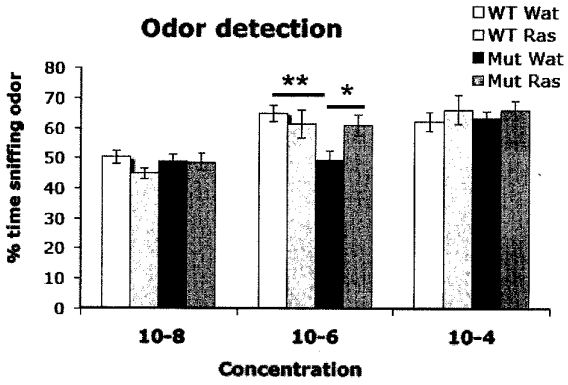
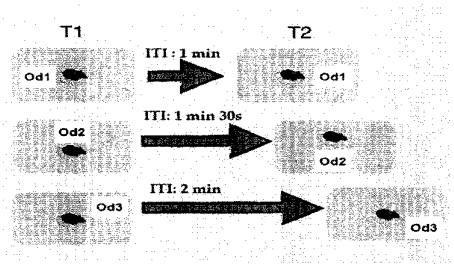
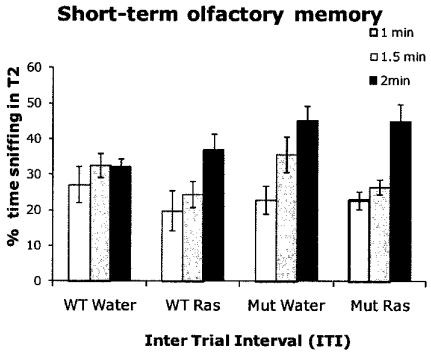

Odor detection
WT Wat
WT Ras
Mut Wat
Mut Ras
% time sniffing odor
80
70
60
50
40
30
20
10
0
**
*
10-8
10-6
10-4
Concentration

Figure 1

A.


T1
T2
ITI : 1 min
Od1
Od1
ITI: 1 min 30s
Od2
Od2
ITI: 2 min
Od3
Od3

B.


Short-term olfactory memory
1 min
1.5 min
2min
% time sniffing in T2
0
10
20
30
40
50
60
WT Water
WT Ras
Mut Water
Mut Ras
Inter Trial Interval (ITI)

C.

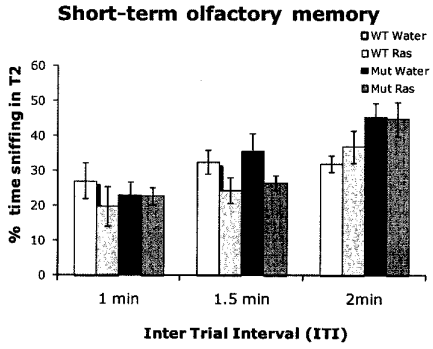
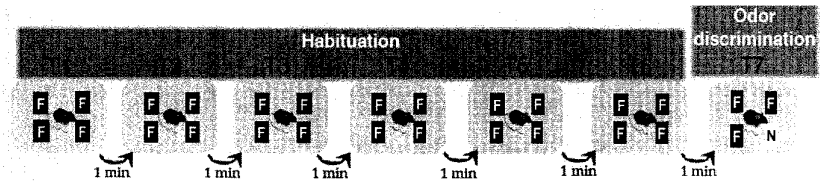
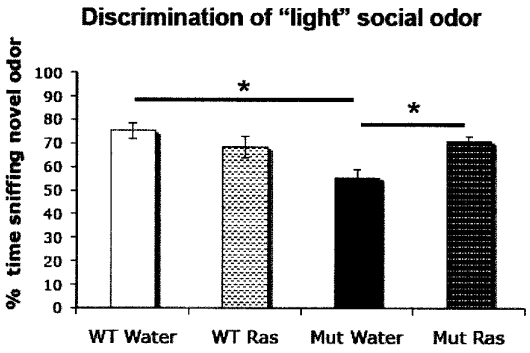

Short-term olfactory memory
WT Water
WT Ras
Mut Water
Mut Ras
% time sniffing in T2
0
10
20
30
40
50
60
1 min
1.5 min
2min
Inter Trial Interval (ITI)

Figure 2

A.


Habituation
Odor discrimination
1 min
1 min
1 min
1 min
1 min
1 min
F
N

B.


Discrimination of "light" social odor
% time sniffing novel odor
100
90
80
70
60
50
40
30
20
10
0
*
*
WT Water
WT Ras
Mut Water
Mut Ras

C.

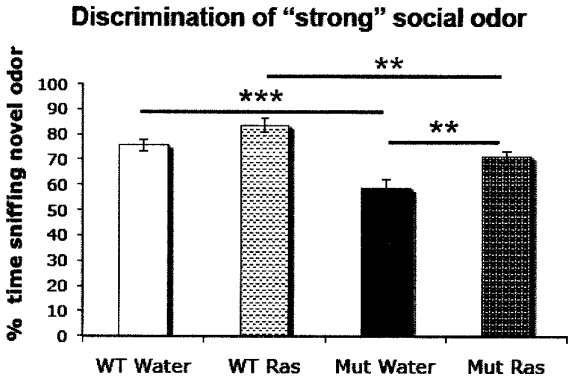
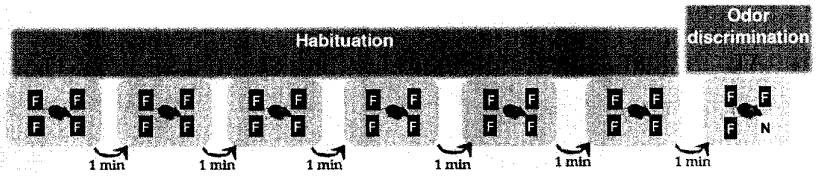

Discrimination of "strong" social odor
% time sniffing novel odor
100
90
80
70
60
50
40
30
20
10
0
**
***
**
WT Water
WT Ras
Mut Water
Mut Ras

Figure 3

A.


Habituation
Odor discrimination
1 min
1 min
1 min
1 min
1 min
1 min
N

B.

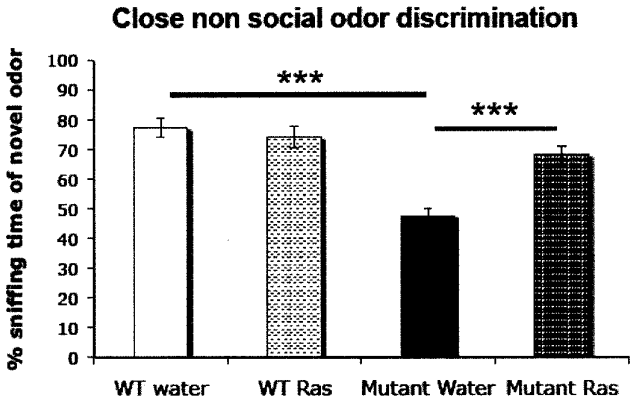
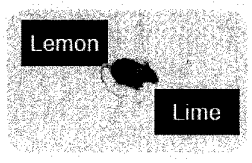

Close non social odor discrimination
% sniffing time of novel odor
100
90
80
70
60
50
40
30
20
10
0
***
***
WT water
WT Ras
Mutant Water
Mutant Ras

Figure 4

A.


Lemon
Lime

B.

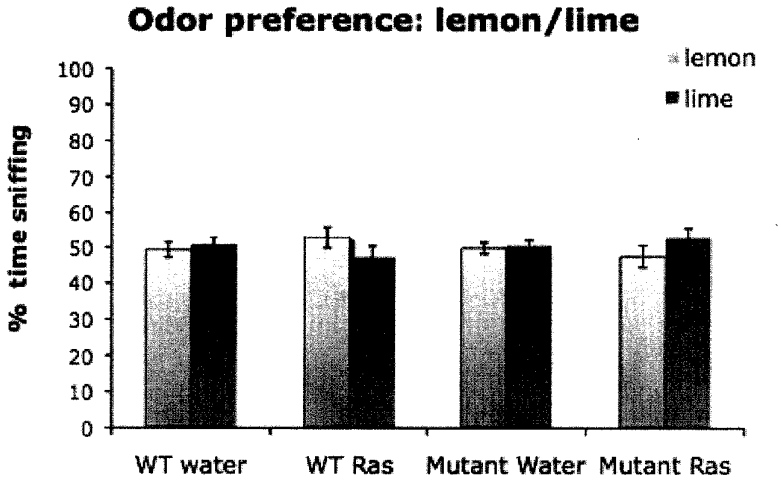
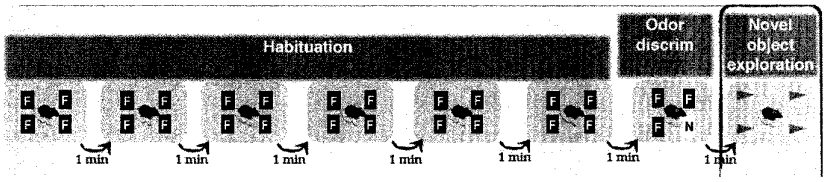

Odor preference: lemon/lime
lemon
lime
% time sniffing
100
90
80
70
60
50
40
30
20
10
0
WT water
WT Ras
Mutant Water
Mutant Ras

Figure 5

A.


Habituation
Odor discrim
Novel object exploration
1 min
1 min
1 min
1 min
1 min
1 min
1 min
N

B.

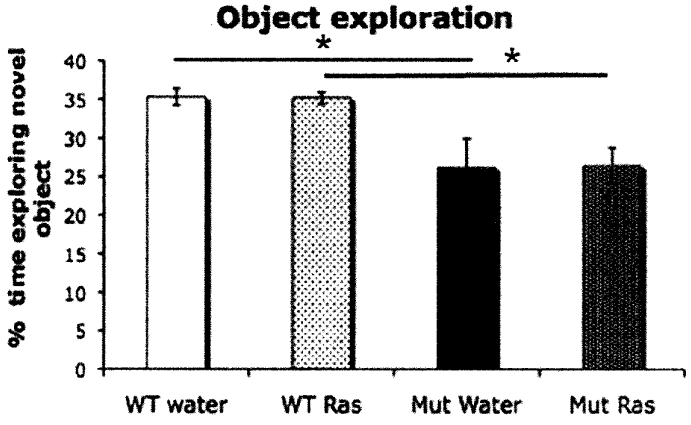
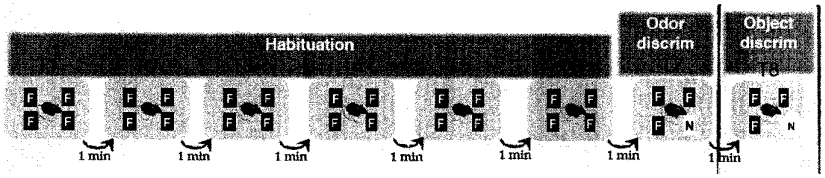

Object exploration
*
*
% time exploring novel object
40
35
30
25
20
15
10
5
0
WT water
WT Ras
Mut Water
Mut Ras

Figure 6

A.


Habituation
Odor discrim
Object discrim
TS
F
N
1 min

B.

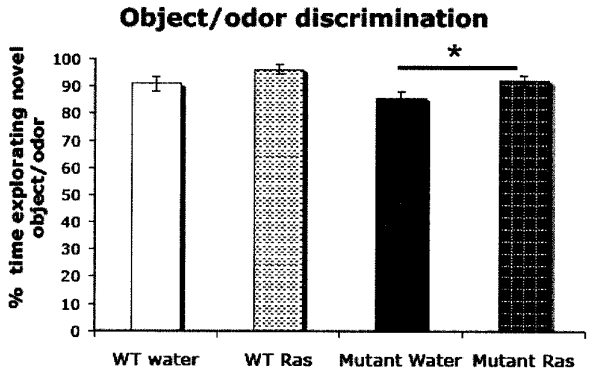

Object/odor discrimination
% time exploring novel object/odor
100
90
80
70
60
50
40
30
20
10
0
*
WT water
WT Ras
Mutant Water
Mutant Ras

Figure 7