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(54) Title: THERAPEUTIC AGENTS, PHARMACEUTICAL COMPOSITIONS, AND ASSOCIATED BIOMARKERS BASED ON TRK-B

(57) Abstract: Therapeutic Agents, Pharmaceutical Compositions, and Associated Biomarkers The invention relates to the identification of pharmaceutical compositions, therapeutic agents, peptides, nucleic acids, genetic constructs, vectors, cells, and medicaments, and their use in methods of treatment. For example, the treatment of neuropathological conditions, in particular Alzheimer's disease. Furthermore, provided herein are biomarkers, methods for their use, methods of diagnosis, methods of monitoring disease progression, and methods for monitoring medicament efficacy, in particular for Alzheimer's disease.

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THERAPEUTIC AGENTS, PHARMACEUTICAL COMPOSITIONS, AND ASSOCIATED BIOMARKERS BASED ON TRK-B

Field of the Invention

The present invention relates to the identification of pharmaceutical compositions, therapeutic agents, peptides, nucleic acids, genetic constructs, vectors, cells, and medicaments, and their use in methods of treatment. For example, the treatment of neuropathological conditions, in particular Alzheimer's disease. Furthermore, provided herein are biomarkers, methods for their use, methods of diagnosis, methods of monitoring disease progression, and methods for monitoring medicament efficacy, in particular for Alzheimer's disease.

Background

Brain-derived Neurotrophic Factor (BDNF) and its full-length cognate receptor, tropomyosin-receptor kinase B-full-length (TrkB-FL), are capable of regulating neuronal differentiation, growth and synaptic transmission and plasticity. This signalling pathway forms one of the most important neuroprotective systems in the developing and mature brain[1].

Dysregulation of BDNF function has been implicated in several diseases leading to sustained neurodegeneration, including Alzheimer's disease (AD). AD is already the most common form of dementia worldwide, and its prevalence is expected to increase further.

BDNF and TrkB-FL levels were shown to be decreased in the brain of human patients with AD[2–4]. The present inventors have previously described the mechanism through which amyloid-β (Aβ) leads to TrkB-FL cleavage. Briefly, the Aβ peptide recruits extra-synaptic NMDARs to upregulate intracellular Ca^{2+} levels[5], leading to calpain overactivation and TrkB-FL cleavage[6]. This cleavage generates two products: (1) a membrane-bound truncated receptor (TrkB-T'), with no apparent function; and (2) an intracellular fragment (TrkB-ICD). The inventors show that this intracellular fragment accumulates in the cell nucleus overtime and displays a strong tyrosine kinase activity[7].

Tejeda *et al.* tested the effect of a peptide comprising a portion of TrkB-FL (referred to as TFL_{518}) that spans the calpain cleavage site[8] and reported that the peptide is not neuroprotective. Hence, Tejeda *et al*. reported that the disclosed peptide is not a therapeutic agent and is not suitable for use in pharmaceutical compositions.

There is a need to develop strategies for the treatment of neuropathological conditions, and in particular AD.

Summary of the Invention

In an aspect of the invention, there is provided a pharmaceutical composition comprising a portion of the tropomyosin-receptor kinase B-full-length (TrkB-FL) protein, wherein the portion spans the calpain cleavage site of TrkB-FL.

In an embodiment, the amino acid sequence of the TrkB-FL protein from which the portion is derived may be according to SEQ ID NO: 1.

In some embodiments, the portion of TrkB-FL may comprise 1 to 10 of the residues on the N-terminal side of the TrkB-FL calpain cleavage site. The portion of TrkB-FL may comprise an amino acid sequence according to SEQ ID NO: 5.

In some embodiments, the portion of TrkB-FL may comprise 1 to 10 of the residues on the C-terminal side of the TrkB-FL calpain cleavage site. The portion of TrkB-FL may comprise an amino acid sequence according to SEQ ID NO: 12.

In some embodiments, the portion of TrkB-FL may be 5 to 20 or 8 to 12 residues in length. The portion of TrkB-FL may be 10 residues in length.

In some embodiments, the amino acid sequence of the portion of TrkB-FL may be according to any one of SEQ ID NO: 18, SEQ ID NO: 19, or SEQ ID NO: 20. The amino acid sequence of the portion of TrkB-FL may be according to any one of SEQ ID NO: 18, SEQ ID NO: 19, or SEQ ID NO: 20, and comprises one or more substitutions, conservative substitutions, modifications, or replacements within said sequence.

The pharmaceutical composition is able to prevent calpain cleavage of TrkB-FL to produce tropomyosin-receptor kinase B-full-length intracellular domain (TrkB-ICD).

In some embodiments, the pharmaceutical composition may be suitable for delivery of the portion of TrkB-FL across the blood brain barrier and into neuronal cells. The pharmaceutical composition may comprise a cell-penetrating peptide. The cell-penetrating peptide may be trans-activating transcriptional activator (TAT). The amino acid sequence of the cell-penetrating peptide may be according to SEQ ID NO: 21.

In some embodiments, the pharmaceutical composition may comprise at least one of a pharmaceutically acceptable carrier, a pharmaceutically acceptable excipient, a pharmaceutically acceptable stabilizer, or a pharmaceutically acceptable preservative, or any combination thereof.

In another aspect of the invention, there is provided a polypeptide comprising an isolated portion of TrkB-FL, wherein the isolated portion of TrkB-FL spans the calpain cleavage site of TrkB-FL.

In an embodiment, the amino acid sequence of the TrkB-FL protein from which the isolated portion is derived is according to SEQ ID NO: 1.

In some embodiments, the isolated portion of TrkB-FL may comprise 1 to 10 of the residues on the N-terminal side of the TrkB-FL calpain cleavage site. The isolated portion of TrkB-FL may comprise an amino acid sequence according to SEQ ID NO: 5.

In some embodiments, the isolated portion of TrkB-FL may comprise 1 to 10 of the residues on the C-terminal side of the TrkB-FL calpain cleavage site. The isolated portion of TrkB-FL may comprise an amino acid sequence according to SEQ ID NO: 12.

In some embodiments, the isolated portion of TrkB-FL may be 5 to 20 or 8 to 12 residues in length. The isolated portion of TrkB-FL may be 10 residues in length.

In some embodiments, the amino acid sequence of the isolated portion of TrkB-FL may be according to any one of SEQ ID NO: 18, SEQ ID NO: 19, or SEQ ID NO: 20. The amino acid sequence of the isolated portion of TrkB-FL may be according to any one of SEQ ID NO: 18, SEQ ID NO: 19, or SEQ ID NO: 20, and comprises one or more substitutions, conservative substitutions, modifications, or replacements within said sequence.

The polypeptide is able to prevent calpain cleavage of TrkB-FL to produce TrkB-ICD.

In some embodiments, the polypeptide may be suitable for delivery of the isolated portion of TrkB-FL across the blood brain barrier and into neuronal cells. The polypeptide may comprise a cell-penetrating peptide. The cell-penetrating peptide may be TAT. The amino acid sequence of the cell-penetrating peptide may be according to SEQ ID NO: 21.

In some embodiments, the polypeptide may comprise a linker. The linker may comprise the amino acid residues KK.

In some embodiments, the polypeptide may comprise an amino acid sequence according to any one of SEQ ID NO: 18, SEQ ID NO: 19, or SEQ ID NO: 20, and may further comprise an amino acid sequence according to SEQ ID NO: 21.

In some embodiments, the polypeptide may comprise an amino acid sequence according to SEQ ID NO: 18, a linker, and an amino acid sequence according to SEQ ID NO: 21. The polypeptide may comprise an amino acid sequence according to SEQ ID NO: 18, a linker which comprises the amino acid residues KK, and an amino acid sequence according to SEQ ID NO: 21. The polypeptide may comprise an amino acid sequence according to SEQ ID NO: 22, SEQ ID NO: 23, or SEQ ID NO: 24.

The polypeptide of the invention may comprise one or more substitutions, conservative substitutions, modifications, or replacements within the amino acid sequence.

In another aspect of the invention, there is provided a nucleic acid encoding any portion of TrkB-FL as disclosed herein.

In another aspect of the invention, there is provided a nucleic acid encoding a polypeptide of the invention.

In another aspect of the invention, there is provided a genetic construct or a vector comprising a nucleic acid of the invention.

In another aspect of the invention, there is provided a cell comprising any portion of TrkB-FL as disclosed herein, a polypeptide according to the invention, a nucleic acid according to the invention, or a genetic construct or vector according to the invention.

In another aspect of the invention, there is provided a pharmaceutical composition comprising a polypeptide, nucleic acid, genetic construct, vector, or cell according to the invention. The pharmaceutical composition may comprise at least one of a pharmaceutically acceptable carrier, a pharmaceutically acceptable excipient, a pharmaceutically acceptable stabilizer, or a pharmaceutically acceptable preservative, or any combination thereof.

In another aspect of the invention, there is provided a pharmaceutical composition, polypeptide, nucleic acid, genetic construct, vector, or cell according to the invention, for use as a medicament.

In some embodiments, the pharmaceutical composition, polypeptide, nucleic acid, genetic construct, vector, or cell according to the invention may be for use in a method of treating Alzheimer's disease (AD), preventing AD, ameliorating AD, delaying the progression of AD, or reducing at least one symptom of AD.

In some embodiments, the pharmaceutical composition, polypeptide, nucleic acid, genetic construct, vector, or cell according to the invention may be for use in a method of treating, preventing, ameliorating, delaying the progression of, or reducing at least one symptom of a neuropathological condition.

In some embodiments, the pharmaceutical composition, polypeptide, nucleic acid, genetic construct, vector, or cell according to the invention may be for use in a method of treating, preventing, ameliorating, delaying the progression of, or reducing at least one symptom of a pathology characterized by excitotoxicity. The pathology may be selected from epilepsy, prion-like diseases, muscular dystrophies, Huntington's disease, Parkinson's disease, multiple sclerosis, ischemia, stroke, or brain trauma.

In some embodiments, the pharmaceutical composition, polypeptide, nucleic acid, genetic construct, vector, or cell according to the invention may be for use in a method of treating, preventing, ameliorating, delaying the progression of, or reducing at least one symptom of a pathology related to TrkB-FL cleavage. The pathology may be selected from depression, anxiety, bipolar disorders, schizophrenia, obesity, autism, rett syndrome, retinal ganglion cell loss, ageing, amyotrophic lateral sclerosis (Lou Gehrig's disease), the adverse neurologic complications of Down syndrome, diabetic peripheral neuropathy, or other types of peripheral neuropathy.

In another aspect of the invention, there is provided a method for treating a subject affected by AD, comprising the administration of a therapeutically effective amount of pharmaceutical composition, polypeptide, nucleic acid, genetic construct, vector, or cell according to the invention to the subject in need of treatment.

In another aspect of the invention, there is provided a method for treating a subject affected by a neuropathological condition, a pathology characterized by excitotoxicity, epilepsy, prion-like diseases, muscular dystrophies, Huntington's disease, Parkinson's disease, multiple sclerosis, ischemia, stroke, brain trauma, a pathology related to TrkB-FL cleavage, depression, anxiety, bipolar disorders, schizophrenia, obesity, autism, rett syndrome, retinal ganglion cell loss, ageing, amyotrophic lateral sclerosis (Lou Gehrig's disease), the adverse neurologic complications of Down syndrome, diabetic peripheral neuropathy, or other types of peripheral neuropathy, comprising the administration of a

therapeutically effective amount of pharmaceutical composition, polypeptide, nucleic acid, genetic construct, vector, or cell according to the invention to the subject in need of treatment.

In some embodiments, the pharmaceutical composition, polypeptide, nucleic acid, genetic construct, vector, or cell of the invention may be used to result in the reduction or reversing of cognitive defects associated with AD.

In another aspect of the invention, there is provided the use of TrkB-FL, TrkB-ICD, TrkB-T', the TrkB-T':TrkB-FL ratio, or the TrkB-ICD:TrkB-FL ratio as a biomarker for AD.

In another aspect of the invention, there is provided a method for diagnosing AD or for determining the stage of AD, comprising:

i) comparing the amount of TrkB-FL and/or TrkB-ICD measured in a sample obtained from a subject to a reference amount, and

ii)

a) determining that said subject has AD, or determining that said subject has a more advanced stage of AD than that represented by the reference amount, if said amount of TrkB-FL is lower than said reference amount and/or if said amount of TrkB-ICD is higher than said reference amount; or

b) determining that said subject has the same stage of AD or AD diagnosis as that represented by the reference amount if said amount of TrkB-FL and/or TrkB-ICD is the same or similar to said reference amount; or

c) determining that said subject does not have AD, or determining that said subject has a less advanced stage of AD than that represented by the reference amount, if said amount of TrkB-FL is higher than said reference amount and/or if said amount of TrkB-ICD is lower than said reference amount.

The method may further comprise, prior to step i), measuring the amount of TrkB-FL and/or TrkB-ICD in a sample obtained from a subject.

In another aspect of the invention, there is provided a method for diagnosing AD or for determining the stage of AD, comprising:

i) comparing the amount of TrkB-T' measured in a sample obtained from a subject to a reference amount, and

ii)

a) determining that said subject has AD, or determining that said subject has a more advanced stage of AD than that represented by the reference amount, if said amount of TrkB-T' is higher than said reference amount; or

b) determining that said subject has the same stage of AD or AD diagnosis as that represented by the reference amount if said amount of TrkB-T' is the same or similar to said reference amount; or

c) determining that said subject does not have AD, or determining that said subject has a less advanced stage of AD than that represented by the reference amount, if said amount of TrkB-T' is lower than said reference amount.

The method may further comprise, prior to step i), measuring the amount of TrkB-T' in a sample obtained from a subject.

In some embodiments, the reference amount may be representative of the amount of TrkB-T', TrkB-FL, and/or TrkB-ICD in a subject without AD, in a subject with mild AD, in a subject with moderate AD, in a subject with severe AD, determined from said subject before disease onset, determined from said subject after diagnosis of mild AD, determined from said subject after diagnosis with moderate AD, determined from said subject after diagnosis with severe AD, or determined from said subject before treatment.

In another aspect of the invention, there is provided a method for diagnosing AD or for determining the stage of AD, comprising:

i) comparing the TrkB-ICD:TrkB-FL ratio measured in a sample obtained from a subject to a reference value, and

ii)

a) determining that said subject has AD or determining that said subject has a more advanced stage of AD than that represented by the reference value, if said TrkB-ICD:TrkB-FL ratio is higher than said reference value; or

b) determining that said subject has the same stage of AD or AD diagnosis as that represented by the reference value if said TrkB-ICD:TrkB-FL ratio is the same or similar to said reference value; or

c) determining that said subject does not have AD, or determining that the subject has a less advanced stage of AD than that represented by the reference value, if said TrkB-ICD:TrkB-FL ratio is lower than said reference value.

The method may further comprise, prior to step i), measuring the amount of TrkB-FL and TrkB-ICD in a sample obtained from the subject, and calculating the TrkB-ICD:TrkB-FL ratio in said sample.

In another aspect of the invention, there is provided a method for diagnosing AD or for determining the stage of AD, comprising:

i) comparing the TrkB-T':TrkB-FL ratio measured in a sample obtained from a subject to a reference value, and

ii)

a) determining that said subject has AD or determining that said subject has a more advanced stage of AD than that represented by the reference value, if said TrkB-T':TrkB-FL ratio is higher than said reference value; or

b) determining that said subject has the same stage of AD or AD diagnosis as that represented by the reference value if said TrkB-T':TrkB-FL ratio is the same or similar to said reference value; or

c) determining that said subject does not have AD, or determining that the subject has a less advanced stage of AD than that represented by the reference value, if said TrkB-T':TrkB-FL ratio is lower than said reference value.

The method may further comprise, prior to step i), measuring the amount of TrkB-FL and TrkB-T' in a sample obtained from the subject, and calculating the TrkB-T':TrkB-FL ratio in said sample.

In some embodiments, the reference value may be representative of the TrkB-ICD:TrkB-FL ratio or the TrkB-T':TrkB-FL ratio in a subject without AD, in a subject with mild AD, in a subject with moderate AD, in a subject with severe AD, determined from said subject before disease onset, determined from said subject after diagnosis of mild AD, determined from said subject after diagnosis with moderate AD, determined from said subject after diagnosis with severe AD, or determined from said subject before treatment.

In some embodiments, the subject may be diagnosed with AD if the subject's measured TrkB-ICD:TrkB-FL ratio or TrkB-T':TrkB-FL ratio is increased by at least 5%, at least 10%, at least 20%, at least 30%, at least 40%, at least 50%, at least 60%, at least 70%, at least 80%, at least 90%, at least 100%, at least 150%, at least 200%, or at least 300% in comparison to a reference value representative of a subject without AD.

In another aspect of the invention, there is provided a method for diagnosing AD, comprising:

i) comparing the TrkB-ICD:TrkB-FL ratio or the TrkB-T':TrkB-FL ratio measured in a sample obtained from a first subject with mild cognitive impairment to a reference value obtained from at least one subject without AD, and

ii)

a) determining that the first subject has AD if said TrkB-ICD:TrkB-FL ratio or TrkB-T':TrkB-FL ratio is increased by at least 5%, at least 10%, at least 20%, at least 30%, at least 40%, at least 50%, at least 60%, at least 70%, at least 80%, at least 90%, at least 100%, at least 150%, at least 200%, or at least 300% in comparison to said reference value; or

b) determining that the first subject does not have AD if said TrkB-ICD:TrkB-FL ratio or TrkB-T':TrkB-FL ratio is not increased compared to said reference value.

The method may further comprise, prior to step i):

measuring the amount of TrkB-FL and TrkB-ICD in a sample obtained from the first subject with mild cognitive impairment, and calculating the TrkB-ICD:TrkB-FL ratio; and/or ,

measuring the amount of TrkB-FL and TrkB-T' in a sample obtained from the first subject with mild cognitive impairment, and calculating the TrkB-T':TrkB-FL ratio.

In another aspect of the invention, there is provided a method for monitoring the efficacy of an AD treatment with an agent, comprising:

i) calculating an expected amount of TrkB-T', TrkB-FL, and/or TrkB-ICD based upon an amount of TrkB-T', TrkB-FL, and/or TrkB-ICD measured in a first sample obtained from a subject with AD and the time elapsed since the first sample was obtained; and

ii) comparing: an amount of TrkB-T', TrkB-FL, and/or TrkB-ICD measured in a second sample obtained from the subject after administration of an agent to the subject, to said expected amount of TrkB-T', TrkB-FL, and/or TrkB-ICD; and

iii)

a) determining that the treatment is efficacious if the amount of TrkB-FL in the second sample is higher than the expected amount of TrkB-FL, if the amount of TrkB-ICB in the second sample is lower than the expected amount of TrkB-ICB, and/or if the amount of TrkB-T' in the second sample is lower than the expected amount of TrkB-T'; or

b) determining that the treatment is not efficacious if the amount of TrkB-FL in the second sample is lower than or the same as the expected amount of TrkB-FL, if the amount of TrkB-ICB in the second sample is higher than or the same as the expected amount of TrkB-ICB, and/or if the amount of TrkB-T' in the second sample is higher than or the same as the expected amount of TrkB-T'.

The method may further comprise, prior to step i), measuring the amount of TrkB-T', TrkB-FL, and/or TrkB-ICD in a first sample obtained from a subject, and prior to step ii), measuring the amount of TrkB-T', TrkB-FL, and TrkB-ICD in a second sample obtained from said subject after administration of an agent to the subject.

In another aspect of the invention, there is provided a method for monitoring the efficacy of an AD treatment with an agent, comprising:

i) calculating an expected TrkB-ICD:TrkB-FL ratio or TrkB-T':TrkB-FL ratio based upon a TrkB-ICD:TrkB-FL ratio or TrkB-T':TrkB-FL ratio measured in a first sample obtained from a subject with AD and the time elapsed since the first sample was obtained; and

ii) comparing: a TrkB-ICD:TrkB-FL ratio or TrkB-T':TrkB-FL ratio measured in a second sample obtained from the subject after administration of an agent to the subject, to said expected TrkB-ICD:TrkB-FL ratio or TrkB-T':TrkB-FL ratio; and

iii)

a) determining that the treatment is efficacious if the TrkB-ICD:TrkB-FL ratio in the second sample is lower than the expected TrkB-ICD:TrkB-FL ratio, or determining that the treatment is efficacious if the TrkB-T':TrkB-FL ratio in the second sample is lower than the expected TrkB-T':TrkB-FL ratio; or

b) determining that the treatment is not efficacious if the TrkB-ICD:TrkB-FL ratio in the second sample is higher than or the same as the expected TrkB-ICD:TrkB-FL ratio, or determining that the treatment is not efficacious if the TrkB-T':TrkB-FL ratio in the second sample is higher than or the same as the expected TrkB-T':TrkB-FL ratio.

The method may further comprise, prior to step i):

measuring the amount of TrkB-FL and TrkB-ICD in the first sample obtained from the subject, and calculating the TrkB-ICD:TrkB-FL ratio in the first sample and, prior to step ii), measuring the amount of TrkB-FL and TrkB-ICD in the second sample obtained from the subject after administration of an agent to the subject, and calculating the TrkB-ICD:TrkB-FL ratio in the second sample; or

measuring the amount of TrkB-FL and TrkB-T' in the first sample obtained from the subject, and calculating the TrkB-T':TrkB-FL ratio in the first sample and, prior to step ii), measuring the amount of TrkB-FL and TrkB-T' in the second sample obtained from the subject after administration of an agent to the subject, and calculating the TrkB-T':TrkB-FL ratio in the second sample.

In another aspect of the invention, there is provided a method for monitoring the efficacy of an AD treatment with an agent, comprising:

i) measuring the amount of TrkB-FL and TrkB-ICD in a first sample obtained from a subject with AD, and

ii) calculating the TrkB-ICD:TrkB-FL ratio in said first sample, and

iii) administering an agent to said subject, and
iv) measuring the amount of TrkB-FL and TrkB-ICD in a second sample obtained from said subject, and
v) calculating the TrkB-ICD:TrkB-FL ratio in said second sample, and
vi)
a) determining that the treatment is efficacious if the TrkB-ICD:TrkB-FL ratio in the second sample is lower than the TrkB-ICD:TrkB-FL ratio in the first sample; or
b) determining that the treatment is not efficacious if the TrkB-ICD:TrkB-FL ratio in the second sample is higher than the TrkB-ICD:TrkB-FL ratio in the first sample.

In another aspect of the invention, there is provided a method for monitoring the efficacy of an AD treatment with an agent, comprising:
i) measuring the amount of TrkB-FL and TrkB-T' in a first sample obtained from a subject with AD, and
ii) calculating the TrkB-T':TrkB-FL ratio in said first sample, and
iii) administering an agent to said subject, and
iv) measuring the amount of TrkB-FL and TrkB-T' in a second sample obtained from said subject, and
v) calculating the TrkB-T':TrkB-FL ratio in said second sample, and
vi)
a) determining that the treatment is efficacious if the TrkB-T':TrkB-FL ratio in the second sample is lower than the TrkB-T':TrkB-FL ratio in the first sample; or
b) determining that the treatment is not efficacious if the TrkB-T':TrkB-FL ratio in the second sample is higher than the TrkB-T':TrkB-FL ratio in the first sample.

In some embodiments, the sample may be cerebrospinal fluid (CSF), blood, plasma, serum, or saliva.

Any of the aspects and embodiments described herein can be combined with any other aspect or embodiment as disclosed here in the Summary of the Invention, in the Drawings, and/or in the Detailed Description of the Invention, including the below specific, non-limiting, examples/embodiments of the present invention.

Unless otherwise defined, all technical and scientific terms used herein have the same meaning as commonly understood by one of ordinary skill in the art to which this application belongs.

Although methods and materials similar to or equivalent to those described herein can be used in the practice and testing of the application, suitable methods and materials are described below. All publications, patent applications, patents, and other references mentioned herein are incorporated by reference.

The references cited herein are not admitted to be prior art to the claimed application. In the case of conflict, the present specification, including definitions, will control. In addition, the materials, methods, and examples are illustrative only and not intended to be limiting.

Other features and advantages of the disclosure will become apparent from the following detailed description in conjunction with the examples.

Brief Description of the Figures

Figure 1. TrkB-FL cleavage increases during AD progression and is prevented by TAT-TrkB. The levels of cerebral TrkB-FL receptors decrease in later stages of the disease concomitantly to an increase of TrkB-ICD levels. In cerebrospinal fluid (CSF), patients with Mild Cognitive Impairment (MCI) due to Alzheimer´s disease (MCI Aβ+) have significantly higher levels of TrkB-ICD when compared with non-AD patients (MCI Aβ-).
a. Classification of AD pathology according to Braak staging (top). Western-blot of human samples probed with anti-Trk C-terminal and anti-β-actin antibodies (bottom).
b. Analysis of bands intensities represented in **a.**. Data normalized for Braak stages 0-II ($p<0.05$ and $p<0.01$, One-way ANOVA, followed by Bonferroni's post-test, n=7-11).
c. Analysis of TrkB-FL transcript (*NTRK2* gene) levels normalized to SV2B transcript. Data normalized for Braak stages 0-II (One-way ANOVA, followed by Bonferroni's post-test, n=11-27).

d. Analysis of the TAT-TrkB predicted 3D structure; asterisk marks cleavage site.
e. Western-blot of neuronal cultures. Aβ-driven cleavage of TrkB-FL was prevented by TAT-TrkB peptide (5 and 20 μM) incubated 1h or 4h before Aβ incubation.
f. Western-blot of adult rat brain cortex homogenate. TAT-TrkB (20, 50 μM) prevented calpain-mediated cleavage of TrkB-FL. Quantifications in Fig.6a-b.
g. Brain endothelial barrier (BEB) *in vitro* translocation kinetics of TAT-TrkB.
Complete statistical details in Supplementary Table 2.
h. Representative western-blot of human CSF samples from one patient with Mild Cognitive Impairment (MCI) (MCI Aβ-) and one with MCI due to AD (MCI Aβ+), probed with anti-Trk C-terminal. Ponceau used as loading control.
i. Average immunoreactive band intensity of TrkB-ICD in CSF from MCI (Aβ-) and from AD (MCI Aβ+) patients (values are normalized to MCI Aβ-). TrkB-ICD levels significantly increase in the CSF of MCI Aβ+ patients when compared to MCI Aβ- patients (*$p<0.05$, Mann-Whitney non-parametric test, n=12-20).

Figure 2. TAT-TrkB prevented the loss of BDNF synaptic effects.
a. Experimental design.
b-e. Time courses of fractional release of [^{3}H]glutamate from synaptosomes, evoked by two 15 mM K^+ stimulus (at 5–7 min and 29-31 min), in the absence or presence of BDNF (30 ng/ml) (**b**), Aβ (200 nM) oligomers (**c**), TAT-TrkB (20 μM) (**d**) and both TAT-TrkB and Aβ oligomers (**e**).
f. Histogram depicting the S2/S1 ratios from the experiments in **b-e**.
g-j. Time courses of the field excitatory postsynaptic potential (fEPSP) slope after delivery (0 min) of a θ-burst in the absence or presence of BDNF (30 ng/ml) to hippocampal slices exposed to vehicle (**g**) or Aβ (200 nM) oligomers (**h**), TAT-TrkB (20 μM) (**i**) and both TAT-TrkB and Aβ oligomers (**j**).
k. Histogram depicting LTP magnitudes from the recordings in **g-j.**
Complete statistical details in Supplementary Table 2.

Figure 3. TAT-TrkB prevented desaturation of hippocampal LTP.
a. Experimental design.
b. Time course of fEPSP slope after three θ-burst, separated by 1h-intervals, to hippocampal slices exposed to vehicle, Aβ (200 nM) oligomers or both Aβ oligomers and TAT-TrkB (20 μM).
c. Histogram depicting the magnitudes of the first, second and third LTPs from the recordings shown in **b.**, and from slices exposed to TAT-TrkB (20 μM) alone.
d. Histogram depicting the Saturation Index (SI) pertaining to the recordings in **b**.
e. Time courses of fEPSP slope after delivery (0 min) of a θ-burst to slices exposed to both Aβ oligomers and TAT-TrkB (20 μM), either superfused with BDNF's scavenger (TrkB-Fc, 2 μg/ml) or not (same data as in Fig.2j).
f. Histogram depicting LTP magnitudes from the recordings in **e.**
Complete statistical details in Supplementary Table 2.

Figure 4. Decreased TrkB-FL protein levels (detected by MS) are not affected by *post-mortem* delay in sample collection.
a. Proteomic analysis of TrkB-FL protein normalized to SV2B protein, using liquid-chromatography tandem mass spectrometry (LC-MS/MS). Samples obtained from human temporal cortical samples, with varying degree of AD-related pathology [n=11 (0-II), n=5 (III-IV) and n=16 (V-VI), mean±s.e.m., one-way ANOVA followed by a Bonferroni's multiple comparison test].
b. Distribution of *post-mortem delay* (PMD) in time categories for the LC-MS/MS samples, according to Braak staging.
c. TrkB-FL protein levels quantified in human temporal cortical samples using LC-MS/MS are plotted as a function of PMD time categories. TrkB-FL levels did not change significantly according to PMD in our cohort; thus, PMD is not a confounder of the association found between TrkB-FL levels and Braak staging [n=7 (2-3h), n=19 (4-5h) and n=6 (6-7h), mean±s.e.m., one-way ANOVA followed by a Bonferroni's multiple comparison test].
Complete statistical details in Supplementary Table 2.

Figure 5. Failed and untested versions of the TAT-TrkB peptide.
a. Predicted secondary structure of TAT-TrkB without a linker sequence was obtained using various structure modelling softwares (ConSSert, Scratch and PEP-FOLD). ConSSert tool: C – coil; E – strand; H – helix. Scratch: C – linear structure; E – extended strand; H – α-helix; T – turn.

b. Western-blot of adult rat brain cortex homogenate, showing decrease of TrkB-FL protein levels with concomitant TrkB-ICD formation when both exogenous m-calpain (1 or 2 enzymatic units, EU) and $CaCl_2$ (2 mM) were added. TrkB-FL cleavage and TrkB-ICD formation were not prevented by the version of TAT-TrkB peptide (20 μM) in **a**. β-actin was used as loading control.
c. Western-blot of DIV8 neuronal cultures showing TrkB-FL cleavage and TrkB-ICD formation with Aβ incubation, not prevented by the version of TAT-TrkB peptide (20 μM) in **a** (1, 5, 20 and 50 μM). β-actin was used as loading control.
d-f. Analysis of the 3D structure, predicted using PEP-FOLD software, of the TAT-TrkB peptide using three different linkers sequences connecting the TAT sequence and the sequence spanning the cleavage site. This online server indicates that these three peptides have predicted stronger α-helix content than the TAT-TrkB version in **a**. After this 3D analysis, we synthesized the peptide with KK as linker (Fig. 1d), since the cleavage site is more exposed without compromising α-helix structure. Other linkers tested: PP, 2 Prolines (d), Q, 1 Glutamine (e) and E, 1 Glutamate (f).

Figure 6. TAT-TrkB peptide is able to prevent TrkB-FL cleavage in a calpain *in vitro* assay from neuronal cultures lysate.
a-b. Analysis of bands intensities represented in Fig. 1f from densitometry quantification of TrkB-FL/TrkB-ICD ratio immunoreactivity, when assay was performed with m-calpain activity (EU, enzymatic units) of 1 EU (Fig. 6a) or 2 EU (Fig. 6b). Data is normalized for co-incubation of m-calpain (1/2 EU) and $CaCl_2$.
c. Western-blot of DIV8 neuronal cultures lysate, showing decrease of TrkB-FL protein levels with concomitant TrkB-ICD formation when both exogenous m-calpain (1 or 2 EU) and $CaCl_2$ (2 mM) were added. TrkB-FL cleavage and TrkB-ICD formation were prevented in the presence of 50 μM TAT-TrkB peptide. GAPDH was used as loading control.
d-e. Analysis of bands intensities represented in **c.** from densitometry quantification of TrkB-FL/TrkB-ICD ratio immunoreactivity, when assay was performed with m-calpain activity of 1 EU (Fig. 6d) or 2 EU (Fig. 6e). Data is normalized for co-incubation of m-calpain (1/2 EU) and $CaCl_2$.

Figure 7. The integrity of the Blood Endothelial Barrier (BEB) *in vitro* model is maintained after incubation with the TAT-TrkB peptide.
a. The BEB *in vitro* model comprises a transwell system with an insert in which bEnd.3 cells are cultured. In this model, the apical chamber replicates the blood compartment, while the basolateral chamber replicates the brain compartment. TAT-TrkB-6-FAM and FD4 probes were added to the apical side; samples were collected from both chambers and fluorescence was measured.
b. After each TAT-TrkB peptide translocation assay (Fig. 1g), the FD4 fluorescent probe was added to the apical chamber and samples were collected 2 h thereafter. Untreated cells (negative control) and EGTA-treated cells (positive control) were also tested in parallel. The fluorescence detected in the basolateral chamber, normalized to the total fluorescence detected in both chambers, is expressed in the y axis. As expected, compared to untreated cells, EGTA significantly increased the permeability of the membrane, probably due to tight junction disruption. On the other hand, the clearance of FD4 from the apical chamber in the presence of TAT-TrkB peptide was negligible, arguing for the lack of fenestrations in the cell barrier and absence of paracellular leakage (n=3 for each condition, datapoints are averages of triplicates, mean±s.e.m., one-way ANOVA followed by a Bonferroni's multiple comparison test).
Complete statistical details in Supplementary Table 2.

Figure 8. Characterization of Aβ species.
a. SDS-PAGE separation of the different Aβ species (monomers, oligomers and fibrils). Species were probed against Aβ. Monomeric Aβ was only detected at a single band with MW lower than 12 kDa, suggesting it was retained at Aβ monomeric MW. Oligomers were mainly present at a MW between 38-225 kDa. Fibrils were predominantly present at high MW (>150 kDa).
b. Aβ species were analyzed by DLS size (hydrodynamic diameter) and distributions are plotted as a function of scattered light intensity percentage (monomers in blue; oligomers in red; fibrils in green) (n=3 Aβ batches). DLS revealed a more heterogeneous size distribution of both oligomeric and fibrillar Aβ, in comparison to monomeric Aβ, with a significant increase in particles with a hydrodynamic diameter above 2500 nm in both cases.

Figure 9. Aβ Oligomers and Fibrils induce neuronal death, dendritic spine loss and impair spontaneous excitatory transmission.

a. Representative images of primary neuronal cultures labelled with propidium iodide (PI) and MAP2 (neuronal marker) after 24 h incubation with (i) vehicle (Veh), (ii) Aβ (200 nM) monomers (AβM), (iii) Aβ oligomers (AβO) and (iv) Aβ fibrils (AβF). Scale bar: 200 μm (left panel). Histogram depicting percentage neuronal death of primary neuronal cultures, as assessed by co-staining with MAP2 and PI (n=5 from 5 independent cell cultures per condition, mean±s.e.m., one-way ANOVA followed by a Bonferroni's multiple comparison test) (right panel).
b. Histogram depicting normalized percentage cell viability as evaluated by the MTT assay following 24 h exposure to vehicle (Veh), Aβ (200 nM) monomers (AβM), oligomers (AβO) or fibrils (AβF) (n=5 from 5 independent cell cultures per condition, mean±s.e.m., one-way ANOVA followed by a Bonferroni's multiple comparison test).
c. Histogram depicting the quantification of dendritic protrusions per 10 μm, following 24h exposure to vehicle (Veh), Aβ (200 nM) monomers (AβM), oligomers (AβO) or fibrils (AβF) (n=5 from 5 independent cell cultures per condition, mean±s.e.m., one-way ANOVA followed by a Bonferroni's multiple comparison test) (left panel). Representative images of dendritic spines are shown per condition (right panel).
d-e. Histograms depicting the values of frequency (d) and amplitude (e) of mEPSC events recorded from primary neuronal cultured cells exposed for 24 h to vehicle (Veh; n=13 cells, from 4 cultures), Aβ (200 nM) monomers (AβM; n=10 cells, from 4 cultures), oligomers (AβO; n=13 cells, from 4 cultures) or fibrils (AβF; n=16 cells from 4 cultures) (mean±s.e.m., one-way ANOVA followed by a Bonferroni's multiple comparison test).
f. Representative mEPSC tracings for each condition are shown.
Complete statistical details in Supplementary Table 2.

Figure 10. Brief exposure to Aβ Oligomers and Fibrils already impairs afferent-evoked excitatory transmission, in the absence of overt cell death.
a. Representative images of acute hippocampal slices labelled with Hoechst (DNA marker), MAP2 (neuronal marker) and PI after 3h incubation with (i-iv) vehicle (Veh), (v-viii) Aβ (200 nM) monomers, (ix-xii) oligomers and (xiii-xvi) fibrils. Scale bar: 300 μm.
b-c. Histograms depicting percentage neuronal death (b) and overall death (c) in the CA1 and CA3 areas of hippocampal slices after 3h incubation with vehicle (Veh), Aβ (200 nM) monomers (AβM), oligomers (AβO) or fibrils (AβF) (n=8 slices, 8 animals per condition, mean±s.e.m., one-way ANOVA followed by a Bonferroni's multiple comparison test).
d. Input/Output curves from hippocampal slices incubated with vehicle or Aβ (200 nM) monomers (AβM), oligomers (AβO) or fibrils (AβF) for 3h (n=7-8 slices, 7-8 rats per condition), where the fEPSP slope is plotted as a function of presynaptic fiber volley (PSFV) amplitude. Data are mean±s.e.m, with nonlinear fittings (left panel). Histogram depicting the top parameter of the fitted curves for each condition ± standard error (n=7-8 slices, 7-8 rats per condition, one-way ANOVA followed by a Bonferroni's multiple comparison test) (right panel).
e. Population spike amplitude is plotted as a function of the fEPSP slope; data from all field responses in which the population spike was elicited were included. The lines represent linear fittings (n=7-8 slices, 7-8 rats per condition) (left panel). Histogram depicting the popspike amplitude / fEPSP slope ratio (n=7-8 slices, 7-8 rats per condition, mean±s.e.m., one-way ANOVA followed by a Bonferroni's multiple comparison test) (right panel).
f. Averaged PPF ratios (fEPSP 2 slope/ fEPSP 1 slope) elicited at different interstimulus intervals (ISI) (10 ms, 20 ms, 50 ms, 70 ms, 100 ms, 150 ms) from hippocampal slices incubated with vehicle or Aβ (200 nM) monomers, oligomers or fibrils (n=5 slices, 5 rats per condition). Data are mean±s.e.m.
Complete statistical details in Supplementary Table 2.

Figure 11. Aβ Monomers and Fibrils do not impair BDNF effect on glutamate release and hippocampal LTP.
a-b Time courses of averaged normalized changes in fractional release of [^{3}H]glutamate evoked by two 15 mM K^+ stimulus of 2 min duration, at 5–7 min and at 29-31 min. BDNF (30 ng/ml) was added at 9 min and remained in the perfusion solution until the end of the experiments (filled circles), as indicated by the horizontal bar. Control curves, in the absence of BDNF, were performed in parallel with the same synaptosomal batch (open circles). Synaptosomal batches were prepared from hippocampal slices previously exposed to Aβ (200 nM) monomers (AβM; a; n=6 experiments, 12 rats) or fibrils (AβF; b; n=5 experiments, 10 rats). Data are mean±s.e.m.
c. Histogram depicting the S2/S1 ratios from the experiments in **a-b** (mean±s.e.m., paired t-tests).
d-e. Time courses of averaged normalized changes in fEPSP slope after delivery (0 min) of a weak θ-burst in the absence (open circles) or presence of BDNF (30 ng/ml, filled circles) to hippocampal slices

exposed to Aβ (200 nM) monomers (AβM; d; n=5 slices, 5 rats per condition) or fibrils (AβF; e; n=6 slices, 6 rats in the absence of BDNF; n=7 slices, 7 rats in the presence of BDNF). Data are mean±s.e.m.
f. Histogram depicting LTP magnitudes from the recordings shown in **d-e** (mean±s.e.m., one-way ANOVA followed by a Bonferroni's multiple comparison test).
Complete statistical details in Supplementary Table 2.

Figure 12. Calpain inhibition prevents the deleterious effects of Aβ Oligomers and Fibrils on hippocampal LTP.
a. Diagram of the experimental design.
b. Time course of averaged normalized changes in fEPSP slope after delivery of three weak θ-burst, separated by 1h-intervals (0 min, 60 min, 120 min), to hippocampal slices exposed to vehicle (n=8 slices, 8 rats) or Aβ (200 nM) monomers (n=7 slices, 7 rats), oligomers (n=8 slices, 8 rats) or fibrils (n=8 slices, 8 rats). Data are mean±s.e.m.
c. Time course of averaged normalized changes in fEPSP slope after delivery of three weak θ-burst , separated by 1h-intervals (0 min, 60 min, 120 min), to hippocampal slices exposed to both MDL28170 (20 μM) and either vehicle (n=7 slices from 7 different rats) or Aβ (200 nM) oligomers (n=7 slices, 7 rats) or fibrils (n=4 slices, 4 rats). Data are mean±s.e.m.
d. Histogram depicting the magnitudes of the first, second and third LTPs from the recordings shown in **b-c**. Data are mean±s.e.m.
e. Histogram depicting the Saturation Index (SI) pertaining to the recordings in **b-c** (n indicated above, mean±95%CI, one-way ANOVA followed by a Bonferroni's multiple comparison test).
Complete statistical details in Supplementary Table 2.

Figure 13. Images of uncropped gels and western blots with molecular weight standards.
Uncropped images of representative western blot images (squared in red) from Figures 1a, 1e and 1f and Figures 5b, 5c and 5c. Three different molecular weight standards were used: Invitrogen SeeBlue Plus2 Pre-stained Standard (Figure 1a), NZYTech Protein Marker II (Figures 1e, 1f and 6c) and Bio-Rad Precision Plus Protein (Figures 5b and 5c). In some cases, membranes were cut before antibody staining in order to allow two different stainings at the same time without reprobing. Sample identified with "*" in the "Figure 1a – 2nd WB" was not quantified, due to its low quality, possibly justified by compromised sample preparation.

Figure 14. Preliminary data regarding the possible biomarker application of TrkB-FL and TrkB-ICD protein levels, as well as TrkB-ICD/TrkB-FL ratio
a. Western-blot of CSF samples obtained from patients diagnosed with and without AD pathophysiology probed with anti-Trk (C-14) antibody and staining for Ponceau as loading control.
b. Quantification of TrkB-FL protein levels represented in a. and normalized to MCI patients without AD diagnosis.
c. Quantification of TrkB-ICD protein levels represented in a. and normalized to MCI patients without AD diagnosis.
d. Quantification of TrkB-ICD/TrkB-FL protein levels represented in a. and normalized to MCI patients without AD diagnosis.

Figure 15. TrkB-ICD overexpression in primary cortical neurons affects transcriptomics and is associated with Long-term memory, as well as Alzheimer's disease.
B1. Experimental timeline of lentiviral transduction of primary neurons and consequent RNA and protein extraction.
B2. Identification of biological processes associated with up- and down-regulated genes, when TrkB-ICD-expressing neurons are compared to eGFP-expressing neurons.
B3. Identification of cellular compartments associated with up- and down-regulated genes, when TrkB-ICD-expressing neurons are compared to eGFP-expressing neurons.
B4. Identification of diseases associated with up- and down-regulated genes, when TrkB-ICD-expressing neurons are compared to eGFP-expressing neurons.
B5. Ideogram – chromosome map – representing transcriptomic alterations induced by TrkB-ICD fragment.

Figure 16. TrkB-ICD overexpression in hippocampus of wild-type animals promotes memory impairment (in Novel-object recognition test), without locomotion and anxiety alterations.

C1. Experimental timeline of intra-hippocampal lentiviral transduction of wild-type animals and consequent behavioural,
C2. Behavioural tests performed,
C3. Open filed test: quantification of mean velocity and distance travelled (locomotion evaluators) and time spent on central zone (anxiety evaluator).
C4. Elevated-plus maze test: quantification of entries and time spent on open arms (anxiety evaluator).
C5. Morris water maze test: learning curve representing the latency to find the platform for 4 consecutive days.
C6. Morris water maze test: quantification of number of platform crossings, as well as percentage of the time spent in the quadrant of the platform.
C7. Novel-object recognition test: exploration time, total and per object, of training day. A and A' represent equal objects.
C8. Novel-object recognition test: exploration time, total and per object, of training day. A and B represent different objects, being B the novel object.

Figure 17. TrkB-ICD overexpression in hippocampus of wild-type animals promote an increase of synaptic plasticity, without alterations in paired-pulse facilitation and post-tethanic pulses.
D1. Time courses of averaged normalized changes in fEPSP slope after delivery (0 min) of a weak θ-burst to hippocampal slices from control animals or animals-expressing TrkB-ICD or GFP. Data are mean±s.e.m.
D2. Histogram depicting LTP magnitudes from the recordings in **D1.**
D3. Histogram depicting PTP magnitudes from the recordings in **D1.**
D4. Histograms of PPF at interstimulus of 10, 20, 50, 70, and 100 ms. The ordinates refer to an average value of PPF measured as a ratio between the second and the first fEPSP slope responses in hippocampal slices from control animals or animals-expressing TrkB-ICD or GFP. Data are mean±s.e.m.

Figure 18. *In vivo* pilot study to evaluate TAT-TrkB efficacy.
A. Timeline of the experimental design.
B. Quantification of TrkB-FL levels in both the hippocampus of wild type (WT, blue – two groups on the left of the graph) and 5xFAD (yellow – two groups on the right of the graph) mice treated with either saline solution (Veh) or with TAT-TrkB (TAT)
C. Comparison of the performance by WT and 5xFAD treated with saline solution (veh) or with TAT-TrkB (TAT) in the spatial learning protocol of the Morris water maze. Learning curve of the mean escape latencies over the 4 days of acquisition training for WT and 5xFAD animals untreated or treated with TAT-TrkB. The uppermost dotted line on the graph is 5xFAD veh.

Detailed Description
As previously shown by the inventors, the accumulation of amyloid-β during AD induces calpain activation which leads to TrkB-FL cleavage and impairment of BDNF neuromodulatory actions. Herein, the inventors provide agents that are capable of preventing the cleavage of TrkB-FL.

In a first aspect of the invention, there is provided a pharmaceutical composition comprising a portion of TrkB-FL, wherein the portion spans the calpain cleavage site of TrkB-FL.

The inventors demonstrate herein that contacting a pharmaceutical composition according to the first aspect to cells, such as neuronal cells, can prevent amyloid-β-induced cleavage of TrkB-FL. Without being bound to a particular theory, the inventors hypothesise that the TrkB-FL portion is able to bind to the TrkB-FL cleavage site and hence protect TrkB-FL from calpain cleavage. Further, the inventors demonstrate that administration of pharmaceutical composition according to the first aspect to a subject in need of treatment will prevent the impairment of BDNF activity and will prevent the accumulation of TrkB-ICD. Hence, the cognitive defects associated with AD will be treated, prevented, ameliorated, delayed, or reduced.

Prior to the present invention, it was not known that portions of TrkB-FL have the aforementioned property. Tejeda *et al.* teaches that a portion of TrkB-FL that spans the calpain cleavage site of TrkB-FL is not suitable for use as a neuroprotective agent[8]. The present inventors have overcome this technical prejudice. The inventors demonstrate herein that said TrkB-FL portion does have the desired activity, but that this activity can be lost if the portion of TrkB-FL is allowed to adopt particular conformations. As such, functional pharmaceutical compositions can be generated by ensuring that the

portion of TrkB-FL is exposed outside of conformational structures, for instance outside of alpha-helical conformations.

The TrkB-FL may be human TrkB-FL.

The amino acid sequence of TrkB-FL may be:

MSPWLKWHGPAMARLWGLCLLVLGFWRASLACPTSCKCSSARIWCTEPSPGIVAFPRLEP
NSVDPENITEILIANQKRLEIINEDDVEAYVGLRNLTIVDSGLKFVAYKAFLKNSNLRHI
NFTRNKLTSLSRRHFRHLDLSDLILTGNPFTCSCDIMWLKTLQETKSSPDTQDLYCLNES
SKNMPLANLQIPNCGLPSARLAAPNLTVEEGKSVTLSCSVGGDPLPTLYWDVGNLVSKHM
NETSHTQGSLRITNISSDDSGKQISCVAENLVGEDQDSVNLTVHFAPTITFLESPTSDHH
WCIPFTVRGNPKPALQWFYNGAILNESKYICTKIHVTNHTEYHGCLQLDNPTHMNNGDYT
LMAKNEYGKDERQISAHFMGRPGVDYETNPNYPEVLYEDWTTPTDIGDTTNKSNEIPSTD
VADQSNREHLSVYAVVVIASVVGFCLLVMLLLLKLARHSKFGMKGPASVISNDDDSASPL
HHISNGSNTPSSSEGGPDAVIIGMTKIPVIENPQYFGITNSQLKPDTFVQHIKRHNIVLK
RELGEGAFGKVFLAECYNLCPEQDKILVAVKTLKDASDNARKDFHREAELLTNLQHEHIV
KFYGVCVEGDPLIMVFEYMKHGDLNKFLRAHGPDAVLMAEGNPPTELTQSQMLHIAQQIA
AGMVYLASQHFVHRDLATRNCLVGENLLVKIGDFGMSRDVYSTDYYRVGGHTMLPIRWMP
PESIMYRKFTTESDVWSLGVVLWEIFTYGKQPWYQLSNNEVIECITQGRVLQRPRTCPQE
VYELMLGCWQREPHTRKNIKSIHTLLQNLAKASPVYLDILG (SEQ ID NO: 1)

The calpain cleavage site is between Asn^{520} and Ser^{521} of SEQ ID NO: 1.

The amino acid sequence of TrkB-ICD may be:

SQLKPDTFVQHIKRHNIVLKRELGEGAFGKVFLAECYNLCPEQDKILVAVKTLKDASDNA
RKDFHREAELLTNLQHEHIVKFYGVCVEGDPLIMVFEYMKHGDLNKFLRAHGPDAVLMAE
GNPPTELTQSQMLHIAQQIAAGMVYLASQHFVHRDLATRNCLVGENLLVKIGDFGMSRDV
YSTDYYRVGGHTMLPIRWMPPESIMYRKFTTESDVWSLGVVLWEIFTYGKQPWYQLSNNE
VIECITQGRVLQRPRTCPQEVYELMLGCWQREPHTRKNIKSIHTLLQNLAKASPVYLDIL
G (SEQ ID NO: 2)

The amino acid sequence of TrkB-T' may be:

MSPWLKWHGPAMARLWGLCLLVLGFWRASLACPTSCKCSSARIWCTEPSPGIVAFPRLEP
NSVDPENITEILIANQKRLEIINEDDVEAYVGLRNLTIVDSGLKFVAYKAFLKNSNLRHI
NFTRNKLTSLSRRHFRHLDLSDLILTGNPFTCSCDIMWLKTLQETKSSPDTQDLYCLNES
SKNMPLANLQIPNCGLPSARLAAPNLTVEEGKSVTLSCSVGGDPLPTLYWDVGNLVSKHM
NETSHTQGSLRITNISSDDSGKQISCVAENLVGEDQDSVNLTVHFAPTITFLESPTSDHH
WCIPFTVRGNPKPALQWFYNGAILNESKYICTKIHVTNHTEYHGCLQLDNPTHMNNGDYT
LMAKNEYGKDERQISAHFMGRPGVDYETNPNYPEVLYEDWTTPTDIGDTTNKSNEIPSTD
VADQSNREHLSVYAVVVIASVVGFCLLVMLLLLKLARHSKFGMKGPASVISNDDDSASPL
HHISNGSNTPSSSEGGPDAVIIGMTKIPVIENPQYFGITN (SEQ ID NO: 3)

A "portion" of a protein, as used herein, is a peptide or polypeptide with a sequence that matches part, but not all, of the parent protein. The portion of a protein may be considered to be a fragment of said protein. In the embodiments, the portion of TrkB-FL is isolated from the full-length TrkB-FL protein but may be within a larger polypeptide or composition. For instance, the TrkB-FL portion may be included within a larger polypeptide that also includes polypeptide sequences not derived from TrkB-FL. The portion of TrkB-FL may be adjoined to amino acid sequences with which it is not associated in nature.

In an embodiment, a peptide which "spans" a specified site may comprise at least one amino acid residue to the N-terminal side of the specified site and at least one amino acid residue to the C-terminal side of the specified site. For example, to span the calpain cleavage site of TrkB-FL, the peptide may comprise at least a residue corresponding to Asn^{520} and at least a residue corresponding to Ser^{521}. In an embodiment, the portion of TrkB-FL that spans the calpain cleavage site may include adequate residues on either side of the cleavage site such that the portion of TrkB-FL is able to prevent of the cleavage of TrkB-FL to produce TrkB-ICD. To confirm this activity, the portion may be tested using the *in vitro* experiments described herein.

The portion of TrkB-FL may include further modifications to the peptide, including naturally occurring modifications, any known post-translational modifications, glycosylation, pegylation, artificial modifications, or a combination.

In an embodiment, the pharmaceutical composition may include one or more portion of TrkB-FL as disclosed herein. In an embodiment, the pharmaceutical composition may comprise a plurality of portions of TrkB-FL as disclosed herein, in combination, admixture, covalently bound, non-covalently bound, or fused. In an embodiment, the pharmaceutical composition may comprise a fusion protein, wherein the fusion protein comprises one or more portion of TrkB-FL, and optionally polypeptide sequences not derived from TrkB-FL.

In particular embodiments, the pharmaceutical composition may comprise a polypeptide defined below as the second aspect of the invention. In other embodiments the pharmaceutical composition may comprise a nanoparticle-based delivery system, suitable for the delivery of the portion of TrkB-FL to neurons affected by AD in a subject. In other embodiments, the pharmaceutical composition or the nanoparticle-based delivered system may comprise an antibody, such as a monoclonal antibody, with which the portion of TrkB-FL is in association. For instance, the portion of TrkB-FL may be bound to the antibody by a cleavable moiety. The monoclonal antibody may be suitable for targeting the pharmaceutical composition to the brain or to the target neurons. For instance, the monoclonal antibody may have specificity for an antigen found in the brain or expressed by the relevant neurons.

In other embodiments, the pharmaceutical composition may comprise an exosome, a vesicle, a polymer-based vector, a lipid-based vector, or any other carrier suitable for the delivery of the portion of TrkB-FL to the brain or to neurons affected by AD in a subject.

In some embodiments, the pharmaceutical composition may comprise an agent for enhancing the permeability of the blood brain barrier (BBB) or for permitting the delivery of the portion of TrkB-FL through the BBB. This agent may form part of the same composition as the portion of TrkB-FL, or may be present in a different composition and administered separately.

The pharmaceutical composition may be suitable for use with any delivery system capable of delivering the peptide portion of TrkB-FL to the relevant neuronal cells of a subject.

The pharmaceutical composition of the first aspect of the invention may include at least one of a pharmaceutically acceptable carrier, a pharmaceutically acceptable excipient, a pharmaceutically acceptable stabilizer, or pharmaceutically acceptable preservative, or any combination thereof.

In an embodiment, the portion of TrkB-FL may comprise 1 to 100, 1 to 75, 1 to 50, 1 to 40, 1 to 30, 1 to 25, 1 to 20, 1 to 15, or 1 to 10 of the residues on the N-terminal side of the TrkB-FL calpain cleavage site. For instance, in an embodiment, the portion of TrkB-FL may include at least 1 and no more than 10 of the consecutive residues that are N-terminal to the calpain cleavage site of TrkB-FL. In particular examples, the portion of TrkB-FL may include the sequence: N, TN, ITN, GITN (SEQ ID NO: 4), FGITN (SEQ ID NO: 5), YFGITN (SEQ ID NO: 6), QYFGITN (SEQ ID NO: 7), PQYFGITN (SEQ ID NO: 8), NPQYFGITN (SEQ ID NO: 9), or ENPQYFGITN (SEQ ID NO: 10). In a particular embodiment, the portion may comprise the five residues that are N-terminal to the TrkB-FL calpain cleavage site, for example FGITN (SEQ ID NO: 5). In an embodiment, the portion may comprise 1 to 100, 1 to 75, 1 to 50, 1 to 40, 1 to 30, 1 to 25, 1 to 20, 1 to 15, or 1 to 10 of the residues on the C-terminal side of the TrkB-FL calpain cleavage site. For instance, in an embodiment, the portion of TrkB-FL may include at least 1 and no more than 10 of the consecutive residues that are C-terminal to the calpain cleavage site of TrkB-FL. In particular examples, the portion of TrkB-FL may include the sequence: S, SQ, SQL, SQLK (SEQ ID NO: 11), SQLKP (SEQ ID NO: 12), SQLKPD (SEQ ID NO: 13), SQLKPDT (SEQ ID NO: 14), SQLKPDTF (SEQ ID NO: 15), SQLKPDTFV (SEQ ID NO: 16), or SQLKPDTFVQ (SEQ ID NO: 17). In a particular embodiment, the portion may comprise the five residues that are C-terminal to the TrkB-FL calpain cleavage site, for example SQLKP (SEQ ID NO: 12). In some embodiments, the aforementioned sequences on the N-terminal side and on the C-terminal side of the calpain cleavage site may be combined so that the TrkB-FL portion is 5 to 20 residues in length, 6 to 15 residues in length, 7 to 13 residues in length, 8 to 12 residues in length, 9 to 11 residues in length, or in particular embodiments 10 residues in length.

In another embodiment, the portion of TrkB-FL spans the calpain cleavage site and is at least 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 25, 30, 40, 50, 75, or 100 residues in length. In another embodiment, the portion of TrkB-FL spans the calpain cleavage site and is no more than 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 25, 30, 40, 50, 75, or 100 residues in length. In some embodiments, the portion of TrkB-FL spans the calpain cleavage site and is 5 to 20 residues in length, 6 to 15 residues in length, 7 to 13 residues in length, 8 to 12 residues in length, or 9 to 11 residues in length. In particular embodiments, the portion of TrkB-FL spans the calpain cleavage site and is 10 residues in length.

In a particular embodiment, the portion of TrkB-FL is according to the amino acid sequence FGITNSQLKP (SEQ ID NO: 18).

In another embodiment, the portion of TrkB-FL is according to the amino acid sequence PQYFGITNSQLKPDTF (SEQ ID NO: 19).

In an embodiment, the portion of TrkB-FL may be according to the amino acid sequence ITNSQLKPDTFVQH (SEQ ID NO: 20). In some embodiments, the portion of TrkB-FL may be as disclosed herein, and wherein the amino acid sequence is not according to SEQ ID NO: 20. In some embodiments, the portion of TrkB-FL spans the calpain cleavage site and is at least 5, 6, 7, 8, 9, 10, 11, 12, 13, or 14 residues in length, and is not according to SEQ ID NO: 20. In another embodiment, the portion of TrkB-FL spans the calpain cleavage site and is no more than 14, 15, 16, 17, 18, 19, 20, 25, 30, 40, 50, 75, or 100 residues in length, and is not according to SEQ ID NO: 20.

In some embodiments, the portion of TrkB-FL may comprise an amino acid sequence according to SEQ ID NO: 18, SEQ ID NO: 19, or SEQ ID NO: 20, wherein the peptide comprises one or more substitutions, modifications, deletions, or replacements within this sequence. For example one, two, three, four, or five substitutions of a residue within SEQ ID NO: 18, SEQ ID NO: 19, or SEQ ID NO: 20 for an alternative amino acid residue. In some embodiments, the polypeptide may comprise one to three substitutions. In particular embodiments, the one or more substitutions are conservative substitutions.

Provided herein is a polypeptide comprising a portion of the TrkB-FL protein as disclosed herein. Hence, in a second aspect of the invention, there is provided a polypeptide comprising an isolated portion of TrkB-FL, wherein the isolated portion of TrkB-FL spans the calpain cleavage site of TrkB-FL. The TrkB-FL portion is “isolated” from the full-length TrkB-FL protein but is within a larger polypeptide. For instance, the portion of TrkB-FL may be included within a larger polypeptide that also includes polypeptide sequences not derived from TrkB-FL. The portion of TrkB-FL may be adjoined to amino acid sequences with which it is not associated in nature. The use of the term “isolated” in connection with the second aspect of the invention is to emphasise that a polypeptide comprising the portion of TrkB-FL cannot be TrkB-FL itself.

The portion of TrkB-FL, as included in the polypeptide of the second aspect of the invention, may be any portion of TrkB-FL as disclosed herein. The pharmaceutical composition of the first aspect of the invention may comprise the polypeptide of the second aspect of the invention.

The polypeptide of the second aspect may comprise a cell-penetrating peptide. The polypeptide of the second aspect may, therefore, be a polypeptide comprising a cell-penetrating peptide and a portion of TrkB-FL as disclosed herein.

The cell-penetrating peptide may allow the polypeptide to cross the blood-brain barrier and enter neuronal cells. The cell-penetrating peptide may therefore facilitate the delivery of the portion of TrkB-FL to a site of interest, for instance defective neuronal cells.

In some embodiments the cell-penetrating peptide is trans-activating transcriptional activator (TAT). The TAT peptide may be according to the following sequence: YGRKKRRQRRR (SEQ ID NO: 21). Other peptides or agents which allow the delivery of the portion of TrkB-FL are also suitable for use with the present invention.

The polypeptide of the second aspect may comprise: a portion of TrkB-FL as disclosed herein, a linker, and a cell-penetrating peptide as disclosed herein. The linker may connect the portion of TrkB-FL to the cell-penetrating peptide.

The linker may ensure that the conformation of the peptide is such that the portion of TrkB-FL and the cell-penetrating peptide remain functional. For instance, the linker may ensure that the portion of TrkB-FL does not adopt an alpha-helical conformation. The linker may ensure that the portion of TrkB-FL is exposed. The linker may ensure that the portion of TrkB-FL is able to bind to TrkB-FL. The conformation of peptides may be predicted by structural prediction techniques, as discussed in the Examples.

In an embodiment, the linker comprises the amino acid residues KK. In another embodiment, the linker consists of the amino acid residues KK.

In another embodiment, the linker comprises an amino acid sequence selected from: PP, Q, E, KK, and combinations thereof. In another embodiment, the linker consists of an amino acid sequence selected from: PP, Q, and E.

In some embodiments, the polypeptide of the second aspect may comprise a portion of TrkB-FL according to an amino acid sequence selected from the group consisting of SEQ ID NO: 18, SEQ ID NO: 19, or SEQ ID NO: 20; a linker as disclosed herein; and a cell-penetrating peptide as disclosed herein. The portion of TrkB-FL may comprise one or more substitutions, modifications, deletions, or replacements as discussed herein.

In some embodiments, the polypeptide of the second aspect may comprise a portion of TrkB-FL according to an amino acid sequence selected from the group consisting of SEQ ID NO: 18, SEQ ID NO: 19, or SEQ ID NO: 20; a linker comprising the amino acid residues KK; and SEQ ID NO: 21. The portion of TrkB-FL may comprise one or more substitutions, modifications, deletions, or replacements as discussed herein.

In particular embodiments, the pharmaceutical composition of the first aspect of the invention or the polypeptide of the second aspect is suitable for administration to a subject, for instance a human, and is able to prevent the amyloid-β-induced calpain cleavage of TrkB-FL within neuronal cells.

In a particular embodiment, the polypeptide of the second aspect may be a polypeptide with an amino acid sequence according to YGRKKRRQRRRKKFGITNSQLKP (SEQ ID NO: 22). In some embodiments, the polypeptide of the second aspect may be a peptide with an amino acid sequence according to SEQ ID NO: 22, wherein the peptide comprises one or more substitutions, modifications, deletions, or replacements within this sequence. For example one, two, three, four, five, six, or seven substitutions for an alternative amino acid residue. In some embodiments, the polypeptide may comprise one to three substitutions. In particular embodiments, the one or more substitutions are conservative substitutions. In certain embodiments, the amino acid sequence corresponding to a portion of TrkB-FL may comprise the one or more substitutions, modifications, deletions, or replacements.

In a particular embodiment, the polypeptide of the second aspect may be a polypeptide with an amino acid sequence according to YGRKKRRQRRRKKPQYFGITNSQLKPDTF (SEQ ID NO: 23). In some embodiments, the polypeptide of the second aspect may be a polypeptide with an amino acid sequence according to SEQ ID NO: 23, wherein the peptide comprises one or more substitutions, modifications, deletions, or replacements within this sequence. For example one, two, three, four, five, six, or seven substitutions for an alternative amino acid residue. In some embodiments, the polypeptide may comprise one to three substitutions. In particular embodiments, the one or more substitutions are conservative substitutions. In certain embodiments, the amino acid sequence corresponding to a portion of TrkB-FL may comprise the one or more substitutions, modifications, deletions, or replacements.

In a particular embodiment, the polypeptide of the second aspect may be a polypeptide with an amino acid sequence according to YGRKKRRQRRRKKITNSQLKPDTFVQH (SEQ ID NO: 24). In some embodiments, the polypeptide of the second aspect may be a peptide with an amino acid sequence according to SEQ ID NO: 24, wherein the peptide comprises one or more substitutions, modifications, deletions, or replacements within this sequence. For example one, two, three, four, five, six, or seven substitutions for an alternative amino acid residue. In some embodiments, the polypeptide may comprise one to three substitutions. In particular embodiments, the one or more substitutions are conservative substitutions. In certain embodiments, the amino acid sequence corresponding to a portion of TrkB-FL may comprise the one or more substitutions, modifications, deletions, or replacements.

In a particular embodiment, the polypeptide of the second aspect may be a polypeptide with an amino acid sequence according to YGRKKRRQRRRPPFGITNSQLKP (SEQ ID NO: 26), YGRKKRRQRRRQFGITNSQLKP (SEQ ID NO: 27), or YGRKKRRQRRREFGITNSQLKP (SEQ ID NO: 28). In some embodiments, the polypeptide of the second aspect may be a peptide with an amino acid sequence according to any of SEQ ID NOs: 26 to 28, wherein the peptide comprises one or more substitutions, modifications, deletions, or replacements within this sequence. For example one, two, three, four, five, six, or seven substitutions for an alternative amino acid residue. In some embodiments, the polypeptide may comprise one to three substitutions. In particular embodiments, the one or more substitutions are conservative substitutions. In certain embodiments, the amino acid sequence corresponding to a portion of TrkB-FL may comprise the one or more substitutions, modifications, deletions, or replacements.

In some embodiments, a polypeptide of the second aspect may form part of a larger polypeptide. In other embodiments, a polypeptide of the second aspect may comprise no additional amino acid sequence beyond the sequence that is explicitly specified.

In a third aspect of the invention, there is provided a nucleic acid encoding a portion of TrkB-FL as disclosed herein.

In a fourth aspect of the invention, there is provided a nucleic acid encoding a polypeptide of the second aspect of the invention.

In a fifth aspect of the invention, there is provided a genetic construct or a vector comprising a nucleic acid of the third or fourth aspects of the invention.

In an embodiment, the genetic construct or vector may be suitable for the delivery of nucleic acid sequences to target cells. In another embodiment, the genetic construct or vector may be suitable for use with molecular biological techniques.

In a particular embodiment, the nucleic acid may encode a portion of TrkB-FL as disclosed herein, a linker as disclosed herein, and a cell-penetrating peptide as disclosed herein. For example, the nucleic acid may encode a peptide with an amino acid sequence according to any one of SEQ ID NO: 19 to SEQ ID NO: 24. In another example, the nucleic acid may encode a peptide with an amino acid sequence according to any one of SEQ ID NO: 26 to SEQ ID NO: 28.

In another embodiment, the vector may be a viral vector, or other recombinant vector, suitable for the delivery of the portion of TrkB-FL or the polypeptide of the second aspect to the neuronal cells of a subject. For instance, the viral vector may be suitable to deliver a nucleic acid encoding the portion of TrkB-FL or the polypeptide of the second aspect to a human AD patient, such that the portion of TrkB-FL is produced in a manner allowing a functional effect on the relevant neuronal cells.

Provided herein is a cell, for example a host cell, cell line, mammalian cell, plant cell, insect cell, stem cell, leukocyte, myeloid cell, or lymphocyte, comprising a peptide, nucleic acid, genetic construct, or vector as disclosed herein. The cell may be for use in a method of treatment as disclosed herein. The cell may be suitable for use in a method of manufacture, for instance for the production of recombinant vectors or viral vectors.

Provided herein is a pharmaceutical composition comprising a polypeptide of the second aspect of the invention, a nucleic acid of the third or fourth aspect of the invention, a vector or genetic construct of the fifth aspect of the invention, or a cell as disclosed herein. The pharmaceutical composition may include at least one of a pharmaceutically acceptable carrier, a pharmaceutically acceptable excipient, a pharmaceutically acceptable stabilizer, or a pharmaceutically acceptable preservative, or any combination thereof.

Provided herein is a kit comprising a pharmaceutical composition of the first aspect of the invention, a polypeptide of the second aspect of the invention, a nucleic acid of the third or fourth aspect of the invention, a vector or genetic construct of the fifth aspect of the invention, a cell as disclosed herein, or a pharmaceutical composition as disclosed herein. The polypeptide, the nucleic acid, the vector, the genetic construct, or the cell may be in a format suitable for storage or shipping, and the kit may further

comprise a diluent suitable for the preparation of a pharmaceutical composition. The kit may comprise a vessel. The kit may comprise instructions for use.

In a sixth aspect of the invention a therapeutic agent or composition, polypeptide, nucleic acid, vector, genetic construct, cell, or pharmaceutical composition as disclosed herein may be for use as a medicament or in a method of treatment. The therapeutic agent or composition, polypeptide, nucleic acid, vector, genetic construct, cell, or pharmaceutical composition disclosed herein may be for use in the treatment, prevention, delay, amelioration, or reduction in the symptons of a neuropathological condition. In particular embodiments, the therapeutic agent or composition, polypeptide, nucleic acid, vector, genetic construct, cell, or pharmaceutical composition disclosed herein may be for use in the treatment, prevention, amelioration, delay, or reduction of the symptoms of Alzheimer's disease.

In an embodiment, a therapeutic agent or composition, polypeptide, nucleic acid, vector, genetic construct, cell, or pharmaceutical composition as disclosed herein may be for use in the treatment of any pathology characterized by excitotoxicity. For example: epilepsy, prion-like diseases, muscular dystrophies, Huntington's disease, Parkinson's disease, multiple sclerosis, ischemia, stroke, or brain trauma.

In an embodiment, a therapeutic agent or composition, polypeptide, nucleic acid, vector, genetic construct, cell, or pharmaceutical composition as disclosed herein may be for use in the treatment of any pathology related to TrkB-FL cleavage (See Gupta *et al.*, *Int. J. Mol. Sci.* **2013**, *14*(5), 10122-1014; and US 2004/0110711 A1, incorporated herein by reference). For example: depression, anxiety, bipolar disorders, schizophrenia, obesity, autism, rett syndrome, retinal ganglion cell loss, or ageing. In other examples, the treatment may be for amyotrophic lateral sclerosis (Lou Gehrig's disease), the adverse neurologic complications of Down syndrome, diabetic peripheral neuropathy, or other types of peripheral neuropathy.

In an embodiment, there is disclosed a method for treating a subject having a neuropathological condition, for instance Alzheimer's disease, comprising the administration of a therapeutically effective amount of the therapeutic agent or composition, polypeptide, nucleic acid, vector, genetic construct, cell, or pharmaceutical composition disclosed herein to the subject in need of treatment.

In some embodiments, there are provided methods of treating mild Alzheimer's disease. For example, the methods disclosed herein may be for the treatment of the prodromal stage or the early stage of Alzheimer's disease. The subjects to be treated may have mild cognitive impairment.

In some embodiments, there are provided methods of treating moderate Alzheimer's disease.

In some embodiments, there are provided methods of treating advanced or severe Alzheimer's disease.

In some embodiments, treatment may result in the prevention, reduction, delay, or reversing of the cognitive defects associated with AD.

In another embodiment, there is disclosed a method for treating a subject having a condition pathology characterized by excitotoxicity, for instance epilepsy, prion-like diseases, muscular dystrophies, Huntington's disease, Parkinson's disease, multiple sclerosis, ischemia, stroke, or brain trauma, comprising the administration of a therapeutically effective amount of the therapeutic agent or composition, polypeptide, nucleic acid, vector, genetic construct, cell, or pharmaceutical composition disclosed herein to the subject in need of treatment.

In another embodiment, there is disclosed a method for treating a subject having a pathology related to TrkB-FL cleavage, for instance depression, anxiety, bipolar disorders, schizophrenia, obesity, autism, rett syndrome, retinal ganglion cell loss, ageing, amyotrophic lateral sclerosis (Lou Gehrig's disease), the adverse neurologic complications of Down syndrome, diabetic peripheral neuropathy, or other types of peripheral neuropathy, comprising the administration of a therapeutically effective amount of the therapeutic agent or composition, polypeptide, nucleic acid, vector, genetic construct, cell, or pharmaceutical composition disclosed herein to the subject in need of treatment.

In an embodiment, the pharmaceutical composition or polypeptide for use in a method of treatment as disclosed herein comprises a portion of TrkB-FL according to an amino acid sequence as set out in any one of SEQ ID NO: 18, SEQ ID NO: 19, or SEQ ID NO: 20.

In an embodiment, the pharmaceutical composition or polypeptide for use in a method of treating AD as disclosed herein comprises a portion of TrkB-FL according to an amino acid sequence as set out in any one of SEQ ID NO: 18, SEQ ID NO: 19, or SEQ ID NO: 20.

In an embodiment, the pharmaceutical composition or polypeptide for use in a method of treating stroke as disclosed herein comprises a portion of TrkB-FL according to an amino acid sequence as set out in any one of SEQ ID NO: 18, SEQ ID NO: 19, or SEQ ID NO: 20.

In an embodiment, the pharmaceutical composition or polypeptide for use in a method of treatment as disclosed herein comprises a peptide according to an amino acid sequence as set out in any one of SEQ ID NO: 22, SEQ ID NO: 23, SEQ ID NO: 24, SEQ ID NO: 26, SEQ ID NO: 27, or SEQ ID NO: 28.

In an embodiment, the pharmaceutical composition or polypeptide for use in a method of treating AD as disclosed herein comprises a peptide according to an amino acid sequence as set out in any one of SEQ ID NO: 22, SEQ ID NO: 23, SEQ ID NO: 24, SEQ ID NO: 26, SEQ ID NO: 27, or SEQ ID NO: 28.

In an embodiment, the pharmaceutical composition or polypeptide for use in a method of treating stroke as disclosed herein comprises a peptide according to an amino acid sequence as set out in any one of SEQ ID NO: 22, SEQ ID NO: 23, SEQ ID NO: 24, SEQ ID NO: 26, SEQ ID NO: 27, or SEQ ID NO: 28.

In an embodiment, there is disclosed a portion of TrkB-FL as disclosed herein for use as medicament. In an embodiment, there is disclosed a portion of TrkB-FL as disclosed herein for use in the treatment, prevention, delay, amelioration, or reduction in the symptoms of a neuropathological condition. In an embodiment, there is disclosed a portion of TrkB-FL as disclosed herein for use in the treatment, prevention, delay, amelioration, or reduction of the symptoms of Alzheimer's disease.

In an embodiment, there is disclosed a portion of TrkB-FL with an amino acid sequence as set out in any one of SEQ ID NO: 18, SEQ ID NO: 19, or SEQ ID NO: 20 for use as medicament. In an embodiment, there is disclosed a portion of TrkB-FL with an amino acid sequence as set out in any one of SEQ ID NO: 18, SEQ ID NO: 19, or SEQ ID NO: 20 for use in the treatment, prevention, delay, amelioration, or reduction of the symptoms of a neuropathological condition. In an embodiment, there is disclosed a portion of TrkB-FL with an amino acid sequence as set out in any one of SEQ ID NO: 18, SEQ ID NO: 19, or SEQ ID NO: 20 for use in the treatment, prevention, delay, amelioration, or reduction of the symptoms of Alzheimer's disease.

In an embodiment, there is disclosed a polypeptide with an amino acid sequence as set out in any one of SEQ ID NO: 22, SEQ ID NO: 23, SEQ ID NO: 24, SEQ ID NO: 26, SEQ ID NO: 27, or SEQ ID NO: 28 for use as medicament. In an embodiment, there is disclosed a polypeptide with an amino acid sequence as set out in any one of SEQ ID NO: 22, SEQ ID NO: 23, SEQ ID NO: 24, SEQ ID NO: 26, SEQ ID NO: 27, or SEQ ID NO: 28 for use in the treatment, prevention, delay, amelioration, or reduction of the symptoms of a neuropathological condition. In an embodiment, there is disclosed a polypeptide with an amino acid sequence as set out in any one of SEQ ID NO: 22, SEQ ID NO: 23, SEQ ID NO: 24, SEQ ID NO: 26, SEQ ID NO: 27, or SEQ ID NO: 28 for use in the treatment, prevention, delay, amelioration, or reduction of the symptoms of Alzheimer's disease.

In an aspect, provided herein is the use of a therapeutic agent or composition, polypeptide, nucleic acid, vector, genetic construct, cell, or pharmaceutical composition as disclosed herein in the manufacture of a medicament for the treatment of treatment, prevention, delay, amelioration, or reduction in the symptoms of AD, a neuropathological condition, a pathology characterized by excitotoxicity, epilepsy, prion-like diseases, muscular dystrophies, Huntington's disease, Parkinson's disease, multiple sclerosis, ischemia, stroke, brain trauma, a pathology related to TrkB-FL cleavage, depression, anxiety, bipolar disorders, schizophrenia, obesity, autism, rett syndrome, retinal ganglion cell loss, ageing, amyotrophic lateral sclerosis (Lou Gehrig's disease), the adverse neurologic complications of Down syndrome, diabetic peripheral neuropathy, or other types of peripheral neuropathy.

The methods of treatment disclosed herein may be monotherapy, wherein the therapeutic agent or composition, polypeptide, nucleic acid, vector, genetic construct, cell, or pharmaceutical composition is used alone. Alternatively, the methods of treatment disclosed herein may be used in combination with another active agent. For instance, one or more agents to increase the permeability of the BBB, one or more agents for the treatment of AD, or one or more agents for the treatment of any indication disclosed herein. As such, the therapeutic agent or composition, polypeptide, nucleic acid, vector, genetic construct, cell, or pharmaceutical composition may be for use in combination therapy.

The therapeutic agent or composition, polypeptide, nucleic acid, vector, genetic construct, cell, or pharmaceutical composition may take any number of forms known in the art depending on the manner in which it is to be used. For example, in the form of a liquid, powder, suspension, tablet, capsule, ointment, cream, gel, hydrogel, aerosol, spray, micellar solution, transdermal patch, or any other suitable form for storage, shipping, or administration.

In some embodiments, the therapeutic agent or composition, polypeptide, nucleic acid, vector, genetic construct, cell, or pharmaceutical composition may be in a format suitable for storage or shipping. For instance, as part of lyophilized compositions which may include other components if necessary for lyophilization or storage, such as stabilizers. Alternatively, the therapeutic agent or composition, polypeptide, nucleic acid, vector, genetic construct, cell, or pharmaceutical composition may be in solution with a diluent, and may be present at a concentration appropriate for storage or shipping.

In some embodiments, the therapeutic agent or composition, polypeptide, nucleic acid, vector, genetic construct, cell, or pharmaceutical composition may be in a format suitable for administration to a patient. For instance, in the form of a liquid suitable for injection, or in a concentrated form suitable for administration after a preparatory step. The therapeutic agent or composition, polypeptide, nucleic acid, vector, genetic construct, cell, or pharmaceutical composition may be in association with carriers for administration, and may be sterile. The therapeutic agent or composition, polypeptide, nucleic acid, vector, genetic construct, cell, or pharmaceutical composition may be in a format suitable for injection into the patient, for instance intravenous injection, subcutaneous injection, or injection into the brain.

In some embodiments, the therapeutic agent or composition, polypeptide, nucleic acid, vector, genetic construct, cell, or pharmaceutical composition may be present in slow-release compositions.

It will be appreciated that the amount of the therapeutic agent or composition, polypeptide, nucleic acid, vector, genetic construct, cell, or pharmaceutical composition that is required is determined by its biological activity and bioavailability, which in turn depends on the mode of administration, the physiochemical properties of the therapeutic agent or composition, polypeptide, nucleic acid, vector, genetic construct, cell, or pharmaceutical composition, and whether it is being used as a monotherapy or in a combined therapy. The frequency of administration will also be influenced by the half-life of the agent within the subject to be treated. Optimal dosages to be administered may be determined by those skilled in the art and will vary depending on the context. Additional factors may depend on the particular subject being treated, the advancement of the disease, disorder, or condition, subject age, subject weight, subject sex, subject diet, and time of administration.

In some examples, the therapeutic agent or composition, polypeptide, nucleic acid, vector, genetic construct, cell, or pharmaceutical composition may be administered as a single dose, yearly dose, monthly dose, weekly dose, or daily dose. The dose may be administered two or more times a day. In an example, the dose may be from 0.001µg to 10mg per kg of body weight, 0.01µg to 1mg per kg of body weight, 0.05µg to 100µg per kg of body weight, or 0.1µg to 10µg per kg of body weight. In an example, the dose may be 0.07µg to 700mg, 0.7µg to 70mg, 3.5µg to 7mg, or 7µg to 0.7mg. In an example, the dose may be at least 10^5, 10^6, 10^7, 10^8, 10^9, 10^{10}, 10^{11}, or 10^{12} cells.

The pharmaceutical compositions of the invention may be manufactured, in a further aspect, using a process comprising contacting a therapeutically effective amount of the therapeutic agent or composition, polypeptide, nucleic acid, vector, genetic construct, or cell of the invention and a pharmaceutically acceptable vehicle, a pharmaceutically acceptable carrier, a pharmaceutically acceptable excipient, a pharmaceutically acceptable stabilizer, or pharmaceutically acceptable preservative, or any combination thereof.

The inventors have previously shown that Aβ-induced calpain activation leads to TrkB cleavage and impairment of BDNF neuromodulatory actions[6].

Herein, the inventors demonstrate that TrkB-FL levels decrease during the progression from mild, moderate, to severe Alzheimer's disease, whereas the levels of TrkB-ICD increase during this same progression. Hence, the levels of TrkB-FL or TrkB-ICD may be used as a biomarker indicating AD or stage of AD.

The inventors provide data herein validating the use of TrkB-T', TrkB-FL or TrkB-ICD quantification as a biomarker. Samples from patients with mild cognitive impairment not associated with AD were compared with samples from patients with mild cognitive impairment associated with AD. The inventors show that TrkB-T', TrkB-FL, TrkB-ICD, the TrkB-T':TrkB-FL ratio, or the TrkB-ICD:TrkB-FL ratio are all suitable for use as a biomarker for Alzheimer's disease. In particular, measurement of the TrkB-ICD:TrkB-FL ratio provided a robust indication of AD in subjects with mild cognitive impairment.

Notably, the inventors also examined the level of calpain activation during the progression of Alzheimer's disease. Calpain activation was found to be less useful as a biomarker in comparison to the level of TrkB-FL, the level of TrkB-ICD, or the TrkB-ICD:TrkB-FL ratio.

Therefore, in another aspect of the invention, there is provided the use of TrkB-FL, TrkB-ICD, TrkB-T', the TrkB-T':TrkB-FL ratio, or the TrkB-ICD:TrkB-FL ratio as a biomarker for Alzheimer's disease.

In an embodiment, there is disclosed a method for diagnosing AD or for determining the stage of AD, comprising: i) measuring the amount of TrkB-FL and/or TrkB-ICD in a sample obtained from a subject, and ii) comparing the amount of TrkB-FL and/or TrkB-ICD to a reference amount.

In an embodiment, there is disclosed a method for diagnosing AD or for determining the stage of AD, comprising comparing the amount of TrkB-FL and/or TrkB-ICD measured in a sample obtained from a subject to a reference amount.

A lower amount of TrkB-FL in the sample obtained from the subject in comparison to the reference amount may be indicative of AD or AD at a more advanced stage than that represented by the reference amount. The same or a similar amount of TrkB-FL may be indicative of AD at the same stage as that represented by the reference amount or of no AD if the reference represents a patient without AD. A higher amount of TrkB-FL in comparison to a reference amount may be indicative of no AD or AD at a less advanced stage than that represented by the reference amount. A higher amount of TrkB-ICD in the sample obtained from the subject in comparison to a reference amount may be indicative of AD or AD at a more advanced stage than that represented by the reference amount. The same or a similar amount of TrkB-ICD may be indicative of AD at the same stage as that represented by the reference amount or of no AD if the reference represents a patient without AD. A lower amount of TrkB-ICD in comparison to a reference amount may be indicative of no AD or AD at a less advanced stage than that represented by the reference amount. Hence, the method allows the determination of whether a subject has AD and/or of the stage of AD.

The reference amount may be representative of the amount of TrkB-FL and/or TrkB-ICD in a subject without AD. The reference amount may be representative of the amount of TrkB-FL and/or TrkB-ICD in a subject with mild AD. The reference amount may be representative of the amount of TrkB-FL and/or TrkB-ICD in a subject with moderate AD. The reference amount may be representative of the amount of TrkB-FL and/or TrkB-ICD in a subject with severe AD. The reference amount may have been determined from the same subject before disease onset, after diagnosis of AD, after diagnosis of mild AD, after diagnosis with moderate AD, or after diagnosis with severe AD. The reference amount may be obtained from a one or more, or a plurality of subjects. The reference amount may have been calculated from pre-collected data or from pre-collected samples. In some embodiments, the reference amount may be adjusted to take into account the age, sex, weight, ethnicity, amount of physical exercise, or other relevant factor of the subject to be tested. The reference amount may represent or take into account the natural variations of the biomarkers found in the representative population, and hence the reference value may be a range.

In an embodiment, the reference amount may be representative of mild AD, wherein the measured amount of TrkB-FL and/or TrkB-ICD in a sample obtained from a subject is indicative of the subject

having AD at a more advanced stage if the amount of TrkB-FL is lower than the reference amount and/or the amount of TrkB-ICD is higher than the reference amount. In an embodiment, the reference amount may be representative of mild AD, wherein the measured amount of TrkB-FL and/or TrkB-ICD in a sample obtained from a subject is indicative of the subject having mild AD if the amount of TrkB-FL and/or TrkB-ICD is the same or similar to the reference amount. In an embodiment, the reference amount may be representative of mild AD, wherein the measured amount of TrkB-FL and/or TrkB-ICD in a sample obtained from a subject is indicative of the subject not having AD or having AD at a less advanced stage if the amount of TrkB-FL is higher than the reference amount and/or the amount of TrkB-ICD is lower than the reference amount.

In an embodiment, the reference amount may be representative of moderate AD, wherein the measured amount of TrkB-FL and/or TrkB-ICD in a sample obtained from a subject is indicative of the subject having AD at a more advanced stage if the amount of TrkB-FL is lower than the reference amount and/or the amount of TrkB-ICD is higher than the reference amount. In an embodiment, the reference amount may be representative of moderate AD, wherein the measured amount of TrkB-FL and/or TrkB-ICD in a sample obtained from a subject is indicative of the subject having moderate AD if the amount of TrkB-FL and/or TrkB-ICD is the same or similar to the reference amount. In an embodiment, the reference amount may be representative of moderate AD, wherein the measured amount of TrkB-FL and/or TrkB-ICD in a sample obtained from a subject is indicative of the subject not having AD or having AD at a less advanced stage if the amount of TrkB-FL is higher than the reference amount and/or the amount of TrkB-ICD is lower than the reference amount.

In an embodiment, the reference amount may be representative of severe AD, wherein the measured amount of TrkB-FL and/or TrkB-ICD in a sample obtained from a subject is indicative of the subject having AD at an even more advanced stage if the amount of TrkB-FL is lower than the reference amount or the amount of TrkB-ICD is higher than the reference amount. In an embodiment, the reference amount may be representative of severe AD, wherein the measured amount of TrkB-FL and/or TrkB-ICD in a sample obtained from a subject is indicative of the subject having severe AD if the amount of TrkB-FL and/or TrkB-ICD is the same or similar to the reference amount. In an embodiment, the reference amount may be representative of severe AD, wherein the measured amount of TrkB-FL and/or TrkB-ICD in a sample obtained from a subject is indicative of the subject not having AD or having AD at a less advanced stage if the amount of TrkB-FL is higher than the reference amount and/or the amount of TrkB-ICD is lower than the reference amount.

In an embodiment, there is disclosed a method for diagnosing AD or for determining the stage of AD, comprising: i) measuring the amount of TrkB-FL and/or TrkB-T' in a sample obtained from a subject, and ii) comparing the amount of TrkB-FL and/or TrkB-T' to a reference amount.

In an embodiment, there is disclosed a method for diagnosing AD or for determining the stage of AD, comprising comparing the amount of TrkB-FL and/or TrkB-T' measured in a sample obtained from a subject to a reference amount.

A lower amount of TrkB-FL in the sample obtained from the subject in comparison to the reference amount may be indicative of AD or AD at a more advanced stage than that represented by the reference amount. The same or a similar amount of TrkB-FL may be indicative of AD at the same stage as that represented by the reference amount or of no AD if the reference represents a patient without AD. A higher amount of TrkB-FL in comparison to a reference amount may be indicative of no AD or AD at a less advanced stage than that represented by the reference amount. A higher amount of TrkB-T' in the sample obtained from the subject in comparison to a reference amount may be indicative of AD or AD at a more advanced stage than that represented by the reference amount. The same or a similar amount of TrkB-T' may be indicative of AD at the same stage as that represented by the reference amount or of no AD if the reference represents a patient without AD. A lower amount of TrkB-T' in comparison to a reference amount may be indicative of no AD or AD at a less advanced stage than that represented by the reference amount. Hence, the method allows the determination of whether a subject has AD and/or of the stage of AD.

The reference amount may be representative of the amount of TrkB-FL and/or TrkB-T' in a subject without AD. The reference amount may be representative of the amount of TrkB-FL and/or TrkB-T' in a subject with mild AD. The reference amount may be representative of the amount of TrkB-FL and/or TrkB-T' in a subject with moderate AD. The reference amount may be representative of the amount of

TrkB-FL and/or TrkB-T' in a subject with severe AD. The reference amount may have been determined from the same subject before disease onset, after diagnosis of AD, after diagnosis of mild AD, after diagnosis with moderate AD, or after diagnosis with severe AD. The reference amount may be obtained from a one or more, or a plurality of subjects. The reference amount may have been calculated from pre-collected data or from pre-collected samples. In some embodiments, the reference amount may be adjusted to take into account the age, sex, weight, ethnicity, amount of physical exercise, or other relevant factor of the subject to be tested. The reference amount may represent or take into account the natural variations of the biomarkers found in the representative population, and hence the reference value may be a range.

In an embodiment, the reference amount may be representative of mild AD, wherein the measured amount of TrkB-FL and/or TrkB-T' in a sample obtained from a subject is indicative of the subject having AD at a more advanced stage if the amount of TrkB-FL is lower than the reference amount and/or the amount of TrkB-T' is higher than the reference amount. In an embodiment, the reference amount may be representative of mild AD, wherein the measured amount of TrkB-FL and/or TrkB-T' in a sample obtained from a subject is indicative of the subject having mild AD if the amount of TrkB-FL and/or TrkB-T' is the same or similar to the reference amount. In an embodiment, the reference amount may be representative of mild AD, wherein the measured amount of TrkB-FL and/or TrkB-T' in a sample obtained from a subject is indicative of the subject not having AD or having AD at a less advanced stage if the amount of TrkB-FL is higher than the reference amount and/or the amount of TrkB-T' is lower than the reference amount.

In an embodiment, the reference amount may be representative of moderate AD, wherein the measured amount of TrkB-FL and/or TrkB- TrkB-T' in a sample obtained from a subject is indicative of the subject having AD at a more advanced stage if the amount of TrkB-FL is lower than the reference amount and/or the amount of TrkB-T' is higher than the reference amount. In an embodiment, the reference amount may be representative of moderate AD, wherein the measured amount of TrkB-FL and/or TrkB-T' in a sample obtained from a subject is indicative of the subject having moderate AD if the amount of TrkB-FL and/or TrkB-T' is the same or similar to the reference amount. In an embodiment, the reference amount may be representative of moderate AD, wherein the measured amount of TrkB-FL and/or TrkB-T' in a sample obtained from a subject is indicative of the subject not having AD or having AD at a less advanced stage if the amount of TrkB-FL is higher than the reference amount and/or the amount of TrkB-T' is lower than the reference amount.

In an embodiment, the reference amount may be representative of severe AD, wherein the measured amount of TrkB-FL and/or TrkB-T' in a sample obtained from a subject is indicative of the subject having AD at an even more advanced stage if the amount of TrkB-FL is lower than the reference amount and/or the amount of TrkB-T' is higher than the reference amount. In an embodiment, the reference amount may be representative of severe AD, wherein the measured amount of TrkB-FL and/or TrkB-T' in a sample obtained from a subject is indicative of the subject having severe AD if the amount of TrkB-FL and/or TrkB-T' is the same or similar to the reference amount. In an embodiment, the reference amount may be representative of severe AD, wherein the measured amount of TrkB-FL and/or TrkB-T' in a sample obtained from a subject is indicative of the subject not having AD or having AD at a less advanced stage if the amount of TrkB-FL is higher than the reference amount and/or the amount of TrkB-T' is lower than the reference amount.

In another embodiment, there is disclosed a method for diagnosing AD or for determining the stage of AD, comprising: i) measuring the amount of TrkB-FL and TrkB-ICD in a sample obtained from a subject, ii) calculating the TrkB-ICD:TrkB-FL ratio, and iii) comparing the TrkB-ICD:TrkB-FL ratio to a reference value.

In another embodiment, there is disclosed a method for diagnosing AD or for determining the stage of AD, comprising comparing the TrkB-ICD:TrkB-FL ratio measured in a sample obtained from a subject to a reference value.

A higher TrkB-ICD:TrkB-FL ratio in comparison to the reference value may be indicative of AD or AD at a more advanced stage than that represented by the reference value. The same or a similar TrkB-ICD:TrkB-FL ratio in comparison to the reference value may be indicative of AD at the same stage as that represented by the reference value or of no AD if the reference represents a patient without AD. A lower TrkB-ICD:TrkB-FL ratio in comparison to the reference value may be indicative of no AD or AD at

a less advanced stage than that represented by the reference value. Hence, the method allows the determination of whether subject has AD and/or of the stage of AD.

The reference value may be representative of the TrkB-ICD:TrkB-FL ratio in a subject without AD. The reference value may be representative of the TrkB-ICD:TrkB-FL ratio in a subject with mild AD. The reference value may be representative of the TrkB-ICD:TrkB-FL ratio in a subject with moderate AD. The reference value may be representative of the TrkB-ICD:TrkB-FL ratio in a subject with severe AD. The reference value may have been determined from the same subject before disease onset, after diagnosis of AD, after diagnosis of mild AD, after diagnosis with moderate AD, or after diagnosis with severe AD. The reference value may be obtained from a one or more, or a plurality of subjects. The reference value may have been calculated from pre-collected data or from pre-collected samples. In some embodiments, the reference value may be adjusted to take into account the age, sex, weight, ethnicity, amount of physical exercise, or other relevant factor of the subject to be tested. The reference value may represent or take into account the natural variations of the biomarkers found in the representative population, and hence the reference value may be a range.

In some embodiments, a subject is diagnosed with AD if the subject's measured TrkB-ICD:TrkB-FL ratio is increased by at least 5%, at least 10%, at least 20%, at least 30%, at least 40%, at least 50%, at least 60%, at least 70%, at least 80%, at least 90%, at least 100%, at least 150%, at least 200%, or at least 300% in comparison to the TrkB-ICD:TrkB-FL ratio measured for subjects without AD or a representative reference value. For instance, a subject with a measured TrkB-ICD:TrkB-FL ratio of 4:1 would have a ratio that is increased by 100% in comparison to a representative value of 2:1. In some embodiments, a subject is diagnosed with AD if the subject's measured TrkB-ICD:TrkB-FL ratio is increased by at least 200% in comparison to the TrkB-ICD:TrkB-FL ratio measured for subjects without AD or a representative reference value. In some embodiments, a subject is diagnosed with AD if the subject's measured TrkB-ICD:TrkB-FL ratio is increased by at least 300% in comparison to the TrkB-ICD:TrkB-FL ratio measured for subjects without AD or a representative reference value. Hence, the method allows the determination of whether subject has AD based upon the subject's measured TrkB-ICD:TrkB-FL ratio.

In some embodiments, the threshold at which a subject is diagnosed with AD depends on the sample being tested. In some embodiments, the subject's TrkB-ICD:TrkB-FL ratio is measured in a plasma sample, and the subject is diagnosed with AD if the measured TrkB-ICD:TrkB-FL ratio is increased by at least 10%, at least 20%, at least 30%, or at least 40% in comparison to the TrkB-ICD:TrkB-FL ratio measured for subjects without AD or a representative reference value. In a particular embodiment, the subject is diagnosed with AD if the measured TrkB-ICD:TrkB-FL ratio is increased by at least 20% in comparison to the TrkB-ICD:TrkB-FL ratio measured for subjects without AD or a representative reference value.

In some embodiments, the threshold at which a subject is diagnosed with AD depends on the sample being tested. In some embodiments, the subject's TrkB-ICD:TrkB-FL ratio is measured in a CSF sample, and the subject is diagnosed with AD if the measured TrkB-ICD:TrkB-FL ratio is increased by at least 20%, at least 30%, at least 40%, or at least 50% in comparison to the TrkB-ICD:TrkB-FL ratio measured for subjects without AD or a representative reference value. In a particular embodiment, the subject is diagnosed with AD if the measured TrkB-ICD:TrkB-FL ratio is increased by at least 40% in comparison to the TrkB-ICD:TrkB-FL ratio measured for subjects without AD or a representative reference value.

In an embodiment, the reference value may be representative of mild AD, wherein the calculated TrkB-ICD:TrkB-FL ratio in a sample obtained from a subject is indicative of the subject having AD at a more advanced stage if the calculated TrkB-ICD:TrkB-FL ratio is higher than the reference value. In an embodiment, the reference value may be representative of mild AD, wherein the calculated TrkB-ICD:TrkB-FL ratio in a sample obtained from a subject is indicative of the subject having mild AD if the calculated TrkB-ICD:TrkB-FL ratio is the same or similar to the reference value. In an embodiment, the reference value may be representative of mild AD, wherein the calculated TrkB-ICD:TrkB-FL ratio in a sample obtained from a subject is indicative of the subject not having AD or having AD at a less advanced stage if the calculated TrkB-ICD:TrkB-FL ratio is lower than the reference value.

In an embodiment, the reference value may be representative of moderate AD, wherein the calculated TrkB-ICD:TrkB-FL ratio in a sample obtained from a subject is indicative of the subject having AD at a

more advanced stage if the calculated TrkB-ICD:TrkB-FL ratio is higher than the reference value. In an embodiment, the reference value may be representative of moderate AD, wherein the calculated TrkB-ICD:TrkB-FL ratio in a sample obtained from a subject is indicative of the subject having moderate AD if the calculated TrkB-ICD:TrkB-FL ratio is the same or similar to the reference value. In an embodiment, the reference value may be representative of moderate AD, wherein the calculated TrkB-ICD:TrkB-FL ratio in a sample obtained from a subject is indicative of the subject not having AD or having AD at a less advanced stage if the calculated TrkB-ICD:TrkB-FL ratio is lower than the reference value.

In an embodiment, the reference value may be representative of severe AD, wherein the calculated TrkB-ICD:TrkB-FL ratio in a sample obtained from a subject is indicative of the subject having AD at an even more advanced stage if the calculated TrkB-ICD:TrkB-FL ratio is higher than the reference value. In an embodiment, the reference value may be representative of severe AD, wherein the calculated TrkB-ICD:TrkB-FL ratio in a sample obtained from a subject is indicative of the subject having severe AD if the calculated TrkB-ICD:TrkB-FL ratio is the same or similar to the reference value. In an embodiment, the reference value may be representative of severe AD, wherein the calculated TrkB-ICD:TrkB-FL ratio in a sample obtained from a subject is indicative of the subject not having AD or having AD at a less advanced stage if the calculated TrkB-ICD:TrkB-FL ratio is lower than the reference value.

In an embodiment, the subject to be tested may have mild cognitive impairment. In another embodiment, the subject to be tested may have cognitive impairment. In other embodiments, the subject to be tested may have mild, moderate, or severe AD.

In another embodiment, there is disclosed a method for diagnosing AD or for determining the stage of AD, comprising: i) measuring the amount of TrkB-FL and TrkB-T' in a sample obtained from a subject, ii) calculating the TrkB-T':TrkB-FL ratio, and iii) comparing the TrkB-T':TrkB-FL ratio to a reference value.

In another embodiment, there is disclosed a method for diagnosing AD or for determining the stage of AD, comprising comparing the TrkB-T':TrkB-FL ratio measured in a sample obtained from a subject to a reference value.

A higher TrkB-T':TrkB-FL ratio in comparison to the reference value may be indicative of AD or AD at a more advanced stage than that represented by the reference value. The same or a similar TrkB-T':TrkB-FL ratio in comparison to the reference value may be indicative of AD at the same stage as that represented by the reference value or of no AD if the reference represents a patient without AD. A lower TrkB-T':TrkB-FL ratio in comparison to the reference value may be indicative of no AD or AD at a less advanced stage than that represented by the reference value. Hence, the method allows the determination of whether subject has AD and/or of the stage of AD.

The reference value may be representative of the TrkB-T':TrkB-FL ratio in a subject without AD. The reference value may be representative of the TrkB-T':TrkB-FL ratio in a subject with mild AD. The reference value may be representative of the TrkB-T':TrkB-FL ratio in a subject with moderate AD. The reference value may be representative of the TrkB-T':TrkB-FL ratio in a subject with severe AD. The reference value may have been determined from the same subject before disease onset, after diagnosis of AD, after diagnosis of mild AD, after diagnosis with moderate AD, or after diagnosis with severe AD. The reference value may be obtained from a one or more, or a plurality of subjects. The reference value may have been calculated from pre-collected data or from pre-collected samples. In some embodiments, the reference value may be adjusted to take into account the age, sex, weight, ethnicity, amount of physical exercise, or other relevant factor of the subject to be tested. The reference value may represent or take into account the natural variations of the biomarkers found in the representative population, and hence the reference value may be a range.

In some embodiments, a subject is diagnosed with AD if the subject's measured TrkB-T':TrkB-FL ratio is increased by at least 5%, at least 10%, at least 20%, at least 30%, at least 40%, at least 50%, at least 60%, at least 70%, at least 80%, at least 90%, at least 100%, at least 150%, at least 200%, or at least 300% in comparison to the TrkB-T':TrkB-FL ratio measured for subjects without AD or a representative reference value. For instance, a subject with a measured TrkB-T':TrkB-FL ratio of 4:1 would have a ratio that is increased by 100% in comparison to a representative value of 2:1. In some embodiments, a subject is diagnosed with AD if the subject's measured TrkB-T':TrkB-FL ratio is

increased by at least 200% in comparison to the TrkB-T':TrkB-FL ratio measured for subjects without AD or a representative reference value. In some embodiments, a subject is diagnosed with AD if the subject's measured TrkB-T':TrkB-FL ratio is increased by at least 300% in comparison to the TrkB-T':TrkB-FL ratio measured for subjects without AD or a representative reference value. Hence, the method allows the determination of whether subject has AD based upon the subject's measured TrkB-T':TrkB-FL ratio.

In some embodiments, the threshold at which a subject is diagnosed with AD depends on the sample being tested. In some embodiments, the subject's TrkB-T':TrkB-FL ratio is measured in a plasma sample, and the subject is diagnosed with AD if the measured TrkB-T':TrkB-FL ratio is increased by at least 10%, at least 20%, at least 30%, or at least 40% in comparison to the TrkB-T':TrkB-FL ratio measured for subjects without AD or a representative reference value. In a particular embodiment, the subject is diagnosed with AD if the measured TrkB-T':TrkB-FL ratio is increased by at least 20% in comparison to the TrkB-T':TrkB-FL ratio measured for subjects without AD or a representative reference value.

In some embodiments, the threshold at which a subject is diagnosed with AD depends on the sample being tested. In some embodiments, the subject's TrkB-T':TrkB-FL ratio is measured in a CSF sample, and the subject is diagnosed with AD if the measured TrkB-T':TrkB-FL ratio is increased by at least 20%, at least 30%, at least 40%, or at least 50% in comparison to the TrkB-T':TrkB-FL ratio measured for subjects without AD or a representative reference value. In a particular embodiment, the subject is diagnosed with AD if the measured TrkB-T':TrkB-FL ratio is increased by at least 40% in comparison to the TrkB-T':TrkB-FL ratio measured for subjects without AD or a representative reference value.

In an embodiment, the reference value may be representative of mild AD, wherein the calculated TrkB-T':TrkB-FL ratio in a sample obtained from a subject is indicative of the subject having AD at a more advanced stage if the calculated TrkB-T':TrkB-FL ratio is higher than the reference value. In an embodiment, the reference value may be representative of mild AD, wherein the calculated TrkB-T':TrkB-FL ratio in a sample obtained from a subject is indicative of the subject having mild AD if the calculated TrkB-T':TrkB-FL ratio is the same or similar to the reference value. In an embodiment, the reference value may be representative of mild AD, wherein the calculated TrkB-T':TrkB-FL ratio in a sample obtained from a subject is indicative of the subject not having AD or having AD at a less advanced stage if the calculated TrkB-T':TrkB-FL ratio is lower than the reference value.

In an embodiment, the reference value may be representative of moderate AD, wherein the calculated TrkB-T':TrkB-FL ratio in a sample obtained from a subject is indicative of the subject having AD at a more advanced stage if the calculated TrkB-T':TrkB-FL ratio is higher than the reference value. In an embodiment, the reference value may be representative of moderate AD, wherein the calculated TrkB-T':TrkB-FL ratio in a sample obtained from a subject is indicative of the subject having moderate AD if the calculated TrkB-T':TrkB-FL ratio is the same or similar to the reference value. In an embodiment, the reference value may be representative of moderate AD, wherein the calculated TrkB-T':TrkB-FL ratio in a sample obtained from a subject is indicative of the subject not having AD or having AD at a less advanced stage if the calculated TrkB-T':TrkB-FL ratio is lower than the reference value.

In an embodiment, the reference value may be representative of severe AD, wherein the calculated TrkB-T':TrkB-FL ratio in a sample obtained from a subject is indicative of the subject having AD at an even more advanced stage if the calculated TrkB-T':TrkB-FL ratio is higher than the reference value. In an embodiment, the reference value may be representative of severe AD, wherein the calculated TrkB-T':TrkB-FL ratio in a sample obtained from a subject is indicative of the subject having severe AD if the calculated TrkB-T':TrkB-FL ratio is the same or similar to the reference value. In an embodiment, the reference value may be representative of severe AD, wherein the calculated TrkB-T':TrkB-FL ratio in a sample obtained from a subject is indicative of the subject not having AD or having AD at a less advanced stage if the calculated TrkB-T':TrkB-FL ratio is lower than the reference value.

In an embodiment, the subject to be tested may have mild cognitive impairment. In another embodiment, the subject to be tested may have cognitive impairment. In other embodiments, the subject to be tested may have mild, moderate, or severe AD.

In an embodiment, there is disclosed a method for diagnosing AD, comprising: i) measuring the amount of TrkB-FL and TrkB-ICD in a sample obtained from a subject with mild cognitive impairment, ii)

calculating the TrkB-ICD:TrkB-FL ratio, and iii) comparing the calculated TrkB-ICD:TrkB-FL ratio to a reference value obtained from at least one subject without Alzheimer's disease, wherein a calculated TrkB-ICD:TrkB-FL ratio increased by at least 5%, at least 10%, at least 20%, at least 30%, at least 40%, at least 50%, at least 60%, at least 70%, at least 80%, at least 90%, at least 100%, at least 150%, at least 200%, or at least 300% in comparison to the reference value is indicative of AD. In an embodiment, a calculated TrkB-ICD:TrkB-FL ratio that is not increased or is increased by no more than 5%, no more than 10%, or no more than 15% in comparison to said reference value may indicate that the subject does not have AD. Hence, the method allows the determination of whether the subject with mild cognitive impairment has AD.

In an embodiment, there is disclosed a method for diagnosing AD, comprising: i) measuring the amount of TrkB-FL and TrkB-T' in a sample obtained from a subject with mild cognitive impairment, ii) calculating the TrkB-T':TrkB-FL ratio, and iii) comparing the calculated TrkB-T':TrkB-FL ratio to a reference value obtained from at least one subject without Alzheimer's disease, wherein a calculated TrkB-T':TrkB-FL ratio increased by at least 5%, at least 10%, at least 20%, at least 30%, at least 40%, at least 50%, at least 60%, at least 70%, at least 80%, at least 90%, at least 100%, at least 150%, at least 200%, or at least 300% in comparison to the reference value is indicative of AD. In an embodiment, a calculated TrkB-T':TrkB-FL ratio that is not increased or is increased by no more than 5%, no more than 10%, or no more than 15% in comparison to said reference value may indicate that the subject does not have AD. Hence, the method allows the determination of whether the subject with mild cognitive impairment has AD.

Also disclosed are methods of treatment comprising: i) any of the methods for determining the stage of AD disclosed herein to identify a patient as having mild AD, and ii) administering a treatment to said patient. The treatment may comprise the administration of any pharmaceutical composition, polypeptide, nucleic acid, genetic construct, vector, or cell of the present invention. The treatment may comprise the administration of cholinesterase inhibitors, for instance donepezil, rivastigmine, or galantamine. The treatment might comprise the administration of choline alphoscerate, idebenone (Ideben), piracetam, quetiapine fumarate (Qutadac), trifluperidol (Triperidol), and/or citicoline.

Further disclosed are methods of treatment comprising: i) any of the methods for determining the stage of AD disclosed herein to identify a patient as having moderate AD, and ii) administering a treatment to said patient. The treatment may comprise the administration of any pharmaceutical composition, polypeptide, nucleic acid, genetic construct, vector, or cell of the present invention. The treatment may comprise the administration of cholinesterase inhibitors, for instance donepezil, rivastigmine, or galantamine. The treatment may comprise the administration of an NMDA antagonist, for instance memantine. The treatment may comprise the administration of both a cholinesterase inhibitor and an NMDA antagonist. The treatment might comprise the administration of choline alphoscerate, idebenone (Ideben), piracetam, quetiapine fumarate (Qutadac), trifluperidol (Triperidol), and/or citicoline.

Further disclosed are methods of treatment comprising: i) any of the methods for determining the stage of AD disclosed herein to identify a patient as having severe AD, and ii) administering a treatment to said patient. The treatment may comprise the administration of any pharmaceutical composition, polypeptide, nucleic acid, genetic construct, vector, or cell of the present invention. The treatment may comprise the administration of cholinesterase inhibitors, for instance donepezil. The treatment may comprise the administration of an NMDA antagonist, for instance memantine. The treatment may comprise the administration of both a cholinesterase inhibitor and an NMDA antagonist. The treatment might comprise the administration of choline alphoscerate, idebenone (Ideben), piracetam, quetiapine fumarate (Qutadac), trifluperidol (Triperidol), and/or citicoline.

In other embodiments, the methods of diagnosis and the methods for determining the stage of a disease which comprise the use of TrkB-FL, TrkB-ICD, TrkB-T', the TrkB-T':TrkB-FL ratio, or the TrkB-ICD:TrkB-FL ratio as a biomarker, may be applied to any pathology characterized by excitotoxicity, epilepsy, prion-like diseases, muscular dystrophies, Huntington's disease, Parkinson's disease, multiple sclerosis, ischemia, stroke, brain trauma, any pathology related to TrkB-FL cleavage, depression, anxiety, bipolar disorders, schizophrenia, obesity, autism, rett syndrome, retinal ganglion cell loss, ageing, amyotrophic lateral sclerosis (Lou Gehrig's disease), the adverse neurologic complications of Down syndrome, diabetic peripheral neuropathy, or other types of peripheral neuropathy/

For any of the methods of diagnosis and any of the methods for determining the stage of a disease disclosed herein, the sample in which the biomarkers are quantified may be CSF, blood, plasma, serum, or saliva. The measurement of TrkB-FL, TrkB-T', and/or TrkB-ICD may be *in vitro*. TrkB-FL, TrkB-T', and/or TrkB-ICD may be measured by mass spectrometry, Western Blotting, or other methods suitable for the identification and quantification of specific proteins or peptides.

In some embodiments, the methods disclosed herein for diagnosing AD or for determining the stage of AD may be used to monitor the efficacy of a treatment. In particular embodiments, the methods disclosed herein for diagnosing AD or for determining the stage of AD may be used to monitor the efficacy of a treatment disclosed herein.

In another aspect of the invention, there is provided the use of TrkB-FL, TrkB-ICD, TrkB-T', the TrkB-T':TrkB-FL ratio, or the TrkB-ICD:TrkB-FL ratio for monitoring the efficacy of a treatment with an agent.

In an embodiment, there is disclosed a method for monitoring the efficacy of a treatment with an agent, comprising: i) measuring the amount of TrkB-FL and/or TrkB-ICD in a first sample obtained from a subject, ii) administering an agent to said subject, and iii) measuring the amount of TrkB-FL and/or TrkB-ICD in a second sample obtained from the subject.

In an embodiment, there is disclosed a method for monitoring the efficacy of a treatment with an agent, comprising: i) measuring the amount of TrkB-FL and/or TrkB-ICD in a first sample obtained from a subject, and ii) measuring the amount of TrkB-FL and/or TrkB-ICD in a second sample obtained from the subject after administration of an agent to the subject.

In an embodiment, there is disclosed a method for monitoring the efficacy of a treatment with an agent, comprising comparing the amount of TrkB-FL and/or TrkB-ICD measured in a first sample obtained from a subject to the amount of TrkB-FL and/or TrkB-ICD measured in a second sample obtained from the subject after administration of an agent to the subject.

In some embodiments, if the amount of TrkB-FL measured in the second sample is higher than the amount of TrkB-FL measured in the first sample, this may be indicative that treatment with the agent is efficacious. In some embodiments, if the amount of TrkB-FL measured in the second sample is the same or similar to the amount of TrkB-FL measured in the first sample, this may be indicative that treatment with the agent has delayed disease progression. In some embodiments, if the amount of TrkB-FL measured in the second sample is lower than the amount of TrkB-FL measured in the first sample, this may be indicative that treatment with the agent is not efficacious. Hence, the method allows the determination of whether a treatment has been efficacious.

In some embodiments, the amount of TrkB-FL measured in the second sample may be compared to an expected amount of TrkB-FL. The expected amount of TrkB-FL may be based upon the amount of TrkB-FL measured in the first sample and adjusted by allowing for the expected disease progression for an untreated patient during the period between obtaining the first sample and obtaining the second sample. In such embodiments, if the amount of TrkB-FL measured in the second sample is higher than the expected amount of TrkB-FL, this may be indicative that treatment with the agent is efficacious. If the amount of TrkB-FL measured in the second sample is the same or similar to the expected amount of TrkB-FL, this may be indicative that treatment with the agent with the agent is not efficacious. If the amount of TrkB-FL measured in the second sample is lower than the expected amount of TrkB-FL, this may be indicative that treatment with the agent is not efficacious. Hence, the method allows the determination of whether a treatment has been efficacious.

In some embodiments, if the amount of TrkB-ICD measured in the second sample is higher than the amount of TrkB-ICD measured in the first sample, this may be indicative that treatment with the agent is not efficacious. In some embodiments, if the amount of TrkB-ICD measured in the second sample is the same or similar to the amount of TrkB-ICD measured in the first sample, this may be indicative that treatment with the agent has delayed disease progression. In some embodiments, if the amount of TrkB-ICD measured in the second sample is lower than the amount of TrkB-ICD measured in the first sample, this may be indicative that treatment with the agent is efficacious. Hence, the method allows the determination of whether a treatment has been efficacious.

In some embodiments, the amount of TrkB-ICD measured in the second sample may be compared to an expected amount of TrkB-ICD. The expected amount of TrkB-ICD may be based upon the amount of TrkB-ICD measured in the first sample and adjusted by allowing for the expected disease progression for an untreated patient during the period between obtaining the first sample and obtaining the second sample. In such embodiments, if the amount of TrkB-ICD measured in the second sample is higher than the expected amount of TrkB-ICD, this may be indicative that treatment with the agent is not efficacious. If the amount of TrkB-ICD measured in the second sample is the same or similar to the expected amount of TrkB-ICD, this may be indicative that treatment with the agent with the agent is not efficacious. If the amount of TrkB-ICD measured in the second sample is lower than the expected amount of TrkB-ICD, this may be indicative that treatment with the agent is efficacious. Hence, the method allows the determination of whether a treatment has been efficacious.

In an embodiment, there is disclosed a method for monitoring the efficacy of a treatment with an agent, comprising: i) measuring the amount of TrkB-FL and/or TrkB-T' in a first sample obtained from a subject, ii) administering an agent to said subject, and iii) measuring the amount of TrkB-FL and/or TrkB-T' in a second sample obtained from the subject.

In an embodiment, there is disclosed a method for monitoring the efficacy of a treatment with an agent, comprising: i) measuring the amount of TrkB-FL and/or TrkB-T' in a first sample obtained from a subject, and ii) measuring the amount of TrkB-FL and/or TrkB-T' in a second sample obtained from the subject after administration of an agent to the subject.

In an embodiment, there is disclosed a method for monitoring the efficacy of a treatment with an agent, comprising comparing the amount of TrkB-FL and/or TrkB-T' measured in a first sample obtained from a subject to the amount of TrkB-FL and/or TrkB-T' measured in a second sample obtained from the subject after administration of an agent to the subject.

In some embodiments, if the amount of TrkB-FL measured in the second sample is higher than the amount of TrkB-FL measured in the first sample, this may be indicative that treatment with the agent is efficacious. In some embodiments, if the amount of TrkB-FL measured in the second sample is the same or similar to the amount of TrkB-FL measured in the first sample, this may be indicative that treatment with the agent has delayed disease progression. In some embodiments, if the amount of TrkB-FL measured in the second sample is lower than the amount of TrkB-FL measured in the first sample, this may be indicative that treatment with the agent is not efficacious. Hence, the method allows the determination of whether a treatment has been efficacious.

In some embodiments, the amount of TrkB-FL measured in the second sample may be compared to an expected amount of TrkB-FL. The expected amount of TrkB-FL may be based upon the amount of TrkB-FL measured in the first sample and adjusted by allowing for the expected disease progression for an untreated patient during the period between obtaining the first sample and obtaining the second sample. In such embodiments, if the amount of TrkB-FL measured in the second sample is higher than the expected amount of TrkB-FL, this may be indicative that treatment with the agent is efficacious. If the amount of TrkB-FL measured in the second sample is the same or similar to the expected amount of TrkB-FL, this may be indicative that treatment with the agent with the agent is not efficacious. If the amount of TrkB-FL measured in the second sample is lower than the expected amount of TrkB-FL, this may be indicative that treatment with the agent is not efficacious. Hence, the method allows the determination of whether a treatment has been efficacious.

In some embodiments, if the amount of TrkB-T' measured in the second sample is higher than the amount of TrkB-T' measured in the first sample, this may be indicative that treatment with the agent is not efficacious. In some embodiments, if the amount of TrkB-T' measured in the second sample is the same or similar to the amount of TrkB-T' measured in the first sample, this may be indicative that treatment with the agent has delayed disease progression. In some embodiments, if the amount of TrkB-T' measured in the second sample is lower than the amount of TrkB-T' measured in the first sample, this may be indicative that treatment with the agent is efficacious. Hence, the method allows the determination of whether a treatment has been efficacious.

In some embodiments, the amount of TrkB-T' measured in the second sample may be compared to an expected amount of TrkB-T'. The expected amount of TrkB-T' may be based upon the amount of TrkB-T' measured in the first sample and adjusted by allowing for the expected disease progression for an

untreated patient during the period between obtaining the first sample and obtaining the second sample. In such embodiments, if the amount of TrkB-T' measured in the second sample is higher than the expected amount of TrkB-T', this may be indicative that treatment with the agent is not efficacious. If the amount of TrkB-T' measured in the second sample is the same or similar to the expected amount of TrkB-T', this may be indicative that treatment with the agent with the agent is not efficacious. If the amount of TrkB-T' measured in the second sample is lower than the expected amount of TrkB-T', this may be indicative that treatment with the agent is efficacious. Hence, the method allows the determination of whether a treatment has been efficacious.

In an embodiment, there is disclosed a method for monitoring the efficacy of a treatment with an agent, comprising: i) measuring the amount of TrkB-FL and TrkB-ICD in a first sample obtained from a subject, ii) calculating the TrkB-ICD:TrkB-FL ratio in said first sample, iii) administering an agent to said subject, iv) measuring the amount of TrkB-FL and TrkB-ICD in a second sample obtained from said subject, and v) calculating the TrkB-ICD:TrkB-FL ratio in said second sample.

In an embodiment, there is disclosed a method for monitoring the efficacy of a treatment with an agent, comprising: i) calculating the TrkB-ICD:TrkB-FL ratio in a first sample obtained from a subject, and ii) calculating the TrkB-ICD:TrkB-FL ratio a second sample obtained from a subject after administration of an agent to the subject.

In an embodiment, there is disclosed a method for monitoring the efficacy of a treatment with an agent, comprising comparing the TrkB-ICD:TrkB-FL ratio measured in a first sample obtained from a subject to the TrkB-ICD:TrkB-FL ratio measured in a second sample obtained from the subject after administration of an agent to the subject.

In some embodiments, if the TrkB-ICD:TrkB-FL ratio measured in the second sample is higher than the TrkB-ICD:TrkB-FL ratio measured in the first sample, this may be indicative that treatment with the agent is not efficacious. In some embodiments, if the TrkB-ICD:TrkB-FL ratio measured in the second sample is the same or similar to the TrkB-ICD:TrkB-FL ratio measured in the first sample, this may be indicative that treatment with the agent is efficacious and has delayed disease progression. In some embodiments, if the TrkB-ICD:TrkB-FL ratio measured in the second sample is lower than the TrkB-ICD:TrkB-FL ratio measured in the first sample, this may be indicative that treatment with the agent is efficacious. Hence, the method may allow the determination of whether a treatment has been efficacious.

In some embodiments, the TrkB-ICD:TrkB-FL ratio measured in the second sample may be compared to an expected TrkB-ICD:TrkB-FL ratio. The expected TrkB-ICD:TrkB-FL ratio may be based upon the TrkB-ICD:TrkB-FL ratio measured in the first sample and adjusted by allowing for the expected disease progression for an untreated patient during the period between obtaining the first sample and obtaining the second sample. In such embodiments, if the TrkB-ICD:TrkB-FL ratio measured in the second sample is higher than the expected TrkB-ICD:TrkB-FL ratio, this may be indicative that treatment with the agent is not efficacious. If the TrkB-ICD:TrkB-FL ratio measured in the second sample is the same or similar to the expected TrkB-ICD:TrkB-FL ratio, this may be indicative that treatment with the agent with the agent is not efficacious. If the TrkB-ICD:TrkB-FL ratio measured in the second sample is lower than the expected TrkB-ICD:TrkB-FL ratio, this may be indicative that treatment with the agent is efficacious. Hence, the method may allow the determination of whether a treatment has been efficacious.

In an embodiment, there is disclosed a method for monitoring the efficacy of a treatment with an agent, comprising: i) measuring the amount of TrkB-FL and TrkB-T' in a first sample obtained from a subject, ii) calculating the TrkB-T':TrkB-FL ratio in said first sample, iii) administering an agent to said subject, iv) measuring the amount of TrkB-FL and TrkB-T' in a second sample obtained from said subject, and v) calculating the TrkB-T':TrkB-FL ratio in said second sample.

In an embodiment, there is disclosed a method for monitoring the efficacy of a treatment with an agent, comprising: i) calculating the TrkB-T':TrkB-FL ratio in a first sample obtained from a subject, and ii) calculating the TrkB-T':TrkB-FL ratio a second sample obtained from a subject after administration of an agent to the subject.

In an embodiment, there is disclosed a method for monitoring the efficacy of a treatment with an agent, comprising comparing the TrkB-T':TrkB-FL ratio measured in a first sample obtained from a subject to the TrkB-T':TrkB-FL ratio measured in a second sample obtained from the subject after administration of an agent to the subject.

In some embodiments, if the TrkB-T':TrkB-FL ratio measured in the second sample is higher than the TrkB-T':TrkB-FL ratio measured in the first sample, this may be indicative that treatment with the agent is not efficacious. In some embodiments, if the TrkB-T':TrkB-FL ratio measured in the second sample is the same or similar to the TrkB-T':TrkB-FL ratio measured in the first sample, this may be indicative that treatment with the agent has delayed disease progression. In some embodiments, if the TrkB-T':TrkB-FL ratio measured in the second sample is lower than the TrkB-T':TrkB-FL ratio measured in the first sample, this may be indicative that treatment with the agent is efficacious. Hence, the method may allow the determination of whether a treatment has been efficacious.

In some embodiments, the TrkB-T':TrkB-FL ratio measured in the second sample may be compared to an expected TrkB-T':TrkB-FL ratio. The expected TrkB-T':TrkB-FL ratio may be based upon the TrkB-T':TrkB-FL ratio measured in the first sample and adjusted by allowing for the expected disease progression for an untreated patient during the period between obtaining the first sample and obtaining the second sample. In such embodiments, if the TrkB-T':TrkB-FL ratio measured in the second sample is higher than the expected TrkB-T':TrkB-FL ratio, this may be indicative that treatment with the agent is not efficacious. If the TrkB-T':TrkB-FL ratio measured in the second sample is the same or similar to the expected TrkB-T':TrkB-FL ratio, this may be indicative that treatment with the agent with the agent is not efficacious. If the TrkB-T':TrkB-FL ratio measured in the second sample is lower than the expected TrkB-T':TrkB-FL ratio, this may be indicative that treatment with the agent is efficacious. Hence, the method may allow the determination of whether a treatment has been efficacious.

The aforementioned methods for monitoring the efficacy of a treatment with an agent may relate to methods of treating AD, in which case the method is performed on samples obtained from subjects with AD. In another embodiment, the methods for monitoring the efficacy of a treatment with an agent may relate to any method of treatment disclosed herein. In other embodiments, the methods for monitoring the efficacy of a treatment with an agent may relate to any method of treatment for a pathology characterized by excitotoxicity, epilepsy, prion-like diseases, muscular dystrophies, Huntington's disease, Parkinson's disease, multiple sclerosis, ischemia, stroke, brain trauma, a pathology related to TrkB-FL cleavage, depression, anxiety, bipolar disorders, schizophrenia, obesity, autism, rett syndrome, retinal ganglion cell loss, ageing, amyotrophic lateral sclerosis (Lou Gehrig's disease), the adverse neurologic complications of Down syndrome, diabetic peripheral neuropathy, or other types of peripheral neuropathy. In these embodiments, the method is performed on samples obtained from subjects with the relevant pathology.

In an embodiment, the agent is a therapeutic agent or composition, polypeptide, nucleic acid, vector, genetic construct, cell, or pharmaceutical composition as disclosed herein. In an embodiment, the agent is a pharmaceutical composition of the first aspect of the invention. In an embodiment, the agent is a polypeptide of the second aspect of the invention.

In an embodiment, there is disclosed a method for monitoring the efficacy of a treatment with an agent, comprising: i) measuring the amount of TrkB-FL and TrkB-ICD in a first sample obtained from a subject, ii) calculating the TrkB-ICD:TrkB-FL ratio in said first sample, iii) administering a pharmaceutical composition of the first aspect of the invention or the polypeptide of the second aspect of the invention to said subject, iv) measuring the amount of TrkB-FL and TrkB-ICD in a second sample obtained from said subject, and v) calculating the TrkB-ICD:TrkB-FL ratio in said second sample.

In an embodiment, there is disclosed a method for monitoring the efficacy of a treatment with an agent, comprising: i) measuring the amount of TrkB-FL and/or TrkB-ICD in a first sample obtained from a subject, and ii) measuring the amount of TrkB-FL and/or TrkB-ICD in a second sample obtained from the subject after administration of a pharmaceutical composition of the first aspect of the invention or the polypeptide of the second aspect of the invention to said subject.

In an embodiment, there is disclosed a method for monitoring the efficacy of a treatment with an agent, comprising: comparing the amount of TrkB-FL and/or TrkB-ICD measured in a first sample obtained from a subject to the amount of TrkB-FL and/or TrkB-ICD measured in a second sample obtained from

the subject after administration of a pharmaceutical composition of the first aspect of the invention or the polypeptide of the second aspect of the invention to said subject.

In an embodiment, there is disclosed a method for monitoring the efficacy of an AD treatment with an agent, comprising: i) measuring the amount of TrkB-FL and TrkB-ICD in a first sample obtained from a subject with AD, ii) calculating the TrkB-ICD:TrkB-FL ratio in said first sample, iii) administering a pharmaceutical composition of the first aspect of the invention or the polypeptide of the second aspect of the invention to said subject, iv) measuring the amount of TrkB-FL and TrkB-ICD in a second sample obtained from said subject, and v) calculating the TrkB-ICD:TrkB-FL ratio in said second sample.

In an embodiment, there is disclosed a method for monitoring the efficacy of an AD treatment with an agent, comprising: i) measuring the amount of TrkB-FL and/or TrkB-ICD in a first sample obtained from a subject with AD, and ii) measuring the amount of TrkB-FL and/or TrkB-ICD in a second sample obtained from the subject after administration of a pharmaceutical composition of the first aspect of the invention or the polypeptide of the second aspect of the invention to said subject.

In an embodiment, there is disclosed a method for monitoring the efficacy of an AD treatment with an agent, comprising comparing the amount of TrkB-FL and/or TrkB-ICD measured in a first sample obtained from a subject with AD to the amount of TrkB-FL and/or TrkB-ICD measured in a second sample obtained from the subject after administration of a pharmaceutical composition of the first aspect of the invention or the polypeptide of the second aspect of the invention to said subject.

In an embodiment, there is disclosed a method for monitoring the efficacy of a treatment with an agent, comprising: i) measuring the amount of TrkB-FL and TrkB-T' in a first sample obtained from a subject, ii) calculating the TrkB-T':TrkB-FL ratio in said first sample, iii) administering a pharmaceutical composition of the first aspect of the invention or the polypeptide of the second aspect of the invention to said subject, iv) measuring the amount of TrkB-FL and TrkB-T' in a second sample obtained from said subject, and v) calculating the TrkB-T':TrkB-FL ratio in said second sample.

In an embodiment, there is disclosed a method for monitoring the efficacy of a treatment with an agent, comprising: i) measuring the amount of TrkB-FL and/or TrkB-T' in a first sample obtained from a subject, and ii) measuring the amount of TrkB-FL and/or TrkB-T' in a second sample obtained from the subject after administration of a pharmaceutical composition of the first aspect of the invention or the polypeptide of the second aspect of the invention to said subject.

In an embodiment, there is disclosed a method for monitoring the efficacy of a treatment with an agent, comprising comparing the amount of TrkB-FL and/or TrkB-T' measured in a first sample obtained from a subject to the amount of TrkB-FL and/or TrkB-T' measured in a second sample obtained from the subject after administration of a pharmaceutical composition of the first aspect of the invention or the polypeptide of the second aspect of the invention to said subject.

In an embodiment, there is disclosed a method for monitoring the efficacy of an AD treatment with an agent, comprising: i) measuring the amount of TrkB-FL and TrkB-T' in a first sample obtained from a subject with AD, ii) calculating the TrkB-T':TrkB-FL ratio in said first sample, iii) administering a pharmaceutical composition of the first aspect of the invention or the polypeptide of the second aspect of the invention to said subject, iv) measuring the amount of TrkB-FL and TrkB-T' in a second sample obtained from said subject, and v) calculating the TrkB-T':TrkB-FL ratio in said second sample.

In an embodiment, there is disclosed a method for monitoring the efficacy of an AD treatment with an agent, comprising: i) measuring the amount of TrkB-FL and/or TrkB-T' in a first sample obtained from a subject with AD, and ii) measuring the amount of TrkB-FL and/or TrkB-T' in a second sample obtained from the subject after administration of a pharmaceutical composition of the first aspect of the invention or the polypeptide of the second aspect of the invention to said subject.

In an embodiment, there is disclosed a method for monitoring the efficacy of an AD treatment with an agent, comprising comparing the amount of TrkB-FL and/or TrkB-T' measured in a first sample obtained from a subject with AD to the amount of TrkB-FL and/or TrkB-T' measured in a second sample obtained from the subject after administration of a pharmaceutical composition of the first aspect of the invention or the polypeptide of the second aspect of the invention to said subject.

For any of the methods for monitoring the efficacy of a treatment disclosed herein, the sample in which the biomarkers are quantified may be CSF, blood, plasma, serum, or saliva. The measurement of TrkB-FL, TrkB-T', and/or TrkB-ICD may be *in vitro*. TrkB-FL, TrkB-T', and/or TrkB-ICD may be measured by mass spectrometry, Western Blotting, or other methods suitable for the identification and quantification of specific proteins or peptides.

A "subject", as used herein, may be a vertebrate, mammal, or domestic animal. Hence, medicaments according to the invention may be used to treat any mammal, for example livestock (*e.g.* a horse, cow, sheep, or pig), pets (*e.g.* a cat, dog, rabbit, or guinea pig), a laboratory animal (*e.g.* a mouse or a rat), or may be used in other veterinary applications. In particular embodiments, the subject is a human being. The methods of diagnosis, methods for determining the stage of a disease, or the methods for monitoring the efficacy of a treatment may be applied to any mammal, for example livestock (*e.g.* a horse, cow, sheep, or pig), pets (*e.g.* a cat, dog, rabbit, or guinea pig), a laboratory animal (*e.g.* a mouse or a rat), or, in particular embodiments, a human being.

A "substitution", as used herein, is the substitution of a given amino acid in a peptide for another amino acid.

A "conservative substitution" or "conserved substitution", as used herein, is the substitution of a given amino acid in a peptide for another amino acid of similar characteristics. For instance, the amino acids may have similar charge, hydrophobicity, or size. The amino acids may be within the same class, for instance aliphatic, hydroxyl- or sulfur- containing, aromatic, basic, or acidic. Conservative substitutions are likely to be phenotypically silent. Examples of conservative substitutions may be within the group glycine, alanine, valine, leucine, and isoleucine; or within the group serine, cysteine, threonine, and methionine; or within the group phenylalanine, tyrosine, and tryptophan; or within the group histidine, lysine, and arginine; or within the group aspartate, glutamate, asparagine, and glutamine.

A "replacement", as used herein, is the replacement of a given amino acid in a peptide for another moiety.

"Modifications" as used herein can refer to post-translation modifications to amino acids; artificial modifications to result in non-naturally occurring amino acids; moieties added to naturally occurring amino acids; sugar residues or modified sugar residues added to amino acids or peptides; additional residues, moieties, or caps to the terminus or termini of peptides; or other modifications known in the art. The modifications may be for the purpose of increasing the stability of the agent, increasing the bioavailability of the agent, altering the charge or the agent, or for the achievement of other desired effects.

A "therapeutically effective amount", as used herein, is any amount which, when administered to a subject, is the amount needed to achieve a measurable effect, to achieve a desired effect, to reduce symptoms of a disease, to prevent a disease, or to treat a disease.

"Pharmaceutically acceptable", as used herein, is the property of being suitable for use with or as part of pharmaceutical compositions or medicaments.

A "neuropathological condition", as used herein, may be any condition with causes harm or results in abnormal function of the nervous system tissue, for instance the brain, of a subject.

All publications, patent applications, patents, and other references mentioned herein are incorporated by reference. The references cited herein are not admitted to be prior art to the claimed application. In the case of conflict, the present specification, including definitions, will control.

In addition, the materials, methods, and examples are illustrative only and not intended to be limiting. Other features and advantages of the disclosure will become apparent from the following detailed description in conjunction with the examples.

Any of the aspects and embodiments described herein can be combined with any other aspect or embodiment as disclosed in the Summary of the Invention, in the Drawings, or in the Detailed Description of the Invention, including the below specific, non-limiting, examples/embodiments of the present invention.

Examples

In Alzheimer's disease (AD) pathophysiology, Brain-derived Neurotrophic Factor (BDNF) signaling is impaired by Amyloid β (Aβ)-triggered cleavage of TrkB-FL, compromising neuronal survival, differentiation and synaptic physiology. Using *post-mortem* human brain samples of AD patients, the inventors demonstrate herein that TrkB-FL cleavage increases during AD progression. The inventors designed a small TAT-TrkB peptide that prevents this cleavage and restores BDNF physiological actions on synaptic transmission and plasticity.

Changes in biomarkers during AD progression

The inventors evaluated TrkB-FL cleavage *in post-mortem* inferior temporal cortical samples from human patients diagnosed with AD, at different stages of disease progression. The inventors detected a significant decrease of TrkB-FL protein levels and an increase in the levels of TrkB-ICD fragment, as AD progressed (Fig. 1a-b). This observation was corroborated by Mass Spectrometry quantification of TrkB-FL ($P<0.05$; Fig.4a). TrkB-FL transcript levels did not significantly change with AD progression ($P>0.05$; Fig.1c) and post-mortem delay time until sample collection did not affect TrkB-FL cleavage ($P>0.05$; Fig.4b-c).

Overall, these data suggest that TrkB-FL cleavage may be potentially implicated in the mechanisms driving AD progression by (1) compromising canonical BDNF signaling and (2) favoring TrkB-ICD formation, which may propagate Aβ-triggered toxicity[6,7].

Use of TrkB-FL and TrkB-ICD as AD biomarkers

The inventors demonstrated that in CSF samples collected from MCI patients diagnosed with AD there is a decrease of TrkB-FL protein levels and a concomitant increase of TrkB-ICD protein levels, when compared to MCI patients without AD diagnosis. Although only preliminary (Fig. 14), this data could be an important starting point to unveil whether these proteins could be applicable in the biomarker field.

TrkB-ICD as a key player in AD pathophysiology

The inventors demonstrated that TrkB-ICD is really affecting the physiological environment, through its overexpression in primary neurons and wild-type animals. Using lentiviral transduction of primary neurons, the inventors demonstrated that TrkB-ICD promoted transcriptomic alterations, being the up-regulated genes mainly associated with the cellular compartment, signal transduction pathways and Alzheimer's disease. It should be highlighted that TrkB-ICD-induced transcriptomic alterations are present in 20 of 21 chromosomes (Fig. 15).

Through intra-hippocampal injection of lentivirus in wild-type animals, the inventors observed that TrkB-ICD-expressing animals presented memory impairment (Novel-object recognition test), without alterations in locomotor and anxious parameters (Fig. 16). After behavioral analysis, animals were functionally evaluated by electrophysiological assays. The inventors observed no alterations in paired pulse facilitation and post-tethanic pulse in animals tested. However, long-term potentiation, which is the neurophysiological basis of memory processes, since it measures synaptic plasticity, was increased in TrkB-ICD-expressing animals, when compared to both control groups (Fig. 17).

Briefly, the inventors observed that the TrkB-ICD fragment *per se* plays a role in normal physiology, by alterations at genomic, functional and behavioral levels. Actually, this fragment alone promoted a dysfunctional synaptic plasticity and memory impairments.

Development of a therapeutic agent

As described above, the inventors have demonstrated that TrkB-FL cleavage may be potentially implicated in the molecular mechanisms driving AD progression. In light of this finding, the inventors have devised an innovative pharmacological strategy.

The inventors designed peptides composed by the TrkB sequence spanning the characterized cleavage site[6] fused to the TAT protein transduction domain (TAT-TrkB; Fig.1d). By binding to this cleavage site, we expected TAT-TrkB to protect TrkB-FL from cleavage.

The blood-brain barrier (BBB) poses a hurdle to several parenthetically administered drugs; therefore, the inventors were careful to design a molecule that could be useful for *in vivo* application, as the TAT sequence increases the capacity to diffuse across cell membranes and the BBB[9,10].

The first TAT-TrkB peptide examined (YGRKKRRQRRRPQYFGITNSQLKPDTF; SEQ ID NO: 25) was not able to prevent TrkB-FL cleavage (Fig. 5a-c) as tested by others[8], possibly due to its weaker α-helix conformation[11–13]. Thus, for subsequent designs, the inventors included a linker between the TAT domain and the TrkB-FL cleavage site[14].

Using 3D structural prediction algorithms, the inventors tested different linkers (Fig.1d, Fig.5d-f) and then selected the peptide displaying the stronger α-helix conformation and greater TrkB-FL cleavage site exposure (Fig.1d).

The examined peptide sequences were: i) YGRKKRRQRRRPQYFGITNSQLKPDTF (no linker); ii) YGRKKRRQRRRPPFGITNSQLKP (PP as linker – SEQ ID NO: 26); iii) YGRKKRRQRRRQFGITNSQLKP (Q as linker – SEQ ID NO: 27); iv) YGRKKRRQRRREFGITNSQLKP (E as linker – SEQ ID NO: 28); and v) YGRKKRRQRRRKKFGITNSQLKP (KK as linker).

The preferred TAT-TrkB peptide (Fig. 1c) contains a linker (KK) connecting the TAT protein transduction domain motif derived from HIV-1 transactivator of transcription protein (YGRKKRRQRRR) and the TrkB-FL sequence (515-524) cleaved by amyloid-β peptide.

In vitro assays confirmed that this TAT-TrkB peptide prevented (1) Aβ-driven TrkB cleavage in neuronal cultures (Fig. 1e) and (2) TrkB-FL cleavage induced by calpain enzymatic assays in (i) rat brain cortex (Fig.1f, Fig.6d-e) and (ii) neuronal cultures homogenates (Fig.6a-c). Furthermore, using a well-established *in vitro* model of the blood endothelial barrier (BEB)[15], the inventors observed that TAT-TrkB peptide translocated the BEB overtime (Fig.1g), without affecting its integrity (Fig.7).

Efficacy of TAT- TrkB

The inventors assessed TAT-TrkB (20 μM) efficacy at the level of synaptic physiology. For functional studies, it was prepared different species of $A\beta_{1-42}$ (200 nM), in order to control for species-related effects and to challenge TAT-TrkB against the most synaptotoxic Aβ species (Supplementary Text, Figs.8-10).

As functional readouts, the inventors (1) quantified the presynaptic release of glutamate from isolated hippocampal synaptosomes through a radioactive assay, and (2) induced Long-Term Potentiation (LTP) in the hippocampal slice *ex vivo* model (Fig.2a); LTP is a plasticity mechanism generally regarded as the neurophysiological correlate of cognition. In control conditions, BDNF (30 ng/ml) boosted both glutamate release ($P<0.01$; Fig.2b, 2f) and LTP magnitude (Fig.2g, 2k), as previously described. In addition, TAT-TrkB *per se* did not affect BDNF effect ($P<0.01$; Fig.2d, 2f, 2i, 2k).

Following exposure to $A\beta_{1-42}$ enriched in oligomeric species, BDNF effect on glutamate release ($P>0.05$; Fig.2c, 2f) and LTP ($P>0.05$; Fig.2h, 2k) was impaired. On the other hand, following exposure to $A\beta_{1-42}$ enriched in monomeric or fibrillar species, BDNF effects were preserved ($P<0.05$; Fig.11).

TAT-TrkB peptide prevented Aβ-driven loss of BDNF effect on glutamate release ($P<0.05$; Fig.2e-f). Unexpectedly, TAT-TrkB prevented Aβ-driven impairment of LTP, even though exogenous BDNF did not boost LTP further ($P>0.05$; Fig.2j-k). An explanation would be that synaptic potentiation is already operating near its 'ceiling' (i.e., LTP is saturated).

Thus, the inventors next induced LTP saturation by delivering successive bouts of naturalistic θ-burst stimulation spaced 1 h apart[16] (Fig.3a). Following exposure to oligomeric-enriched $A\beta_{1-42}$ – but not in other species – the inventors observed a significant LTP desaturation ($P<0.05$; Fig.3b-d; Fig.12). TAT-TrkB alone did not affect the saturation profile ($P>0.05$; Fig 3b-d). After co-exposure to $A\beta_{1-42}$ oligomers and TAT-TrkB, the desaturation was prevented ($P>0.05$; Fig.3b-d), but the saturation profile was not affected when compared to the control condition – hence, the lack of effect of exogenous BDNF on LTP is not yet justified. Another explanation would be that TAT-TrkB, by preventing TrkB-FL cleavage, already allows for the effects of endogenous BDNF. In physiological conditions, endogenous BDNF does not significantly contribute to θ-burst-induced LTP in young animals[17]. However, upon aging and in disease states, the compensatory role of endogenous BDNF may become more prominent. In line with this hypothesis, the inventors observed that BDNF's scavenger (TrkB-Fc) counteracts the effect of TAT-TrkB on LTP reestablishment ($P<0.05$; Fig.3e-f), revealing that endogenous BDNF becomes crucial to maintain hippocampal LTP in Aβ-toxic conditions.

The inventors also found MDL28170 (20 μM), a calpain inhibitor, to prevent LTP impairment caused by both oligomer- and fibril-enriched Aβ (Fig.12c-e). Nonetheless, calpains are involved in several physiological processes[18], thus a general calpain inhibitor would have little clinical value.

In this work, the inventors have identified a new therapeutic target and designed and validated a new pharmacological tool –TAT-TrkB. Furthermore, we provided the groundwork that establishes its efficacy in vitro and ex vivo. By preserving BDNF signaling, this peptide has the potential of a disease-modifying drug to prevent and/or reverse AD cognitive deficits. Follow-up in vivo animal studies are warranted.

***In vivo* pilot study to evaluate TAT-TrkB efficacy.**

Figure 18a provides the timeline of the experimental design of an *in vivo* study. Wild type (WT) and 5xFAD (Alzheimer's disease mouse model) animals were subject to daily intraperitoneal (5 times/week) administration of TAT-TrkB for 10 consecutive weeks. The effect of this regime on the learning and the memory of the animal was evaluated using the Morris Water Maze test.

The inventors observed that TAT-TrkB was able to significantly prevent the learning weakening in the last two days of the acquisition phase, when compared to vehicle-treated animals, highlighting its protective effect. The inventors when on to confirm that the beneficial effect was established through the prevention of TrkB-FL cleavage in transgenic animals. For that, the inventors quantified TrkB-FL cleavage by WB analysis, using hippocampal tissue. The inventors confirmed TrkB-FL cleavage in vehicle-treated transgenic animals, when compared to vehicle-treated wild-type animals. Importantly, the inventors also observed that treatment with TAT-TrkB peptide in transgenic animals was able to restore TrkB-FL protein levels Therefore, these results clearly show that TAT-TrkB peptide is indeed functional regarding the *in vivo* prevention of TrkB-FL cleavage, confirming the *in vitro* and *ex vivo* results also provided herein.

In summary, the daily intraperitoneal (5 times/week) administration of TAT-TrkB for 10 consecutive weeks to wild type (WT) and to 5xFAD (Alzheimer's disease mouse model) animals significantly improves the learning and memory of 5xFAD animals evaluated in Morris Water Maze test and increases TrkB-FL levels suggesting a reduction of its cleavage.

Methods

Processing and Analysis of Human Brain Samples

Human *post-mortem* brain samples (from inferior temporal cortex) were collected and RNA and protein were extracted, as previously described in detail [19]. Samples were classified according to Braak Staging and grouped into three categories: stages 0-II (Mild AD), stages III-IV (Moderate AD) and stages V-VI (Severe AD) [20]. Previous quantifications of these tissue samples showed that β-secretase activity and soluble Aβ42 peptide levels were correlated with the severity of AD pathology. Furthermore, increasing levels of Aβ42 total- and phosphorylated-tau in the cerebrospinal fluid (CSF) of patients from the same cohort were found to be associated with the severity of disease, according to Braak staging. Thus, these data validate the use of this cohort to assess TrkB-FL cleavage at different severity stages of AD pathology. Sample collection and use was approved by the Ethics Committee of Kuopio University Hospital, University of Eastern Finland, the Finnish National Supervisory Authority, and the Finnish Ministry of Social Affairs and Health (License number 362/06.01.03.01/2017).

WB, qPCR and Mass Spectrometry for Human Samples

Western-Blot, mRNA and MS analysis were performed in a subset of the samples; demographics are described in **Supplementary Table 1**.

TAT-TrkB Peptide Design and Structural Prediction

The final TAT-TrkB peptide (Fig. 1d) contains a linker (KK) connecting (1) the TAT protein transduction domain motif derived from the HIV-1 protein Trans-Activator of Transcription (TAT) (YGRKKRRQRRR) and (2) the TrkB-FL sequence (515-524) that is cleaved by the amyloid-β peptide.

Several TAT-TrkB peptide sequences were simulated: final TAT-TrkB – YGRKKRRQRRRKKFGITNSQLKP; first version without the linker: YGRKKRRQRRRPQYFGITNSQLKPDTF; with PP as linker: YGRKKRRQRRRPPFGITNSQLKP; with Q as linker: YGRKKRRQRRRQFGITNSQLKP; with E as linker: YGRKKRRQRRREFGITNSQLKP (Fig. 5). For BEB assays, 6-FAM fluorophore was fused to the N-terminal of the final version of TAT-TrkB

peptide.The peptides were synthesized by GenScript Corporation (Piscataway, NJ, USA) and prepared in sterile MiliQ water as 1 mM stock solution.
For structural predictions, ConSSert software (available at http://ares.tamu.edu/conSSert/)[21] and the SSPro8 tool from Scratch server (available at http://scratch.proteomics.ics.uci.edu/)[22] were used. For 3D structural predictions, the PEP-FOLD 3.0 software via the online server Mobyle@RPBS v1.5.1 (http://mobyle.rpbs.univ-paris-diderot.fr/)[23] was used. After initial studies aiming to determine peptide concentration for optimal activity, all the remaining experiments were performed using TAT-TrkB 20μM, which is within the concentration range of similar peptides previously described[8,13,24].

Aβ Species Preparation
Aβ peptide 1-42 (1 mg/ml) (A-42-T, GenicBio, Shanghai, China) was suspended in phosphate-buffered saline (PBS) (supplemented with 0.1% ammonia solution) and adjusted to a final pH 7.2. Species separation was based on an ultrafiltration process, as previously described [25]. Briefly, monomers were immediately isolated by centrifugal ultrafiltration (10kDa Amicon Ultra, Millipore) and the flow-through (monomers) recovered and spectrophotometrically assayed (ε_{280}=1490 $M^{-1}cm^{-1}$). Aβ (220 μM) was allowed to oligomerize by constant shaking at 600 rpm, at 37 ºC for 16 h (oligomers) or 5 d (fibrils). After oligomerization, samples were ultracentrifuged (40,000g, 30 min). For fibril separation, the resulting 5 d pellet (fibrils) was washed with PBS and re-ultracentrifuged twice. Total fibrils amount is given by the difference between the starting oligomerization amount and the resulting supernatant amount (ε_{280}=1490 $M^{-1}cm^{-1}$). For oligomers separation, the 16 h ultracentrifuged supernatant was further separated in centrifugal filters (30kDa Amicon Ultra). The retained fraction (oligomers >30kDa) concentration was spectrophotometrically assayed.

Methods for Aβ species characterization
Aβ species (0.5 μg) were characterized by (1) sodium dodecyl sulfate-polyacrylamide gel electrophoresis (SDS–PAGE) in 4-15% gradient gels (Mini-PROTEAN® TGX™, Bio-Rad) followed by western-blotting (6E10 anti-Aβ antibody, #SIG-39300, BioLegend, CA, USA) using standard procedures; and by (2) dynamic light scattering (DLS), performed as previously [26]. Briefly, the DLS experiments were performed in a Malvern Zetasizer Nano ZS (Malvern, UK) with backscattering detection at 173°, equipped with a He-Ne laser (λ=632.8 nm), using glass cuvettes with round aperture at 25 °C. Aβ species were diluted to 22 μM in Tris-buffer. Samples were allowed to equilibrate for 15 min at 25 °C before each of 8 measurements set (each set is the average of 10 runs, with 10 s per run). Each experiment was repeated at least 3 times. Data was evaluated in Zetasizer Nano ZS software (Malvern, UK) (Fig. 8).

Animals
Male Wistar rats were used for acute hippocampal slice preparation, while embryos from female pregnant Sprague-Dawley rats were used to prepare primary neuronal cultures. The animals were purchased from Charles River (Barcelona, Spain) and kept under standardized temperature, humidity and lighting conditions, with access to water and food *ad libitum*. All animal procedures were carried out according to the Portuguese law and the European Community Guidelines for Animal Care (European Union Council Directive – 2010/63/ EU). Throughout the underlying experimental work, care was taken to minimize the number of animals sacrificed.

Primary Cortical Neuronal Cultures
Primary neuronal cultures were prepared as routinely in the lab [6]. Briefly, animals were deeply anesthetized with isoflurane (Esteve, Barcelona, Spain) in an anaesthesia chamber before being sacrificed by decapitation. Embryos (E17-E18) were rapidly removed from the uterus and brains were dissected and placed in cold Ca^{2+}- and Mg^{2+}-free Hank's Balanced Salt Solution (HBSS) (Gibco, Paisley, UK). Cerebral cortex was isolated, mechanically fragmented and digested with 0.025% (wt/vl) trypsin solution (Gibco, Paisley, UK) in HBSS for 15 min at 37°C. After digestion, cells were precipitated by centrifugation at 1200 rpm. The supernatant was removed and 20% Fetal Bovine Serum (FBS) (Gibco, Paisley, UK) was added to HBSS. Cells resuspension by pipette aspiration was required between centrifugations in order to dissociate cells from tissue. The washing process was repeated five times to neutralize trypsin. Afterwards, cells were resuspended in Neurobasal medium (Gibco, Paisley, UK) supplemented with 0.5 mM L-glutamine, 25 mM glutamic acid, 2% B-27 and 25 U/mL penicillin/streptomycin (all from Gibco, Paisley, UK). To obtain single cells and avoid cellular clusters or tissue fragments, the suspension was filtered with a nylon filter (BD Falcon™ Cell Strainer 70 μM, Thermo Fisher Scientific, Waltham, MA, USA) and cell density was determined by counting cells in a 0.4% trypan blue solution using a hemacytometer. Cells were plated on coverslips at a $6x10^4$ cells/cm^2

density for Western blot analysis and evaluation of 3-(4,5-dimethylthiazol-2-yl)-2,5-diphenyl tetrazolium (MTT) bromide metabolism and at a $5x10^4$ cells/cm^2 density for immunocytochemistry and patch-clamp recordings. Cultures were maintained in an incubator with a humidified atmosphere of 5%/95% CO_2/O_2 at 37 ºC with no media change. The coverslips were previously sterilized under UV light and coated with 10 µg/ml of poly-D-lysine (PDL, Sigma-Aldrich, St. Louis, MO, USA) overnight and subsequently washed with sterile H_2O.

Calpain in vitro Assays and Rat Brain Homogenate Preparation

For calpain enzymatic assays, rat cortical tissue or neuronal cultured cells were homogenized in Radio Immuno Precipitation Assay (RIPA) buffer, containing 50 mM Tris-HCl [pH = 7.5], 150 mM NaCl, 5 mM ethylenediamine tetra-acetic acid, 0.1% sodium dodecyl sulfate (SDS), 1% [vl/vl] Triton X-100, protease inhibitors (Roche, Penzberg, Germany) and phosphatase inhibitors (10 mM NaF and 5 mM Na_3VO_4). For tissue homogenization, Vibracell VC250 Ultrasonic Liquid Processor was used (Sonics & Materials, Inc, CT, USA). Protein concentration was measured using Bio-Rad DC reagent (Bio-Rad Laboratories, Berkeley, CA, USA) after homogenates clarification by centrifugation (16,000g, 4ºC, 10 min). The purified rat m-calpain (1 or 2 enzymatic units, EU) (Calbiochem, San Diego, CA, USA) was incubated for 30 min at 25 ºC in a 100 µL final volume of lysis buffer containing the homogenate protein (100 µg for rat brain cortex experiments and 65µg for neuronal cultured cells), 2 mM of $CaCl_2$ and TAT-TrkB peptide (5, 20 or 50µM). Enzymatic digestion was stopped by boiling the samples at 95º C in the presence of the denaturing SDS-sample buffer, proceeding immediately to Western Blot analysis.

Western Blot analysis

After treatments, as indicated in figure descriptions, primary neuronal cultures (at DIV 8 or DIV14-16) and rat cortical samples were washed with ice-cold PBS and lysed as described above. All samples were prepared with the same amount of total protein (40 µg), unless stated otherwise. A loading buffer (350 mM Tris pH 6.8, 10% SDS, 30% glycerol, 600 mM Dithiothreitol, 0.06% bromophenol blue) was added and the mixture was boiled at 95-100°C for 10 min. Next, all samples and the molecular weight size marker (NZYTech, Lisbon, Portugal) were loaded and separated on 10% SDS–PAGE in a standard migration buffer (25 mM Tris pH 8.3, 192 mM Glycine, 10% SDS), at a constant voltage between 80–120 mV. Then, proteins were transferred onto PVDF membranes (GE Healthcare, Buckinghamshire, UK), previously soaked for 5 min in a standard buffer (25 mM Tris pH = 8.3, 192 mM Glycine, 15% methanol) for wet transfer conditions. After 1h30 of transfer, membranes were stained with Ponceau S solution (#09276-6X1EA-F, Sigma-Aldrich, St. Louis, MO, USA) to evaluate protein transfer efficacy. Membranes were blocked with a 3% (wt/vl) Bovin Serum Albumin in Tris-buffered saline (20 mM Tris base, 137 mM NaCl and 0.1% Tween-20) and subsequently incubated overnight with a primary antibody, the Trk-FL rabbit polyclonal antibody (1:1000) raised against the C-terminus (C-14) (#sc-11, Santa Cruz Biotechnology, Dallas, TX, USA) and for 1h at RT with goat anti-rabbit IgG-horseradish peroxidase-conjugated secondary antibody (1:10000) (#sc-2004, Santa Cruz Biotechnology, Dallas, TX, USA). Finally, immunoreactivity was detected using the ECL system (ECL chemiluminescence detection system, GE Healthcare), an appropriate exposure time in a ChemiDoc (Bio-Rad, XRS+) and quantified by the digital densitometry tool of ImageJ 1.45 software (Bethesda, MD, USA). GAPDH or β-actin were used as loading control (mouse anti-GAPDH (1:5000), #AM4300, Thermo Fischer Scientific, Waltham, MA, USA; mouse anti-β-actin (1:1000), #ab8226, Abcam Biochemicals (Cambridge, MA, USA); goat anti-mouse IgG-horseradish peroxidase-conjugated secondary antibody (1:10000), #sc-2005, Santa Cruz Biotechnology, Dallas, TX, USA). Figure 13 shows all the samples quantified and uncropped gels and blots with molecular weight standards; two samples were not considered for the analysis (one due to low quality; the other was judged as a statistical outlier, with a quantification value greater than the mean + 2.5 s.d. of the remaining observations).

Blood-Endothelial Barrier (BEB) Translocation and Integrity Assays

To evaluate the ability of the TAT-TrkB peptide to translocate the BEB, the inventors used a well-established *in vitro* model [15]. It comprises a transwell system with an insert in which bEnd.3 brain endothelioma cells (ATTCC-CRL-2299, Lot. 59618606) are cultured for 9 days. In this model, the apical chamber replicates the blood compartment, while the basolateral chamber replicates the brain compartment (Fig. 7a). For these experiments, 6-FAM was fused to the N-terminal of the TAT-TrkB peptide, in order to detect the peptide by fluorescence. The TAT-TrkB-6-FAM peptide (5 µM, diluted in DMEM without phenol red) was delivered to the apical compartment. After incubation times of 1h, 4h and 24h, in different inserts, medium from the apical and basolateral compartments was collected and fluorescence measured at 495 nm excitation and 517 nm emission wavelengths using the Varioskan LUX Multimode microplate reader (Thermo Scientific, Rockford, IL, USA ThermoFisher Scientific).

Peptide translocation was quantified as the fluorescence detected in the basolateral compartment normalized to the sum of the fluorescence detected in both compartments. Immediately after the TAT-TrkB.6-FAM translocation assays, *in vitro* integrity studies were performed. For these, FD4 fluorescent probe (diluted in DMEM without phenol red to a final absorbance below 0.1) was added to the apical compartment of the same inserts and incubated for 2h. FD4 is a fluorescently labelled dextran with 4 kDa and negligible translocation when cells integrity is guaranteed. In parallel, FD4 was also loaded to the apical compartment of inserts with untreated cells (negative control), as well as with cells exposed to EGTA (5 mM), together with FD4. EGTA serves as a positive control, since it is known to disrupt tight junctions and other cell-cell adhesions. Again, samples were collected from both compartments and fluorescence measured at 493 nm excitation and 520 nm emission wavelengths using the Varioskan LUX Multimode microplate reader. FD4 basal recovery was quantified as the fluorescence detected in the basolateral compartment normalized to the sum of the fluorescence detected in both compartments. For both assays, values were obtained from triplicates of three independent experiments.

Acute Hippocampal Slice Preparation

Young adult (7–10 weeks old) male Wistar rats were sacrificed by decapitation under deep isoflurane anaesthesia. The brain was quickly removed, hemisected and both hippocampi were dissected free within ice-cold artificial cerebrospinal fluid (aCSF) (mM: NaCl 124; KCl 3; NaH_2PO_4 1.25; $NaHCO_3$ 26; $MgSO_4$ 1; $CaCl_2$ 2; and glucose 10), previously gassed with 95% O_2 and 5% CO_2, pH 7.4.

Slices (400 µm-thick) were cut perpendicularly to the long axis of the hippocampus with a McIlwain tissue chopper and allowed to recover for at least 60 min in a resting chamber, filled with the gassed aCSF, at room temperature (RT) (22-24ºC).

Culture and Slice Incubation with Aβ Species

For the experiments in Fig. 9, primary neuronal cultures were incubated in supplemented Neurobasal medium at 37ºC, with either vehicle or one of $A\beta_{1-42}$ (200 nM) species (monomers, oligomers or fibrils) at DIV14-16 for 24h.

Hippocampal slices were incubated with vehicle or $A\beta_{1-42}$ (200 nM) species (monomers, oligomers or fibrils) for 3h at RT in gassed aCSF. We chose to perform slice incubation at RT, to avoid neuronal damage by hypoxic injury [27].

This $A\beta_{1-42}$ concentration (200 nM) was chosen according to previous studies [25,28–30] and based on estimates that, in brain parenchyma of AD patients, Aβ is present at a concentration within the nanomolar range[31].

MTT Assay

Viability of mature (DIV14-16) primary cortical neuronal cells incubated with vehicle or Aβ species for 24 h was evaluated by the metabolism of 3-(4,5-dimethylthiazol-2-yl)-2,5-diphenyl tetrazolium (MTT) bromide (#CT01, Sigma-Aldrich, MO, USA). MTT was added to the original culture medium and incubated for 3 h. After incubation, the converted die was solubilized with dimethylsulfoxide (DMSO) (Merck, Kenilworth, NJ, USA). Absorbance of converted die was measured at 570 nm with background subtraction at 650 nm in a microplate reader Infinite M200 (Tecan, Männedorf, Switzerland).

Propidium Iodide (PI) staining and Immunocytochemistry

Immediately after treatments, mature (DIV14-16) primary neuronal cultures were incubated with 500 nM PI (#81845, Sigma-Aldrich, MO, USA) and maintained in an incubator with a humidified atmosphere of 5% CO_2 at 37 ºC for 30 min. Neuronal cultures were then washed with PBS and fixed in 4% paraformaldehyde in PBS (pH = 7.4) for 15 min at RT. Cells were treated with blocking solution (3% [wt/vl] bovine serum albumin, BSA, Sigma-Aldrich, MO, USA) in PBS with 0.1% (vl/vl) Triton X-100 for 1 h to block unspecific binding. After washing, cells were incubated overnight at 4°C with mouse microtubule-associated protein 2 (MAP2) primary antibody (1:200 in blocking solution) (#2603311, Millipore, Billerica, MA, USA), to specifically detect neurons. Afterwards, cells were washed and incubated with goat anti-mouse Alexa Fluor® 568 secondary antibody (1:200 in blocking solution) (#A10042, Invitrogen, Carlsbad, CA, USA), for 1h at RT, in the dark. Coverslips were mounted in Mowiol mounting solution and observed using an inverted fluorescent microscope Axiovert 135 TV (Carl Zeiss Microscopy, Thornwood, NY, USA). Six random microscopic fields per sample of approximately 80 cells were counted and mean values expressed as percentage of PI-positive neurons.

Spine Density Count

Cells were fixed and treated with blocking solution as described above. Next, cells were incubated with mouse MAP2 primary antibody (1:200 in blocking solution), overnight at 4°C and subsequently washed

and incubated with goat anti-mouse Alexa Fluor® 568 secondary antibody (1:200 in blocking solution), for 1h at RT, in the dark. Then, cells were incubated for 30 min with Alexa Fluor® 488 Phalloidin (1:40 in PBS) (#A12379, Invitrogen, Carlsbad, CA, USA), which recognizes filamentous actin (F-actin). F-actin has an important role in the constitution of the cytoskeleton of dendritic spines [32]. After washing, coverslips were mounted and cells were imaged as described above. Spine density is expressed as the number of small protrusions (either mushroom-shape spines or filopodia) extending ≤3 µm from their parent dendrite with a distance >25 µm from the cell body, normalized to 10 µm of the parent dendrite, as previously reported [33]. Dendritic spines were counted offline using ImageJ 1.45 (Bethesda, MD, USA). Six neurons per condition per culture were analyzed and in each neuron protrusions were counted in 3 different dendrites.

mEPSC Recordings

Miniature excitatory postsynaptic currents (mEPSCs) of isolated primary neurons were evaluated by whole-cell patch clamp, immediately after treatments, as routinely in the lab [34]. Briefly, cells were visualized with an upright microscope (Axioskop 2FS, Carl Zeiss Microscopy, Thornwood, NY, USA) equipped with differential interference contrast optics using a Zeiss AxioCam MRm camera and a X40 IR-Achroplan objective. The resting membrane potential was measured immediately upon establishing whole-cell configuration. mEPSCs recordings were performed at RT and in voltage-clamp mode (Vh = –60 mV), using an Axopatch 200B amplifier (Molecular Devices, CA, USA). The extracellular media was gassed aCSF supplement with tetrodotoxin (TTX, 500 nM), a sodium channel blocker, and gabazine (GBZ, 50 µM), a $GABA_A$ receptor antagonist. Patch pipettes (4– to 7–MΩ resistance) were filled with an internal solution containing (in mM): K-gluconate 125, KCl 11, $CaCl_2$ 0.1, $MgCl_2$ 2, EGTA 1, HEPES 10, MgATP 2, NaGTP 0.3, Phosphocreatine 1, pH 7.3, adjusted with 1 M KOH, 280-290 mOsm. Acquired signals were filtered using an in-built, 2-kHz, three-pole Bessel filter, and data were digitized at 5 or 10 kHz under control of the pCLAMP 10 (Molecular Devices, CA, USA) software program. The junction potential was not compensated for, and offset potentials were nulled before giga-seal formation. Small voltage steps (–5 mV, 50 ms) were used to monitor the access resistance throughout experiments. The holding current was also constantly monitored and experiments in which any of these parameters varied by more than 20% were discarded. Analysis of miniature events was performed using the Mini Analysis Software (Synaptosoft Inc., NJ, USA), and event detection threshold was set at three times the root mean square (RMS) baseline (noise). mEPSCs frequency, average amplitude, rise and decay times were established by analysing 5–10 min of recording periods per cell.

PI and Immunohistochemistry

After treatments, hippocampal slices were incubated with 500 nM PI for 30 min at RT in gassed aCSF and then fixed in 4% paraformaldehyde in PBS (pH = 7.4) for 15 min at RT. Next, slices were dehydrated with sequential solutions of 10%, 20% and 30% sucrose, embedded in Tissue-Tek O.C.T. (Sakura Finetek, Torrence, CA, USA) and stored at –80°C. Serial 20-µm-thick hippocampal sections were cut on a cryostat (Leica Biosystems, Wetzlar, Germany) and mounted on SuperFrost-Plus glass slides (Thermo Scientific, Rockford, IL, USA). Hippocampal slices were then rehydrated and boiled three times in 10 mM citrate buffer, pH 6. Next, slices were treated with blocking solution (3% [wt/vl] BSA) in PBS with 0.1% (vl/vl) Triton X-100 for 1 h. After washing, slices were incubated with mouse MAP2 primary antibody (1:200 in blocking solution), overnight at 4°C. Afterwards, slices were washed and incubated with goat anti-mouse Alexa Fluor® 568 secondary antibody (1:200 in blocking solution), for 1h at RT, in the dark. After incubation with 5 µg/mL Hoechst dye (#33258, Sigma-Aldrich, St. Louis, MO, USA) for 5 min, slices were washed, mounted in Mowiol mounting solution and sections were imaged with an inverted fluorescent microscope Axiovert 135 TV (Carl Zeiss Microscopy, Thornwood, NY, USA). CA1 and CA3 areas were analyzed and mean values are expressed as percentage of PI-positive cells and percentage of PI-positive neurons.

Extracellular Ex Vivo Recordings

Slices were transferred to a submerging chamber (1 ml) and continuously superfused at a 3 ml/min rate with gassed aCSF at 32ºC. Perfusion tubes were coated with 0.1 mg/ml BSA prior to experiments to avoid adsorption of BDNF to the tubes [35]. Evoked field excitatory postsynaptic potentials (fEPSP) were recorded extracellularly through a microelectrode filled with 4 M NaCl (2–8 MΩ resistance) placed in the *stratum radiatum* of the CA1 area, as previously described [34,35]. One pathway of the Schaffer collateral/commissural fibers was stimulated (rectangular pulses of 0.1 ms duration) at every 15 s (for I/O curves, basal synaptic transmission and Paired-Pulse Facilitation (PPF) recordings) or every 20 s (for LTP recordings), by a bipolar concentric wire electrode placed on the Schaffer fibers in the stratum *radiatum*, in the CA1 area. The initial intensity of the stimulus was adjusted to obtain a submaximal

fEPSP slope with a minimum population spike contamination, near one-fifth of the fEPSP slope obtained with supramaximal stimulation. The averages of eight consecutive fEPSPs were obtained and the slope of the initial phase of the potential was quantified. Recordings were obtained with an Axoclamp 2B amplifier (Axon Instruments, Foster City, CA), digitized and continuously stored on a personal computer with the LTP program [36]. All the protocols detailed below were started only after a stable baseline of at least 20 minutes.

Input/Output Curves. The stimulus delivered to the slice was decreased until no fEPSP was evoked and subsequently increased by steps of 20 μA. Data from three consecutive averaged fEPSPs were collected for each stimulation intensity. The range of inputs delivered to slices was typically from 80 μA to a supramaximal stimulation of 320 μA. Maximum slope values were obtained by extrapolation upon nonlinear fitting of the I/O curve. Whenever the stimulus was intense enough to elicit a population spike (depolarization that follows the fEPSP), its amplitude was measured. Each popspike amplitude replicate was plotted as a function of the slope of the associated fEPSP and the popspike/fEPSP ratio calculated as the quotient between these values [34].

Long-Term Potentiation induction and saturation. A weak LTP-inducing θ-burst protocol consisting of four trains of 100 Hz, four stimuli, separated by 200 ms was used (4x4) [34,37]. The intensity of the stimulus was never changed. LTP magnitude was quantified as the normalized change in the average slope of the fEPSP taken from 50 to 60 min after LTP induction in relation to the average slope of the fEPSP measured during the 10 min that preceded the induction of LTP.

For the experiments in **Figure 2**, Brain-Derived Neurotrophic Factor (BDNF, 30 ng/ml) was added to the superfusing solution 20 min before the induction of LTP. Controls for these experiments were performed in different slices, without BDNF superfusion, on the same day. Generally, when testing BDNF effect on synaptic plasticity, two independent pathways of the same hippocampal slice are used, one serving as test and the other as internal control [35,38]. However, because in the present experimental design slices were previously exposed to vehicle/Aβ for 3 h, we chose to test BDNF effect in different slices from the same rats. Otherwise, time between the end of vehicle/Aβ treatment and LTP induction would be consistently longer when BDNF was to be tested (as BDNF can only be added to the superfusing solution after LTP is induced in the first pathway).

For the experiments in **Figure 3a-d**, in order to test LTP saturation, we induced three consecutive θ-burst (4x4) paradigms in the same pathway spaced by 1 h intervals. We based our experimental design on previous results showing that LTP has a refractory period of 60 min before which a new LTP cannot be effectively induced [16]. We calculated the Saturation Index (SI) as the quotient of the sum of the three LTP magnitudes by the magnitude of the first LTP [(LTP1+LTP2+LTP3)/LTP1) (hence, if SI ≈ 3, LTP is fully saturated; if SI > 3, LTP is not saturated; the higher the SI, the more desaturated LTP is).

For the experiments in **Figure 3e-f,** BDNF's scavenger, TrkB-Fc (2 μg/ml), was added to the superfusion solution 30 min before induction of LTP and remained in the bath up to the end of the experiment.

Paired-Pulse Facilitation (PPF) Recordings. PPF was quantified as the ratio between the second versus the first fEPSP slope (fEPSP2/fEPSP1) responses at different interstimulus intervals (10–150 ms) [34].

[^{3}H]Glutamate Release Assays

Isolation of Synaptosomes. The synaptosomal fraction from rat hippocampi was prepared as routinely in the lab [39]. Hippocampal slices (male Wistar rats, 7–10 weeks old) were prepared and treated with vehicle or $A\beta_{1-42}$, as described above. Then, slices were added to 5 ml of ice-cold isosmotic sucrose solution (0.32 M, containing 1 mM EDTA, 1 mg/ml BSA, 10 mM HEPES, pH 7.4), and homogenized in a Potter-Elvehjem homogenizer with a Teflon piston (four up-and-down strokes) and the volume completed to 10 ml with the sucrose solution. After a first centrifugation at 3,000g for 10 min (Heraeus sepatech – Biofuge 28RS centrifuge with 3746 rotor), the supernatant was collected and centrifuged at 14,000g for 12 min. The whole procedure was conducted at 4°C. The pellet was resuspended in 1 ml 45% Percoll in KHR solution consisting of (in mM) NaCl 140, EDTA 1, HEPES 10, KCl 5, and glucose 5, and centrifuged at 16,000g for 2 min. The synaptosomal fraction corresponds to the top buoyant layer and was collected from the tube. Percoll was removed by two washes with 1 ml KHR solution centrifuged at 16,000g for 2 min each; synaptosomes were then kept on ice and used within 3 hours. The synaptosomal protein concentration was assayed using the Bio-Rad DC™ protein assay and BSA as standard.

[^{3}H]Glutamate Release from Hippocampal Synaptosomes. [^{3}H]Glutamate release from hippocampal synaptosomes was performed as routinely in the lab [39]. Synaptosomes (protein concentration 1–2 mg/ml) were resuspended in oxygenated Krebs medium (in mM: NaCl 125, KCl 3, NaH2PO4 1, glucose 10 NaHCO3 25, CaCl2 1.5 and MgSO4 1.2) and allowed to equilibrate for 5 min at 37°C. From this time onward, all solutions applied to the synaptosomes were kept at 37 ºC and continuously gassed with

O_2/CO_2 (95%/5%). Then, synaptosomes were loaded with 0.2 µM [^{3}H]glutamate (specific activity 30–60 Ci/mmol) for 5 min and equally layered over Whatman GF/C filters (Milipore, MA, USA) onto an eight-chamber superfusion apparatus (flow rate, 0.6 ml/min; chamber volume, 90 µl).The constant and rapid flow rate washes out endogenously related substances, thus ensuring drug effect specificity [40]. After a 20 min washout period, the effluent was collected for 40 min in 2 min intervals. Glutamate release from synaptosomes was elicited during 2 min with a high-K^+ solution (15 mM, isomolar substitution of Na^+ with K^+ in the perfusion buffer) at the 5th [first stimulation period (S1)] and 29th [second stimulation period (S2)] min after starting sample collection. BDNF (30 ng/ml) was added to the superfusion medium at the 9th min, therefore before S2, and remained in the bath up to the end of the experiments (as indicated by the horizontal bars in Fig. 2b-e and Fig. 11a.b). Control curves, in the absence of BDNF, were performed in parallel with the same synaptosomal batch.

Calculation of drug effects on glutamate release. At the end of each experiment, aliquots (500 µl) of each sample as well as the filters from each superfusion chamber were analyzed by liquid scintillation counting. The fractional release was expressed as the percentage of total radioactivity present in the synaptosomes at each time point. The amount of radioactivity released by each pulse of K^+ (S1 and S2) was calculated by integration of the area of the peak upon subtraction of the estimated basal tritium release. Each condition was tested in duplicate. Hence, in each experiment, two synaptosome-loaded chambers were used as control chambers, the others being used as test chambers. Each one of the chambers was used as control or as one of the test conditions in different days.

Drugs and Reagents

$A\beta_{25-35}$ was purchased from Bachem (Bubendorf, Switzerland) and prepared in 1 mg/ml stock solution in sterile MiliQ water. $A\beta_{1-42}$ (1 mg/ml) (A-42-T, GenicBio, Shanghai, China) was suspended in phosphate-buffered saline (PBS) (supplemented with 0.1% ammonia solution) and adjusted to a final pH 7.2. BDNF was generously supplied by Regeneron Pharmaceuticals (Tarrytown, NY) in a 1.0 mg/ml stock solution in 150 mM NaCl, 10 mM sodium phosphate buffer, and 0.004% Tween 20. The recombinant human TrkB/Fc chimera, TrkB-Fc, was purchased from R&D systems (Minneapolis, MN) and made up in a 50 µg/ml stock solution in PBS with 0.1% BSA. TTX and gabazine were purchased from Abcam Biochemicals (Cambridge, MA, USA) and prepared in distilled water as 1 and 10 mM stock solutions, respectively. MDL28170 was bought from Tocris (Ballwin, MO, USA), and prepared in a 20 mM stock solution in DMSO. [3H]Glutamate (L-[G-3H]glutamic acid, specific activity 45 Ci/mmol) was purchased from PerkinElmer Life Sciences (Waltham, MA, USA). Percoll, EDTA, KCl, MgSO4·7H2 O, NaCl, and NaH2PO4·H2O were bought from Sigma-Aldrich (St. Louis, MO, USA); glucose, sucrose, HEPES, NaH2PO4 ·H2O, NaOH, and HCl were bought from Merck (Kenilworth, NJ, USA). The other reagents, drugs and antibodies needed for this work were purchased and prepared as described in the respective sections above.

Statistical Analysis

Sample sizes were determined based on preliminary results or similar experiments carried out in the past. Values are presented individually in scattered dot blots, with bars overlaid to depict mean±s.e.m or mean±95%CI, as indicated. Hyperbolic regressions (Fig. 1g and Fig. 10d) and linear regressions (Fig. 10e) were fitted using the least squares method. Statistical analyses were designed under the assumption of normal distribution and similar variance among groups. For inference analysis, paired t-tests, unpaired t-tests or one-way ANOVA followed by a Bonferroni's multiple comparison post hoc tests were used, as specified in the figure legends and detailed in Supplementary Table 2. $P < 0.05$ was considered statistically significant. All statistical analysis was performed on Prism 8 (version 8.1.2, GraphPad Software Inc.).

$A\beta_{1-42}$ Species Molecular Characterization

The Aβ species prepared were initially characterized by SDS–PAGE followed by immunoblotting (Fig. 8a). Through use of denaturing conditions, only stable oligomers were retained at higher MW, while unstable Aβ was dissociated into monomers. Monomeric Aβ was only detected at a single band with MW lower than 12 kDa, suggesting it was retained at Aβ monomeric MW. Oligomers were mainly present at a MW between 38-225 kDa. Fibrils were mainly present at high MW (>150 kDa). Afterwards, the species were analyzed by DLS, which allowed to determine the profile of particle size distribution. Consistently with the previous analysis, DLS revealed a more heterogeneous size distribution of oligomeric Aβ, in comparison to monomeric, and of Aβ fibrils, in comparison to both monomeric and oligomeric Aβ, with a significant increase in particles with a hydrodynamic diameter above 2500 nm (Fig. 8b).

$A\beta_{1-42}$ Species Biological Effects

We initially probed the biological effects of these species on primary neuronal cultures after 24h exposure. We observed that oligomeric and fibrillar, but not monomeric, species induced (1) a small, yet consistent decrease in cell viability, (2) a decrease in dendritic spine density; and (3) an impairment in excitatory spontaneous synaptic transmission, as evaluated by whole-cell voltage-clamp recordings of miniature excitatory postsynaptic current (mEPSC) (Fig. 9). Subsequently, we evaluated the species after 3h exposure in the ex vivo preparation of rat hippocampal slices. We observed no short-term cellular death induced by $A\beta_{1-42}$ species (Fig. 10a-c). However, even after brief (3h) exposure to oligomeric- and fibrillar-enriched $A\beta_{1-42}$, we could detect a decrease in the depolarization slope of field responses adjusted for the presynaptic fiber volley amplitude (PSFA) (Fig. 10d). We also measured the amplitude of the population spike (popspike) whenever the stimulus intensity was sufficient to elicit it (typically, above 220 μA stimulus intensity) and plotted it against the corresponding fEPSP slope (Fig. 10e). The popspike amplitude is a measure of CA1 pyramidal cell output, while the fEPSP slope evaluates the response to Schaffer collateral fibers depolarization induced by an electrical stimulus. Therefore, by correlating these two variables, it is possible to assess the hippocampal circuit computation of the afferent stimulation. Linear fittings of these values show that no gross changes were induced by any of the Aβ species (Fig. 10e). Finally, none of the Aβ species significantly impaired Paired-Pulse Facilitation (PPF), which is a pre-synaptic mechanism of short-term plasticity (Fig. 10f).

The details of one or more embodiments of the invention are set forth in the accompanying description above. Although any methods and materials similar or equivalent to those described herein can be used in the practice or testing of the present invention, exemplary methods and materials are described.

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The invention can also be defined by reference to the following clauses.

1. A pharmaceutical composition comprising a portion of the tropomyosin-receptor kinase B-full-length (TrkB-FL) protein, wherein the portion spans the calpain cleavage site of TrkB-FL.

2. A polypeptide comprising an isolated portion of TrkB-FL, wherein the isolated portion of TrkB-FL spans the calpain cleavage site of TrkB-FL.

3. The pharmaceutical composition or polypeptide according to clause 1 or clause 2, wherein the amino acid sequence of the TrkB-FL protein from which the portion is derived is according to SEQ ID NO: 1.

4. The pharmaceutical composition or polypeptide according to any one of clauses 1 to 3, wherein the portion of TrkB-FL:

(i) comprises 1 to 10 of the residues on the N-terminal side of the TrkB-FL calpain cleavage site and/or 1 to 10 of the residues on the C-terminal side of the TrkB-FL calpain cleavage site; or

(ii) comprises an amino acid sequence according to SEQ ID NO: 5 and/or SEQ ID NO: 12; or

(iii) is 5 to 20, 8 to 12, or 10 residues in length.

5. The pharmaceutical composition or polypeptide according to clause 1 or clause 2, wherein the amino acid sequence of the portion of TrkB-FL is according to any one of SEQ ID NO: 18, SEQ ID NO: 19, or SEQ ID NO: 20.

6. The pharmaceutical composition or polypeptide according to any preceding clause, wherein the pharmaceutical composition or polypeptide is able to prevent calpain cleavage of TrkB-FL to produce tropomyosin-receptor kinase B-full-length intracellular domain (TrkB-ICD).

7. The pharmaceutical composition or polypeptide according to any preceding clause, wherein the pharmaceutical composition or polypeptide is suitable for delivery of the portion of TrkB-FL across the blood brain barrier and into neuronal cells.

8. The pharmaceutical composition or polypeptide according to any preceding clause, wherein the pharmaceutical composition or polypeptide comprises a cell-penetrating peptide.

9. The pharmaceutical composition or polypeptide according to clause 8, wherein the cell-penetrating peptide is trans-activating transcriptional activator (TAT); optionally wherein the amino acid sequence of the cell-penetrating peptide is according to SEQ ID NO: 21.

10. The polypeptide according to any one of clauses 2 to 9, wherein the polypeptide comprises a linker; optionally wherein the linker comprises the amino acid residues KK.

11. The polypeptide according to clause 2, wherein the polypeptide comprises:

(i) an amino acid sequence according to any one of SEQ ID NO: 18, SEQ ID NO: 19, or SEQ ID NO: 20, and further comprises an amino acid sequence according to SEQ ID NO: 21; or

(ii) an amino acid sequence according to SEQ ID NO: 18, a linker, and an amino acid sequence according to SEQ ID NO: 21; or

(iii) an amino acid sequence according to SEQ ID NO: 18, a linker which comprises the amino acid residues KK, and an amino acid sequence according to SEQ ID NO: 21.

12. The polypeptide according to clause 2, wherein polypeptide comprises an amino acid sequence according to SEQ ID NO: 22, SEQ ID NO: 23, SEQ ID NO: 24, SEQ ID NO: 26, SEQ ID NO: 27, or SEQ ID NO: 28.

13. The polypeptide according to any one of clauses 4 to 12, wherein the polypeptide comprises one or more substitutions, conservative substitutions, modifications, or replacements within a recited amino acid sequence.

14. A pharmaceutical composition or polypeptide according to any one of clauses 1 to 13, for use as a medicament.

15. A pharmaceutical composition or polypeptide according to any one of clauses 1 to 13, for use in a method of treating Alzheimer's disease (AD), preventing AD, ameliorating AD, delaying the progression of AD, or reducing at least one symptom of AD.

16. A pharmaceutical composition or polypeptide according to any one of clauses 1 to 13, for use in a method of treating, preventing, ameliorating, delaying the progression of, or reducing at least one symptom of:

(i) a neuropathological condition; or

(ii) a pathology characterized by excitotoxicity; optionally wherein the pathology is selected from epilepsy, prion-like diseases, muscular dystrophies, Huntington's disease, Parkinson's disease, multiple sclerosis, ischemia, stroke, or brain trauma; or

(iii) a pathology related to TrkB-FL cleavage; optionally wherein the pathology is selected from depression, anxiety, bipolar disorders, schizophrenia, obesity, autism, rett syndrome, retinal ganglion cell loss, ageing, amyotrophic lateral sclerosis (Lou Gehrig's disease), the adverse neurologic complications of Down syndrome, diabetic peripheral neuropathy, or other types of peripheral neuropathy.

17. Use of TrkB-FL, TrkB-ICD, TrkB-T', the TrkB-T':TrkB-FL ratio, or the TrkB-ICD:TrkB-FL ratio as a biomarker for AD.

18. A method for diagnosing AD or for determining the stage of AD, comprising:

i) comparing the amount of TrkB-FL, TrkB-T', and/or TrkB-ICD measured in a sample obtained from a subject to a reference amount, and

ii)

a) determining that said subject has AD, or determining that said subject has a more advanced stage of AD than that represented by the reference amount, if said amount of TrkB-FL is lower than said reference amount, if said amount of TrkB-ICD is higher than said reference amount, and/or if said amount of TrkB-T' is higher than said reference amount; or

b) determining that said subject has the same stage of AD or AD diagnosis as that represented by the reference amount if said amount of TrkB-FL, TrkB-T', and/or TrkB-ICD is the same or similar to said reference amount; or

c) determining that said subject does not have AD, or determining that said subject has a less advanced stage of AD than that represented by the reference amount, if said amount of TrkB-FL is higher than said reference amount, if said amount of TrkB-ICD is lower than said reference amount, and/or if said amount of TrkB-T' is lower than said reference amount; optionally wherein

the reference amount is representative of the amount of TrkB-T', TrkB-FL, and/or TrkB-ICD in a subject without AD, in a subject with mild AD, in a subject with moderate AD, in a subject with severe AD, determined from said subject before disease onset, determined from said subject after diagnosis of mild AD, determined from said subject after diagnosis with moderate AD, determined from said subject after diagnosis with severe AD, or determined from said subject before treatment.

19. A method for diagnosing AD or for determining the stage of AD, comprising:

i) comparing the TrkB-ICD:TrkB-FL ratio measured in a sample obtained from a subject to a reference value, and

ii)

a) determining that said subject has AD or determining that said subject has a more advanced stage of AD than that represented by the reference value, if said TrkB-ICD:TrkB-FL ratio is higher than said reference value; or

b) determining that said subject has the same stage of AD or AD diagnosis as that represented by the reference value if said TrkB-ICD:TrkB-FL ratio is the same or similar to said reference value; or

c) determining that said subject does not have AD, or determining that the subject has a less advanced stage of AD than that represented by the reference value, if said TrkB-ICD:TrkB-FL ratio is lower than said reference value.

20. A method for diagnosing AD or for determining the stage of AD, comprising:

i) comparing the TrkB-T':TrkB-FL ratio measured in a sample obtained from a subject to a reference value, and

ii)

a) determining that said subject has AD or determining that said subject has a more advanced stage of AD than that represented by the reference value, if said TrkB-T':TrkB-FL ratio is higher than said reference value; or

b) determining that said subject has the same stage of AD or AD diagnosis as that represented by the reference value if said TrkB-T':TrkB-FL ratio is the same or similar to said reference value; or

c) determining that said subject does not have AD, or determining that the subject has a less advanced stage of AD than that represented by the reference value, if said TrkB-T':TrkB-FL ratio is lower than said reference value.

21. The method of clause 19 or 20, wherein the reference value is representative of the TrkB-ICD:TrkB-FL ratio or the TrkB-T':TrkB-FL ratio in a subject without AD, in a subject with mild AD, in a subject with moderate AD, in a subject with severe AD, determined from said subject before disease onset, determined from said subject after diagnosis of mild AD, determined from said subject after diagnosis with moderate AD, determined from said subject after diagnosis with severe AD, or determined from said subject before treatment.

22. The method of any one of clauses 19 to 21, wherein said subject is diagnosed with AD if the subject's measured TrkB-ICD:TrkB-FL ratio or TrkB-T':TrkB-FL ratio is increased by at least 5%, at least 10%, at least 20%, at least 30%, at least 40%, at least 50%, at least 60%, at least 70%, at least 80%, at least 90%, at least 100%, at least 150%, at least 200%, or at least 300% in comparison to a reference value representative of a subject without AD.

23. A method for diagnosing AD, comprising:

i) comparing the TrkB-ICD:TrkB-FL ratio or the TrkB-T':TrkB-FL ratio measured in a sample obtained from a first subject with mild cognitive impairment to a reference value obtained from at least one subject without AD, and

ii)

a) determining that the first subject has AD if said TrkB-ICD:TrkB-FL ratio or TrkB-T':TrkB-FL ratio is increased by at least 5%, at least 10%, at least 20%, at least 30%, at least 40%, at least 50%, at least 60%, at least 70%, at least 80%, at least 90%, at least 100%, at least 150%, at least 200%, or at least 300% in comparison to said reference value; or

b) determining that the first subject does not have AD if said TrkB-ICD:TrkB-FL ratio or TrkB-T':TrkB-FL ratio is not increased compared to said reference value.

24. A method for monitoring the efficacy of an AD treatment with an agent, comprising:

i) calculating an expected amount of TrkB-T', TrkB-FL, and/or TrkB-ICD based upon an amount of TrkB-T', TrkB-FL, and/or TrkB-ICD measured in a first sample obtained from a subject with AD and the time elapsed since the first sample was obtained; and

ii) comparing an amount of TrkB-T', TrkB-FL, and/or TrkB-ICD measured in a second sample obtained from the subject after administration of an agent to the subject, to said expected amount of TrkB-T', TrkB-FL, and/or TrkB-ICD; and

iii)

a) determining that the treatment is efficacious if the amount of TrkB-FL in the second sample is higher than the expected amount of TrkB-FL, if the amount of TrkB-ICB in the second sample is lower than the expected amount of TrkB-ICB, and/or if the amount of TrkB-T' in the second sample is lower than the expected amount of TrkB-T'; or

b) determining that the treatment is not efficacious if the amount of TrkB-FL in the second sample is lower than or the same as the expected amount of TrkB-FL, if the amount of TrkB-ICB in the second sample is higher than or the same as the expected amount of TrkB-ICB, and/or if the amount of TrkB-T' in the second sample is higher than or the same as the expected amount of TrkB-T'.

25. A method for monitoring the efficacy of an AD treatment with an agent, comprising:

i) calculating an expected TrkB-ICD:TrkB-FL ratio or TrkB-T':TrkB-FL ratio based upon a TrkB-ICD:TrkB-FL ratio or TrkB-T':TrkB-FL ratio measured in a first sample obtained from a subject with AD and the time elapsed since the first sample was obtained; and

ii) comparing: a TrkB-ICD:TrkB-FL ratio or TrkB-T':TrkB-FL ratio measured in a second sample obtained from the subject after administration of an agent to the subject, to said expected TrkB-ICD:TrkB-FL ratio or TrkB-T':TrkB-FL ratio; and

iii)

a) determining that the treatment is efficacious if the TrkB-ICD:TrkB-FL ratio in the second sample is lower than the expected TrkB-ICD:TrkB-FL ratio, or determining that the treatment is efficacious if the TrkB-T':TrkB-FL ratio in the second sample is lower than the expected TrkB-T':TrkB-FL ratio; or

b) determining that the treatment is not efficacious if the TrkB-ICD:TrkB-FL ratio in the second sample is higher than or the same as the expected TrkB-ICD:TrkB-FL ratio, or determining that the treatment is not efficacious if the TrkB-T':TrkB-FL ratio in the second sample is higher than or the same as the expected TrkB-T':TrkB-FL ratio.

Supplementary Table 1. Number of cases and age of patients included in the molecular studies.

Braak Stage	N	Age (mean ± SD)	P *
Western Blot Analysis			
0 – II	11	79.00 ± 11.68	0.7417
III – IV	7	82.00 ± 5.77	
V – VI	8	81.88 ± 8.59	
Mass Spectrometry Analysis			
0 – II	11	83.75 ± 8.60	0.5496
III – IV	5	81.50 ± 3.73	
V – VI	16	80.28 ± 8.45	
Transcriptomics Analysis			
0 – II	27	79.21 ± 10.95	0.5031
III – IV	11	82.85 ± 6.83	
V – VI	17	81.32 ± 6.95	

SD. Standard Deviation.

* One-way ANOVA

FIGURE NUMBER	TEST USED		n			DESCRIPTIVE STATS (AVERAGE, VARIANCE)		P VALUE		DEGREES OF FREEDOM & F/t/z/R/ETC VALUE
	WHICH TEST?	SECTION & PARAGRAPH #	EXACT VALUE	DEFINED?	SECTION & PARAGRAPH #	REPORTED?	SECTION & PARAGRAPH #	EXACT VALUE	SECTION & PARAGRAPH #	VALUE
1b, left pannel	one-way ANOVA followed by a Bonferroni's Multiple Comparison Test	Fig. legend	11, 7, 8	Human samples from independent patients	Fig. legend	error bars are mean +/- SEM	Fig. legend	P = 0.0264	Main Text	F (2, 23) = 4.277
1b, right pannel	one-way ANOVA followed by a Bonferroni's Multiple Comparison Test	Fig. legend	11, 7, 8	Human samples from independent patients	Fig. legend	error bars are mean +/- SEM	Fig. legend	P=0.0072	Main Text	F (2, 23) = 6.168
1c	one-way ANOVA followed by a Bonferroni's Multiple Comparison Test	Fig. legend	27, 11, 17	Human samples from independent patients	Fig. legend	error bars are mean +/- SEM	Fig. legend	P = 0.0751	Main Text	F (2, 52) = 2.722
2f	Paired t-test	Fig. legend	veh: 16 (w/o BDNF), 16 (w/ BDNF); AbOlig: 5 (w/o BDNF), 5 (w/ BDNF); TAT; 5 (w/o BDNF), 5 (w/ BDNF); TAT+AbOlig: 4 (w/o BDNF), 4 (w/ BDNF)	Rats from independent litters	Fig. legend	error bars are mean +/- SEM	Fig. legend	P=0.0026; P=0.0578; P= 0.0199; P= 0.0139	Main Text	t=3.610, df=15; t=2.636, df=4; t=3.753, df=4; t=5.184, df=3
2k	one-way ANOVA followed by a Bonferroni's Multiple	Fig. legend	8, 6, 8, 7, 10, 7, 15, 13	Rats from independent litters	Fig. legend	error bars are mean +/- SEM	Fig. legend	P=6.34E-07	Main Text	F (7, 66) = 7.886

	Comparison Test									
3d	one-way ANOVA followed by a Bonferroni's Multiple Comparison Test	Fig. legend	8, 8, 8, 8	Rats from independent litters	Fig. legend	error bars are mean +/- 95% CI	Fig. legend	P=1.33E-04	Main Text	F (3, 28) = 9.849
3f	Unpaired t-test	Fig. legend	15, 3	Rats from independent litters	Fig. legend	error bars are mean +/- SEM	Fig. legend	P = 0.0237	Main Text	t=2.500, df=16
S1a	one-way ANOVAfollowed by a Bonferroni's Multiple Comparison Test	Fig. legend	11, 5, 16	Human samples from independent patients	Fig. legend	error bars are mean +/- SEM	Fig. legend	P = 0.0140	Supl Fig. legend	F (2, 29) = 4.962
S1c	one-way ANOVA followed by a Bonferroni's Multiple Comparison Test	Fig. legend	7, 19, 6	Human samples from independent patients	Fig. legend	error bars are mean +/- SEM	Fig. legend	P=0.7767	Supl Fig. legend	F (2, 29) = 0.2549
S4b	one-way ANOVA followed by a Bonferroni's Multiple Comparison Test	Fig. legend	3, 3, 3, 3, 3	Independent bEnd.3 cell cultures	Fig. legend	error bars are mean +/- SEM	Fig. legend	P = 0.0017	Supl Fig. legend	F(4, 10) = 9.818
S6a	one-way ANOVA followed by a Bonferroni's Multiple Comparison Test	Fig. legend	5, 5, 5, 5	Independent neuronal cultures	Fig. legend	error bars are mean +/- SEM	Fig. legend	P=0.0245	Supl Fig. legend	F (3, 16) = 4.101

S6b	one-way ANOVA followed by a Bonferroni's Multiple Comparison Test	Fig. legend	5, 5, 5, 5	Independent neuronal cultures	Fig. legend	error bars are mean +/- SEM	Fig. legend	P=0.0182	Supl Fig. legend	F (3, 16) = 4.484
S6c	one-way ANOVA followed by a Bonferroni's Multiple Comparison Test	Fig. legend	5, 5, 5, 5	Independent neuronal cultures	Fig. legend	error bars are mean +/- SEM	Fig. legend	P=0.0097	Supl Fig. legend	F (3, 16) = 5.338
S6d	one-way ANOVA followed by a Bonferroni's Multiple Comparison Test	Fig. legend	13, 10, 13, 16	Independent neuronal cultures	Fig. legend	error bars are mean +/- SEM	Fig. legend	P=0.0131	Supl Fig. legend	F (3, 48) = 3.975
S6e	one-way ANOVA followed by a Bonferroni's Multiple Comparison Test	Fig. legend	13, 10, 13, 16	Independent neuronal cultures	Fig. legend	error bars are mean +/- SEM	Fig. legend	P=0.9699	Supl Fig. legend	F (3, 48) = 0.08127
S7b, left pannel	one-way ANOVA followed by a Bonferroni's Multiple Comparison Test	Fig. legend	8, 8, 8, 8	Rats from independent litters	Fig. legend	error bars are mean +/- SEM	Fig. legend	P=0.7148	Supl Fig. legend	F (3, 28) = 0.4565
S7b, right pannel	one-way ANOVAfollowed by a Bonferroni's Multiple Comparison Test	Fig. legend	8, 8, 8, 8	Rats from independent litters	Fig. legend	error bars are mean +/- SEM	Fig. legend	P=0.7194	Supl Fig. legend	F (3, 28) = 0.4498

S7c, left pannel	one-way ANOVA followed by a Bonferroni's Multiple Comparison Test	Fig. legend	8, 8, 8, 8	Rats from independent litters	Fig. legend	error bars are mean +/- SEM	Fig. legend	P=0.5405	Supl Fig. legend	F (3, 28) = 0.7340
S7c, right pannel	one-way ANOVA followed by a Bonferroni's Multiple Comparison Test	Fig. legend	8, 8, 8, 8	Rats from independent litters	Fig. legend	error bars are mean +/- SEM	Fig. legend	P=0.6960	Supl Fig. legend	F (3, 28) = 0.4842
S7d	one-way ANOVA followed by a Bonferroni's Multiple Comparison Test	Fig. legend	8, 7, 8, 8	Rats from independent litters	Fig. legend	error bars are mean +/- SEM	Fig. legend	P=1.17E-10	Supl Fig. legend	F (3, 27) = 45.17
S7e	one-way ANOVA followed by a Bonferroni's Multiple Comparison Test	Fig. legend	8, 7, 8, 8	Rats from independent litters	Fig. legend	error bars are mean +/- SEM	Fig. legend	P=0.8883	Supl Fig. legend	F (3, 27) = 0.2104
S8c	Paired t-test	Fig. legend	AbMon: 6 (w/o BDNF), 6 (w/ BDNF); AbFib: 5 (w/o BDNF), 5 (w/ BDNF);	Rats from independent litters	Fig. legend	error bars are mean +/- SEM	Fig. legend	P=0.0194; P=0.0135	Supl Fig. legend	t=3.392, df=5; t=4.216, df=4
S8f	Unpaired t-test	Fig. legend	AbMon: 5 (w/o BDNF), 5 (w/ BDNF); AbFib: 6 (w/o BDNF), 7 (w/ BDNF);	Rats from independent litters	Fig. legend	error bars are mean +/- SEM	Fig. legend	P=0.0477; P=0.0184	Supl Fig. legend	t=2.336, df=8; t=2.766, df=11
S9e	one-way ANOVA followed by a Bonferroni's Multiple Comparison Test	Fig. legend	Veh: 8 (w/o MDL), 7 (w/ MDL); AbMon: 7 (w/o MDL); AbOlig: 8 (w/o MDL), 7 (w/ MDL); AbFib: 8 (w/o MDL), 4 (w/ MDL)	Rats from independent litters	Fig. legend	error bars are mean +/- 95% CI	Fig. legend	P=8.24E-06	Supl Fig. legend	F (6, 42) = 8.044

Supl Table 1	one-way ANOVA	Table	11, 7, 8	Independent human patients	Table	data are mean +/- SD	Table	P=0.7417	Supl Table	F (2, 23) = 0.3027
Supl Table 1	one-way ANOVA	Table	11, 5, 16	Independent human patients	Table	data are mean +/- SD	Table	P=0.5496	Supl Table	F (2, 29) = 0.6610
Supl Table 1	one-way ANOVA	Table	27,11, 17	Independent human patients	Table	data are mean +/- SD	Table	P=0.5013	Supl Table	F (2, 52) = 0.6997

Claims

1. A pharmaceutical composition comprising a portion of the tropomyosin-receptor kinase B-full-length (TrkB-FL) protein, wherein the portion spans the calpain cleavage site of TrkB-FL.

2. The pharmaceutical composition according to claim 1, wherein the amino acid sequence of the TrkB-FL protein from which the portion is derived is according to SEQ ID NO: 1.

3. The pharmaceutical composition according to claim 1 or claim 2, wherein the portion of TrkB-FL comprises 1 to 10 of the residues on the N-terminal side of the TrkB-FL calpain cleavage site.

4. The pharmaceutical composition according to claim 1 or claim 2, wherein the portion of TrkB-FL comprises an amino acid sequence according to SEQ ID NO: 5.

5. The pharmaceutical composition according to any one of claims 1 to 4, wherein the portion of TrkB-FL comprises 1 to 10 of the residues on the C-terminal side of the TrkB-FL calpain cleavage site.

6. The pharmaceutical composition according to any one of claims 1 to 4, wherein the portion of TrkB-FL comprises an amino acid sequence according to SEQ ID NO: 12.

7. The pharmaceutical composition according to any one of claims 1 to 6, wherein the portion of TrkB-FL is 5 to 20 or 8 to 12 residues in length.

8. The pharmaceutical composition according to any one of claims 1 to 6, wherein the portion of TrkB-FL is 10 residues in length.

9. The pharmaceutical composition according to claim 1, wherein the amino acid sequence of the portion of TrkB-FL is according to any one of SEQ ID NO: 18, SEQ ID NO: 19, or SEQ ID NO: 20.

10. The pharmaceutical composition according to claim 1, wherein the amino acid sequence of the portion of TrkB-FL is according to any one of SEQ ID NO: 18, SEQ ID NO: 19, or SEQ ID NO: 20, and comprises one or more substitutions, conservative substitutions, modifications, or replacements within said sequence.

11. The pharmaceutical composition according to any preceding claim, wherein the pharmaceutical composition is able to prevent calpain cleavage of TrkB-FL to produce tropomyosin-receptor kinase B-full-length intracellular domain (TrkB-ICD).

12. The pharmaceutical composition according to any preceding claim, wherein the pharmaceutical composition is suitable for delivery of the portion of TrkB-FL across the blood brain barrier and into neuronal cells.

13. The pharmaceutical composition according to any preceding claim, wherein the pharmaceutical composition comprises a cell-penetrating peptide.

14. The pharmaceutical composition according to claim 13, wherein the cell-penetrating peptide is trans-activating transcriptional activator (TAT).

15. The pharmaceutical composition according to claim 14, wherein the amino acid sequence of the cell-penetrating peptide is according to SEQ ID NO: 21.

16. The pharmaceutical composition according to any preceding claim, comprising at least one of a pharmaceutically acceptable carrier, a pharmaceutically acceptable excipient, a pharmaceutically acceptable stabilizer, or a pharmaceutically acceptable preservative, or any combination thereof.

17. A polypeptide comprising an isolated portion of TrkB-FL, wherein the isolated portion of TrkB-FL spans the calpain cleavage site of TrkB-FL.

18. The polypeptide according to claim 17, wherein the amino acid sequence of the TrkB-FL protein from which the isolated portion is derived is according to SEQ ID NO: 1.

19. The polypeptide according to claim 17 or claim 18, wherein the isolated portion of TrkB-FL comprises 1 to 10 of the residues on the N-terminal side of the TrkB-FL calpain cleavage site.

20. The polypeptide according to claim 17 or claim 18, wherein the isolated portion of TrkB-FL comprises an amino acid sequence according to SEQ ID NO: 5.

21. The polypeptide according to any one of claims 17 to 20, wherein the isolated portion of TrkB-FL comprises 1 to 10 of the residues on the C-terminal side of the TrkB-FL calpain cleavage site.

22. The polypeptide according to any one of claims 17 to 20, wherein the isolated portion of TrkB-FL comprises an amino acid sequence according to SEQ ID NO: 12.

23. The polypeptide according to any one of claims 17 to 22, wherein the isolated portion of TrkB-FL is 5 to 20 or 8 to 12 residues in length.

24. The polypeptide according to any one of claims 17 to 22, wherein the isolated portion of TrkB-FL is 10 residues in length.

25. The polypeptide according to claim 17, wherein the amino acid sequence of the isolated portion of TrkB-FL is according to any one of SEQ ID NO: 18, SEQ ID NO: 19, or SEQ ID NO: 20.

26. The polypeptide according to claim 17, wherein the amino acid sequence of the isolated portion of TrkB-FL is according to any one of SEQ ID NO: 18, SEQ ID NO: 19, or SEQ ID NO: 20, and comprises one or more substitutions, conservative substitutions, modifications, or replacements within said sequence.

27. The polypeptide according to any one of claims 17 to 26, wherein the polypeptide is able to prevent calpain cleavage of TrkB-FL to produce TrkB-ICD.

28. The polypeptide according to any one of claims 17 to 27, wherein the polypeptide is suitable for delivery of the isolated portion of TrkB-FL across the blood brain barrier and into neuronal cells.

29. The polypeptide according to any one of claims 17 to 28, wherein the polypeptide comprises a cell-penetrating peptide.

30. The polypeptide according to claim 29, wherein the cell-penetrating peptide is TAT.

31. The polypeptide according to claim 30, wherein the amino acid sequence of the cell-penetrating peptide is according to SEQ ID NO: 21.

32. The polypeptide according to any one of claims 17 to 31, wherein the polypeptide comprises a linker.

33. The polypeptide according to claim 32, wherein the linker comprises the amino acid residues KK.

34. The polypeptide according to claim 17, wherein the polypeptide comprises an amino acid sequence according to any one of SEQ ID NO: 18, SEQ ID NO: 19, or SEQ ID NO: 20, and further comprises an amino acid sequence according to SEQ ID NO: 21.

35. The polypeptide according to claim 17, wherein the polypeptide comprises an amino acid sequence according to SEQ ID NO: 18, a linker, and an amino acid sequence according to SEQ ID NO: 21.

36. The polypeptide according to claim 17, wherein the polypeptide comprises an amino acid sequence according to SEQ ID NO: 18, a linker which comprises the amino acid residues KK, and an amino acid sequence according to SEQ ID NO: 21.

37. The polypeptide according to claim 17, wherein polypeptide comprises an amino acid sequence according to SEQ ID NO: 22, SEQ ID NO: 23, SEQ ID NO: 24, SEQ ID NO: 26, SEQ ID NO: 27, or SEQ ID NO: 28.

38. The polypeptide according to any one of claims 34 to 37, wherein the polypeptide comprises one or more substitutions, conservative substitutions, modifications, or replacements within a recited amino acid sequence.

39. A nucleic acid encoding a portion of TrkB-FL according to any one of claims 1 to 10.

40. A nucleic acid encoding a polypeptide according to any one of claims 17 to 38.

41. A genetic construct or a vector comprising a nucleic acid according to claim 39 or claim 40.

42. A cell comprising a portion of TrkB-FL according to any one of claims 1 to 10, a polypeptide according to any one of claims 17 to 38, a nucleic acid according to claim 39 or claim 40, or a genetic construct or vector according to claim 41.

43. A pharmaceutical composition comprising a polypeptide, nucleic acid, genetic construct, vector, or cell according to any one of claims 17 to 42.

44. A pharmaceutical composition according to claim 43, comprising at least one of a pharmaceutically acceptable carrier, a pharmaceutically acceptable excipient, a pharmaceutically acceptable stabilizer, or a pharmaceutically acceptable preservative, or any combination thereof.

45. A pharmaceutical composition, polypeptide, nucleic acid, genetic construct, vector, or cell according to any one of claims 1 to 44, for use as a medicament.

46. A pharmaceutical composition, polypeptide, nucleic acid, genetic construct, vector, or cell according to any one of claims 1 to 44, for use in a method of treating Alzheimer's disease (AD), preventing AD, ameliorating AD, delaying the progression of AD, or reducing at least one symptom of AD.

47. A pharmaceutical composition, polypeptide, nucleic acid, genetic construct, vector, or cell according to any one of claims 1 to 44, for use in a method of treating, preventing, ameliorating, delaying the progression of, or reducing at least one symptom of a neuropathological condition.

48. A pharmaceutical composition, polypeptide, nucleic acid, genetic construct, vector, or cell according to any one of claims 1 to 44, for use in a method of treating, preventing, ameliorating, delaying the progression of, or reducing at least one symptom of a pathology characterized by excitotoxicity.

49. A pharmaceutical composition, polypeptide, nucleic acid, genetic construct, vector, or cell for use according to claim 48, wherein the pathology is selected from epilepsy, prion-like diseases, muscular dystrophies, Huntington's disease, Parkinson's disease, multiple sclerosis, ischemia, stroke, or brain trauma.

50. A pharmaceutical composition, polypeptide, nucleic acid, genetic construct, vector, or cell according to any one of claim 1 to 44, for use in a method of treating, preventing, ameliorating, delaying the progression of, or reducing at least one symptom of a pathology related to TrkB-FL cleavage.

51. A pharmaceutical composition, polypeptide, nucleic acid, genetic construct, vector, or cell for use according to claim 50, wherein the pathology is selected from depression, anxiety, bipolar disorders, schizophrenia, obesity, autism, rett syndrome, retinal ganglion cell loss, ageing, amyotrophic lateral sclerosis (Lou Gehrig's disease), the adverse neurologic complications of Down syndrome, diabetic peripheral neuropathy, or other types of peripheral neuropathy.

52. A method for treating a subject affected by AD, comprising the administration of a therapeutically effective amount of pharmaceutical composition, polypeptide, nucleic acid, genetic construct, vector, or cell according to any one of claims 1 to 44 to the subject in need of treatment.

53. A method for treating a subject affected by a neuropathological condition, a pathology characterized by excitotoxicity, epilepsy, prion-like diseases, muscular dystrophies, Huntington's disease, Parkinson's disease, multiple sclerosis, ischemia, stroke, brain trauma, a pathology related to TrkB-FL cleavage, depression, anxiety, bipolar disorders, schizophrenia, obesity, autism, rett syndrome, retinal ganglion cell loss, ageing, amyotrophic lateral sclerosis (Lou Gehrig's disease), the adverse neurologic complications of Down syndrome, diabetic peripheral neuropathy, or other types of peripheral neuropathy, comprising the administration of a therapeutically effective amount of pharmaceutical composition, polypeptide, nucleic acid, genetic construct, vector, or cell according to any one of claims 1 to 44 to the subject in need of treatment.

54. The pharmaceutical composition, polypeptide, nucleic acid, genetic construct, vector, or cell for use according to claim 46, or the method of claim 52, wherein the method for treating results in the reduction or reversing of cognitive defects associated with AD.

55. Use of TrkB-FL, TrkB-ICD, TrkB-T', the TrkB-T':TrkB-FL ratio, or the TrkB-ICD:TrkB-FL ratio as a biomarker for AD.

56. A method for diagnosing AD or for determining the stage of AD, comprising:
i) comparing the amount of TrkB-FL and/or TrkB-ICD measured in a sample obtained from a subject to a reference amount, and
ii)
a) determining that said subject has AD, or determining that said subject has a more advanced stage of AD than that represented by the reference amount, if said amount of TrkB-FL is lower than said reference amount and/or if said amount of TrkB-ICD is higher than said reference amount; or
b) determining that said subject has the same stage of AD or AD diagnosis as that represented by the reference amount if said amount of TrkB-FL and/or TrkB-ICD is the same or similar to said reference amount; or
c) determining that said subject does not have AD, or determining that said subject has a less advanced stage of AD than that represented by the reference amount, if said amount of TrkB-FL is higher than said reference amount and/or if said amount of TrkB-ICD is lower than said reference amount.

57. The method of claim 56, further comprising, prior to step i), measuring the amount of TrkB-FL and/or TrkB-ICD in a sample obtained from a subject.

58. A method for diagnosing AD or for determining the stage of AD, comprising:
i) comparing the amount of TrkB-T' measured in a sample obtained from a subject to a reference amount, and
ii)
a) determining that said subject has AD, or determining that said subject has a more advanced stage of AD than that represented by the reference amount, if said amount of TrkB-T' is higher than said reference amount; or
b) determining that said subject has the same stage of AD or AD diagnosis as that represented by the reference amount if said amount of TrkB-T' is the same or similar to said reference amount; or
c) determining that said subject does not have AD, or determining that said subject has a less advanced stage of AD than that represented by the reference amount, if said amount of TrkB-T' is lower than said reference amount.

59. The method of claim 58, further comprising, prior to step i), measuring the amount of TrkB-T' in a sample obtained from a subject.

60. The method of any one of claims 56 to 59, wherein the reference amount is representative of the amount of TrkB-T', TrkB-FL, and/or TrkB-ICD in a subject without AD, in a subject with mild AD, in a subject with moderate AD, in a subject with severe AD, determined from said subject before disease

onset, determined from said subject after diagnosis of mild AD, determined from said subject after diagnosis with moderate AD, determined from said subject after diagnosis with severe AD, or determined from said subject before treatment.

61. A method for diagnosing AD or for determining the stage of AD, comprising:
i) comparing the TrkB-ICD:TrkB-FL ratio measured in a sample obtained from a subject to a reference value, and
ii)
a) determining that said subject has AD or determining that said subject has a more advanced stage of AD than that represented by the reference value, if said TrkB-ICD:TrkB-FL ratio is higher than said reference value; or
b) determining that said subject has the same stage of AD or AD diagnosis as that represented by the reference value if said TrkB-ICD:TrkB-FL ratio is the same or similar to said reference value; or
c) determining that said subject does not have AD, or determining that the subject has a less advanced stage of AD than that represented by the reference value, if said TrkB-ICD:TrkB-FL ratio is lower than said reference value.

62. The method of claim 61, further comprising, prior to step i), measuring the amount of TrkB-FL and TrkB-ICD in a sample obtained from the subject, and calculating the TrkB-ICD:TrkB-FL ratio in said sample.

63. A method for diagnosing AD or for determining the stage of AD, comprising:
i) comparing the TrkB-T':TrkB-FL ratio measured in a sample obtained from a subject to a reference value, and
ii)
a) determining that said subject has AD or determining that said subject has a more advanced stage of AD than that represented by the reference value, if said TrkB-T':TrkB-FL ratio is higher than said reference value; or
b) determining that said subject has the same stage of AD or AD diagnosis as that represented by the reference value if said TrkB-T':TrkB-FL ratio is the same or similar to said reference value; or
c) determining that said subject does not have AD, or determining that the subject has a less advanced stage of AD than that represented by the reference value, if said TrkB-T':TrkB-FL ratio is lower than said reference value.

64. The method of claim 63, further comprising, prior to step i), measuring the amount of TrkB-FL and TrkB-T' in a sample obtained from the subject, and calculating the TrkB-T':TrkB-FL ratio in said sample.

65. The method of any one of claims 61 to 64, wherein the reference value is representative of the TrkB-ICD:TrkB-FL ratio or the TrkB-T':TrkB-FL ratio in a subject without AD, in a subject with mild AD, in a subject with moderate AD, in a subject with severe AD, determined from said subject before disease onset, determined from said subject after diagnosis of mild AD, determined from said subject after diagnosis with moderate AD, determined from said subject after diagnosis with severe AD, or determined from said subject before treatment.

66. The method of any one of claims 61 to 65, wherein said subject is diagnosed with AD if the subject's measured TrkB-ICD:TrkB-FL ratio or TrkB-T':TrkB-FL ratio is increased by at least 5%, at least 10%, at least 20%, at least 30%, at least 40%, at least 50%, at least 60%, at least 70%, at least 80%, at least 90%, at least 100%, at least 150%, at least 200%, or at least 300% in comparison to a reference value representative of a subject without AD.

67. A method for the treatment of AD, wherein the method comprises:
i) the method for determining the stage of AD according to any one of claims 56 to 66;
ii) identifying a subject as having mild, moderate, or severe AD; and
iii) administering a treatment to said subject.

68. The method of claim 67, wherein the treatment comprises the administration of a pharmaceutical composition, polypeptide, nucleic acid, genetic construct, vector, or cell according to any one of claims 1 to 44.

69. The method of claim 67 or 68, wherein the treatment comprises the administration of a cholinesterase inhibitor and/or an NMDA antagonist.

70. A method for diagnosing AD, comprising:
i) comparing the TrkB-ICD:TrkB-FL ratio or the TrkB-T':TrkB-FL ratio measured in a sample obtained from a first subject with mild cognitive impairment to a reference value obtained from at least one subject without AD, and
ii)
a) determining that the first subject has AD if said TrkB-ICD:TrkB-FL ratio or TrkB-T':TrkB-FL ratio is increased by at least 5%, at least 10%, at least 20%, at least 30%, at least 40%, at least 50%, at least 60%, at least 70%, at least 80%, at least 90%, at least 100%, at least 150%, at least 200%, or at least 300% in comparison to said reference value; or
b) determining that the first subject does not have AD if said TrkB-ICD:TrkB-FL ratio or TrkB-T':TrkB-FL ratio is not increased compared to said reference value.

71. The method of claim 70, further comprising prior to step i):
measuring the amount of TrkB-FL and TrkB-ICD in a sample obtained from the first subject with mild cognitive impairment, and calculating the TrkB-ICD:TrkB-FL ratio; and/or ,
measuring the amount of TrkB-FL and TrkB-T' in a sample obtained from the first subject with mild cognitive impairment, and calculating the TrkB-T':TrkB-FL ratio.

72. A method for monitoring the efficacy of an AD treatment with an agent, comprising:
i) calculating an expected amount of TrkB-T', TrkB-FL, and/or TrkB-ICD based upon an amount of TrkB-T', TrkB-FL, and/or TrkB-ICD measured in a first sample obtained from a subject with AD and the time elapsed since the first sample was obtained; and
ii) comparing: an amount of TrkB-T', TrkB-FL, and/or TrkB-ICD measured in a second sample obtained from the subject after administration of an agent to the subject, to said expected amount of TrkB-T', TrkB-FL, and/or TrkB-ICD; and
iii)
a) determining that the treatment is efficacious if the amount of TrkB-FL in the second sample is higher than the expected amount of TrkB-FL, if the amount of TrkB-ICB in the second sample is lower than the expected amount of TrkB-ICB, and/or if the amount of TrkB-T' in the second sample is lower than the expected amount of TrkB-T'; or
b) determining that the treatment is not efficacious if the amount of TrkB-FL in the second sample is lower than or the same as the expected amount of TrkB-FL, if the amount of TrkB-ICB in the second sample is higher than or the same as the expected amount of TrkB-ICB, and/or if the amount of TrkB-T' in the second sample is higher than or the same as the expected amount of TrkB-T'.

73. The method of claim 72, further comprising, prior to step i), measuring the amount of TrkB-T', TrkB-FL, and/or TrkB-ICD in a first sample obtained from a subject, and prior to step ii), measuring the amount of TrkB-T', TrkB-FL, and TrkB-ICD in a second sample obtained from said subject after administration of an agent to the subject.

74. A method for monitoring the efficacy of an AD treatment with an agent, comprising:
i) calculating an expected TrkB-ICD:TrkB-FL ratio or TrkB-T':TrkB-FL ratio based upon a TrkB-ICD:TrkB-FL ratio or TrkB-T':TrkB-FL ratio measured in a first sample obtained from a subject with AD and the time elapsed since the first sample was obtained; and
ii) comparing: a TrkB-ICD:TrkB-FL ratio or TrkB-T':TrkB-FL ratio measured in a second sample obtained from the subject after administration of an agent to the subject, to said expected TrkB-ICD:TrkB-FL ratio or TrkB-T':TrkB-FL ratio; and
iii)
a) determining that the treatment is efficacious if the TrkB-ICD:TrkB-FL ratio in the second sample is lower than the expected TrkB-ICD:TrkB-FL ratio, or determining that the treatment is efficacious if the TrkB-T':TrkB-FL ratio in the second sample is lower than the expected TrkB-T':TrkB-FL ratio; or

b) determining that the treatment is not efficacious if the TrkB-ICD:TrkB-FL ratio in the second sample is higher than or the same as the expected TrkB-ICD:TrkB-FL ratio, or determining that the treatment is not efficacious if the TrkB-T':TrkB-FL ratio in the second sample is higher than or the same as the expected TrkB-T':TrkB-FL ratio.

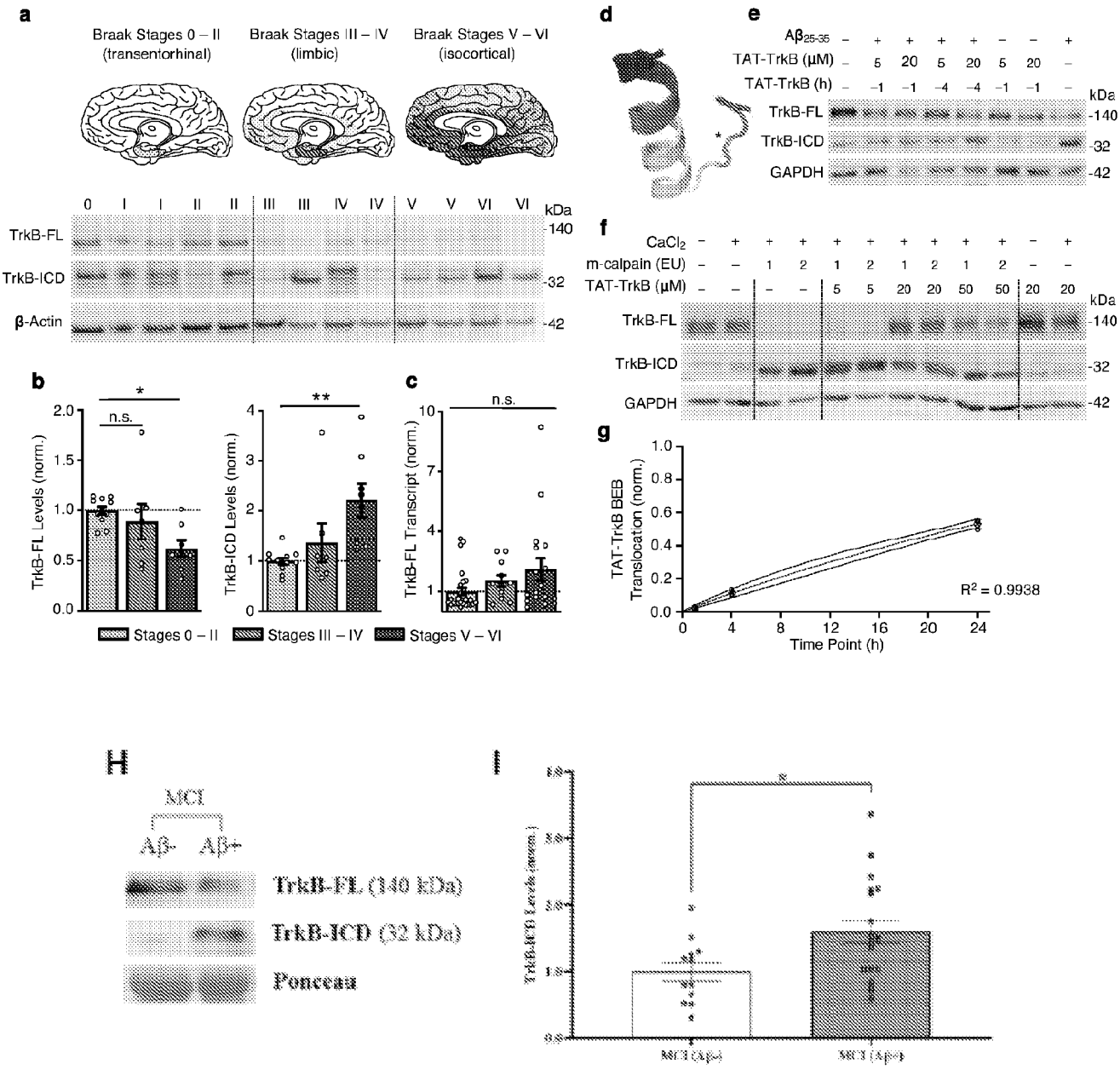
75. The method of claim 74, further comprising prior to step i):
measuring the amount of TrkB-FL and TrkB-ICD in the first sample obtained from the subject, and calculating the TrkB-ICD:TrkB-FL ratio in the first sample and, prior to step ii), measuring the amount of TrkB-FL and TrkB-ICD in the second sample obtained from the subject after administration of an agent to the subject, and calculating the TrkB-ICD:TrkB-FL ratio in the second sample; or
measuring the amount of TrkB-FL and TrkB-T' in the first sample obtained from the subject, and calculating the TrkB-T':TrkB-FL ratio in the first sample and, prior to step ii), measuring the amount of TrkB-FL and TrkB-T' in the second sample obtained from the subject after administration of an agent to the subject, and calculating the TrkB-T':TrkB-FL ratio in the second sample.

76. A method for monitoring the efficacy of an AD treatment with an agent, comprising:
i) measuring the amount of TrkB-FL and TrkB-ICD in a first sample obtained from a subject with AD, and
ii) calculating the TrkB-ICD:TrkB-FL ratio in said first sample, and
iii) administering an agent to said subject, and
iv) measuring the amount of TrkB-FL and TrkB-ICD in a second sample obtained from said subject, and
v) calculating the TrkB-ICD:TrkB-FL ratio in said second sample, and
vi)
a) determining that the treatment is efficacious if the TrkB-ICD:TrkB-FL ratio in the second sample is lower than the TrkB-ICD:TrkB-FL ratio in the first sample; or
b) determining that the treatment is not efficacious if the TrkB-ICD:TrkB-FL ratio in the second sample is higher than the TrkB-ICD:TrkB-FL ratio in the first sample.

77. A method for monitoring the efficacy of an AD treatment with an agent, comprising:
i) measuring the amount of TrkB-FL and TrkB-T' in a first sample obtained from a subject with AD, and
ii) calculating the TrkB-T':TrkB-FL ratio in said first sample, and
iii) administering an agent to said subject, and
iv) measuring the amount of TrkB-FL and TrkB-T' in a second sample obtained from said subject, and
v) calculating the TrkB-T':TrkB-FL ratio in said second sample, and
vi)
a) determining that the treatment is efficacious if the TrkB-T':TrkB-FL ratio in the second sample is lower than the TrkB-T':TrkB-FL ratio in the first sample; or
b) determining that the treatment is not efficacious if the TrkB-T':TrkB-FL ratio in the second sample is higher than the TrkB-T':TrkB-FL ratio in the first sample.

78. The method of any one of claims 56 to 77, wherein said sample is cerebrospinal fluid (CSF), blood, plasma, erum, or saliva.

Figure 1


a
Braak Stages 0 – II (transentorhinal)
Braak Stages III – IV (limbic)
Braak Stages V – VI (isocortical)
0 I I II II III III IV IV V V VI VI kDa
TrkB-FL
TrkB-ICD
β-Actin
140
32
42
b
TrkB-FL Levels (norm.)
TrkB-ICD Levels (norm.)
n.s.
*
**
Stages 0 – II
Stages III – IV
Stages V – VI
c
TrkB-FL Transcript (norm.)
n.s.
d
e
Aβ25-35
TAT-TrkB (μM)
TAT-TrkB (h)
TrkB-FL
TrkB-ICD
GAPDH
f
CaCl2
m-calpain (EU)
TAT-TrkB (μM)
g
TAT-TrkB BEB Translocation (norm.)
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MCI
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TrkB-ICD (32 kDa)
Ponceau
I

Figure 2

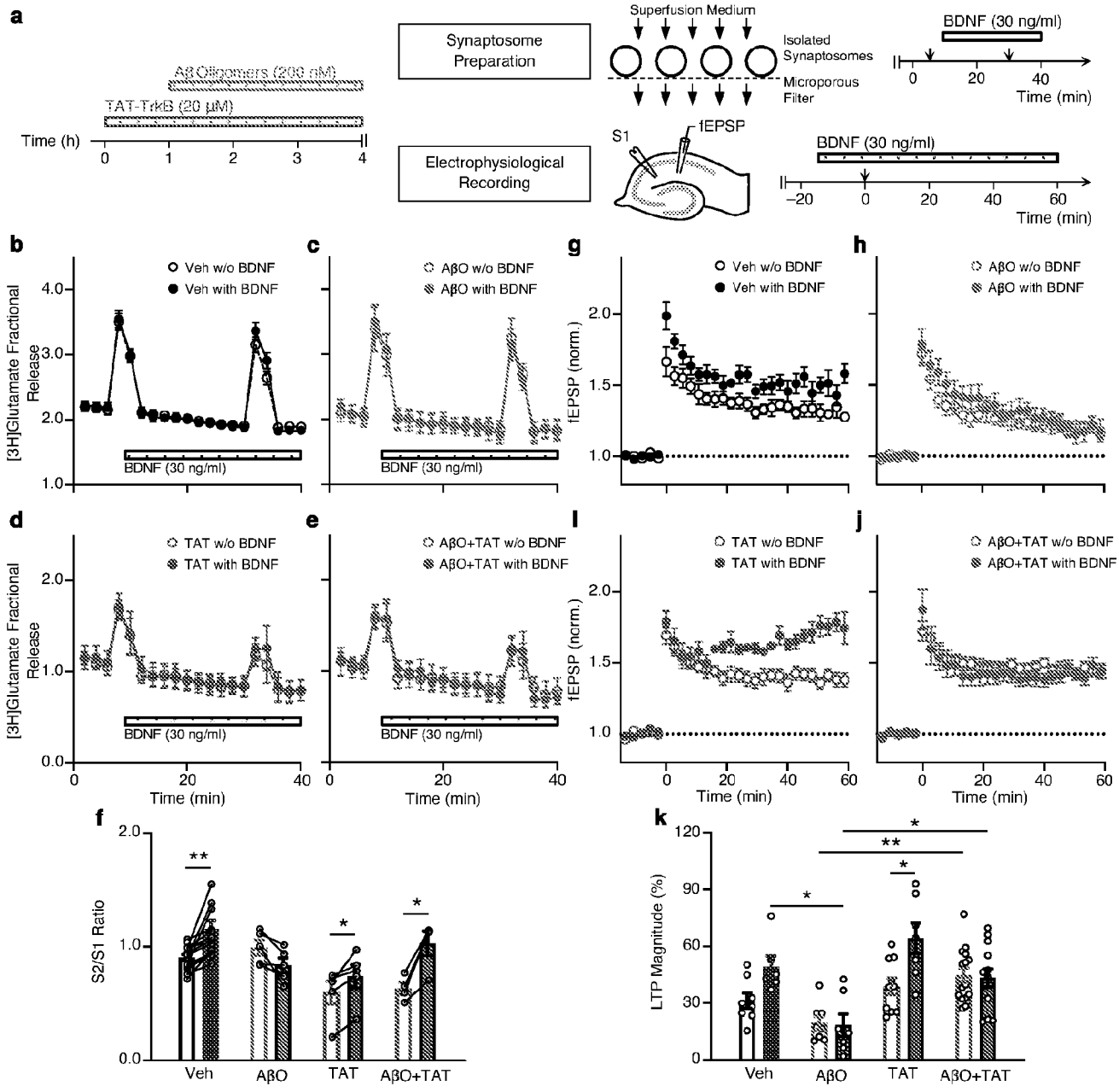

a
Aβ Oligomers (200 nM)
TAT-TrkB (20 μM)
Time (h)
0 1 2 3 4
Synaptosome Preparation
Electrophysiological Recording
Superfusion Medium
Isolated Synaptosomes
Microporous Filter
S1
fEPSP
BDNF (30 ng/ml)
0 20 40
Time (min)
BDNF (30 ng/ml)
−20 0 20 40 60
Time (min)
b
Veh w/o BDNF
Veh with BDNF
[3H]Glutamate Fractional Release
BDNF (30 ng/ml)
c
AβO w/o BDNF
AβO with BDNF
BDNF (30 ng/ml)
g
Veh w/o BDNF
Veh with BDNF
fEPSP (norm.)
h
AβO w/o BDNF
AβO with BDNF
d
TAT w/o BDNF
TAT with BDNF
[3H]Glutamate Fractional Release
BDNF (30 ng/ml)
Time (min)
e
AβO+TAT w/o BDNF
AβO+TAT with BDNF
BDNF (30 ng/ml)
Time (min)
i
TAT w/o BDNF
TAT with BDNF
fEPSP (norm.)
Time (min)
j
AβO+TAT w/o BDNF
AβO+TAT with BDNF
Time (min)
f
S2/S1 Ratio
Veh AβO TAT AβO+TAT
k
LTP Magnitude (%)
Veh AβO TAT AβO+TAT

Figure 3

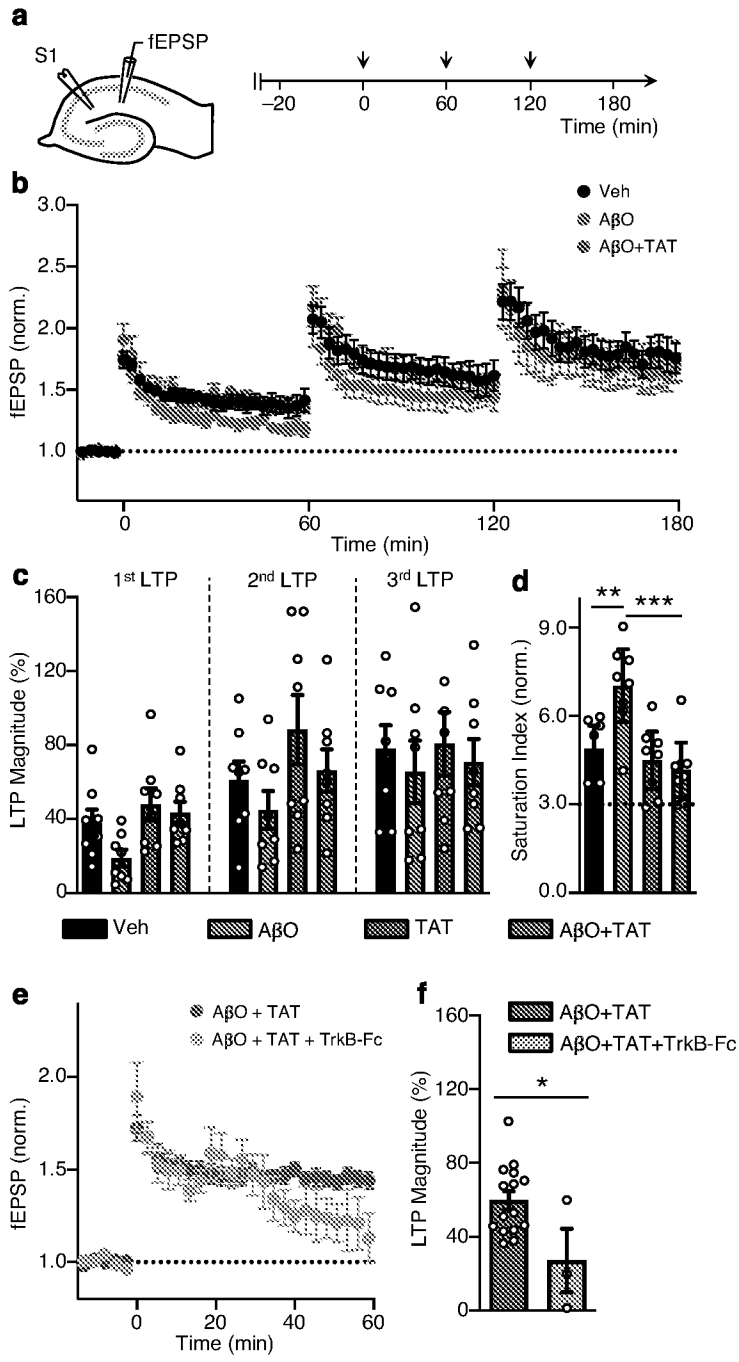

a
S1
fEPSP
–20
0
60
120
180
Time (min)
b
Veh
AβO
AβO+TAT
fEPSP (norm.)
3.0
2.5
2.0
1.5
1.0
0
60
120
180
Time (min)
c
1st LTP
2nd LTP
3rd LTP
LTP Magnitude (%)
160
120
80
40
0
Veh
AβO
TAT
AβO+TAT
d
**
***
Saturation Index (norm.)
9.0
6.0
3.0
0.0
e
AβO + TAT
AβO + TAT + TrkB-Fc
fEPSP (norm.)
2.0
1.5
1.0
0
20
40
60
Time (min)
f
AβO+TAT
AβO+TAT+TrkB-Fc
*
LTP Magnitude (%)
160
120
80
40
0

Figure 4

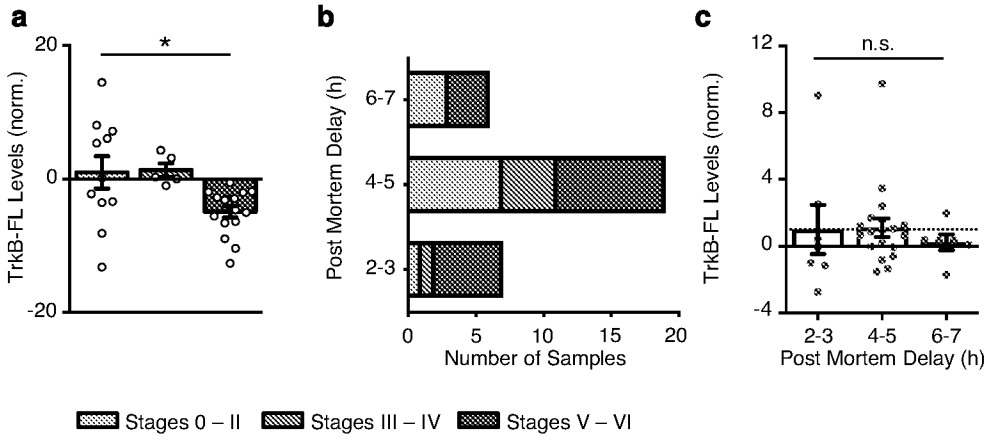

a
b
c
20
0
-20
*
TrkB-FL Levels (norm.)
6-7
4-5
2-3
Post Mortem Delay (h)
0
5
10
15
20
Number of Samples
12
8
4
0
-4
n.s.
TrkB-FL Levels (norm.)
2-3
4-5
6-7
Post Mortem Delay (h)
Stages 0 – II
Stages III – IV
Stages V – VI

Figure 5

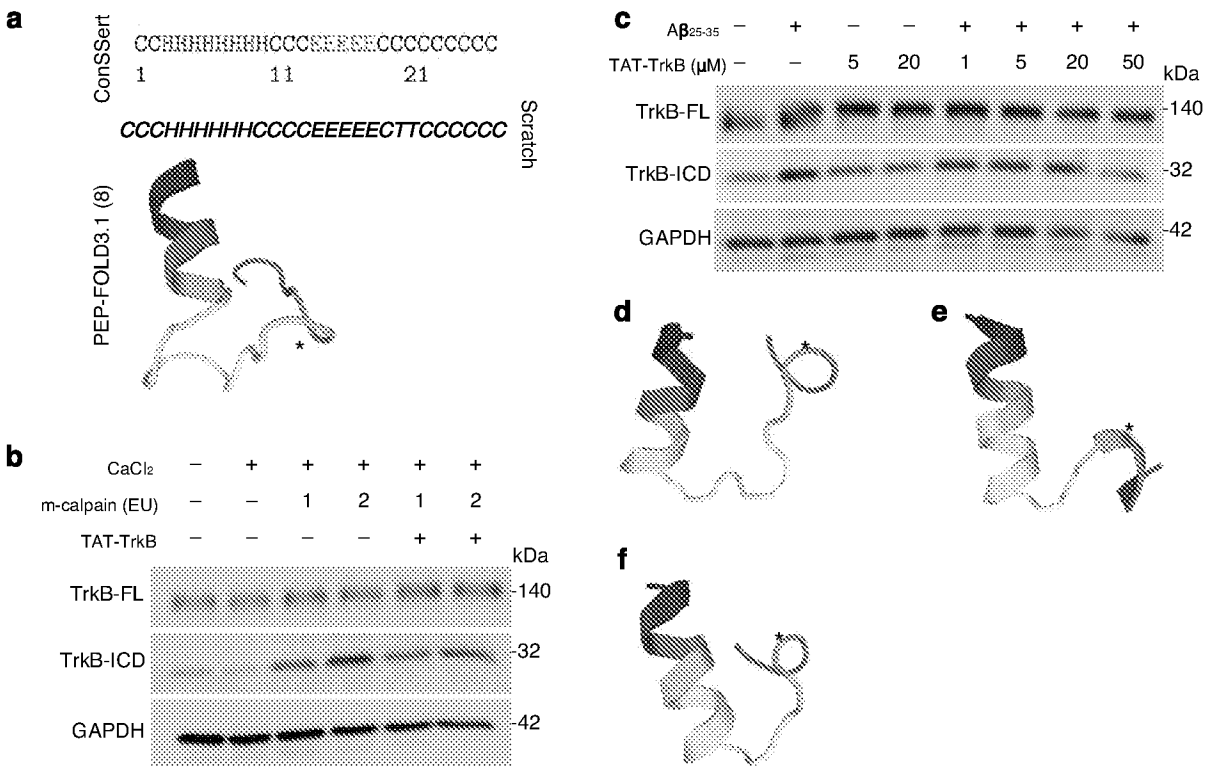

a
ConSSert
CCHHHHHHHHCCCCEEEEECCCCCCCCC
1
11
21
CCCHHHHHHCCCCEEEEECTTCCCCCC
Scratch
PEP-FOLD3.1 (8)
b
CaCl2 – + + + + +
m-calpain (EU) – – 1 2 1 2
TAT-TrkB – – – – + +
kDa
TrkB-FL
140
TrkB-ICD
32
GAPDH
42
c
Aβ25-35 – + – – + + + +
TAT-TrkB (μM) – – 5 20 1 5 20 50
kDa
TrkB-FL
140
TrkB-ICD
32
GAPDH
42
d
e
f

Figure 6

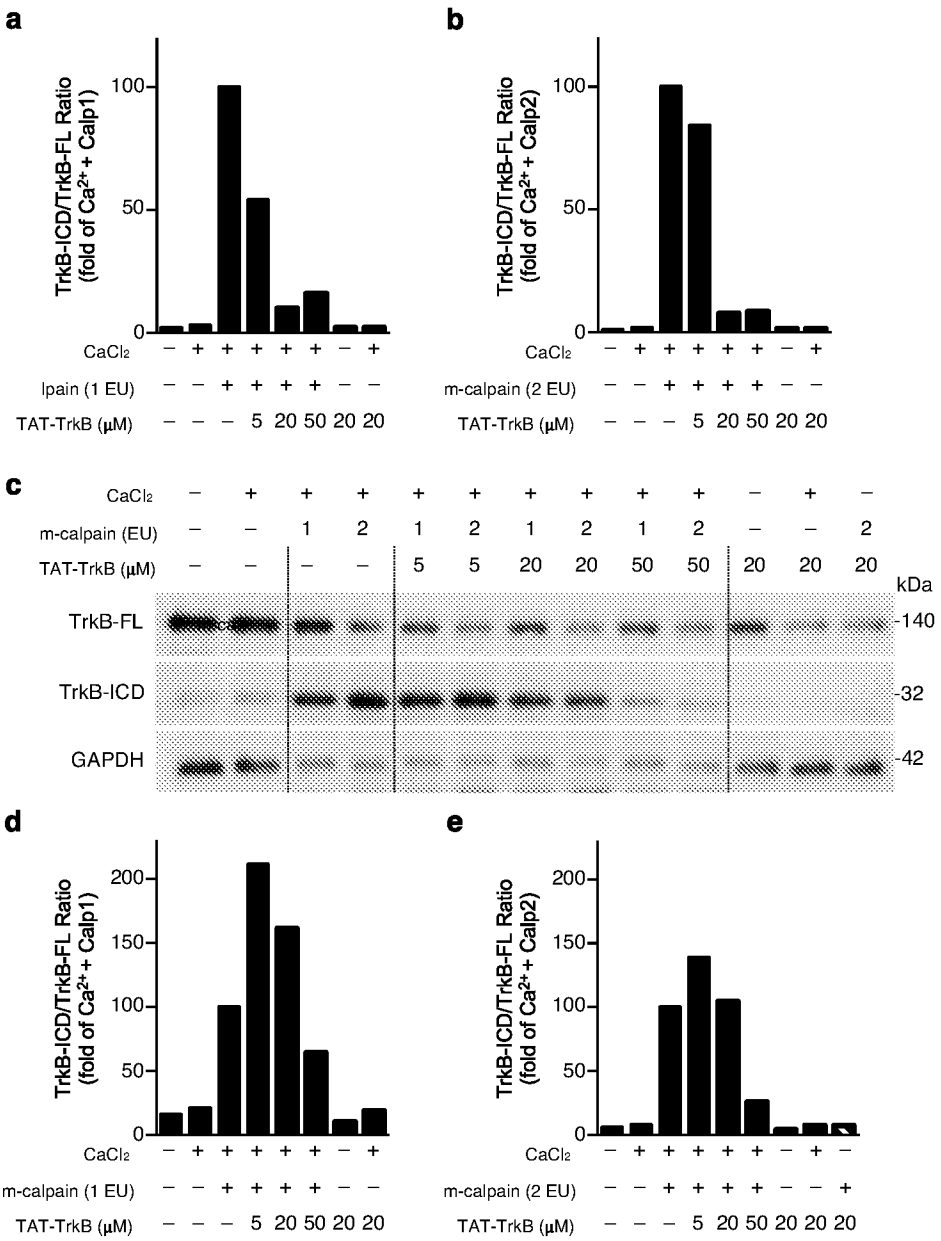

a
TrkB-ICD/TrkB-FL Ratio (fold of Ca2+ + Calp1)
100
50
0
CaCl2 – + + + + + – +
lpain (1 EU) – – + + + + – –
TAT-TrkB (μM) – – – 5 20 50 20 20
b
TrkB-ICD/TrkB-FL Ratio (fold of Ca2+ + Calp2)
100
50
0
CaCl2 – + + + + + – +
m-calpain (2 EU) – – + + + + – –
TAT-TrkB (μM) – – – 5 20 50 20 20
c
CaCl2 – + + + + + + + + + – + –
m-calpain (EU) – – 1 2 1 2 1 2 1 2 – – 2
TAT-TrkB (μM) – – – – 5 5 20 20 50 50 20 20 20
kDa
TrkB-FL
-140
TrkB-ICD
-32
GAPDH
-42
d
TrkB-ICD/TrkB-FL Ratio (fold of Ca2+ + Calp1)
200
150
100
50
0
CaCl2 – + + + + + – +
m-calpain (1 EU) – – + + + + – –
TAT-TrkB (μM) – – – 5 20 50 20 20
e
TrkB-ICD/TrkB-FL Ratio (fold of Ca2+ + Calp2)
200
150
100
50
0
CaCl2 – + + + + + – + –
m-calpain (2 EU) – – + + + + – – +
TAT-TrkB (μM) – – – 5 20 50 20 20 20

Figure 7

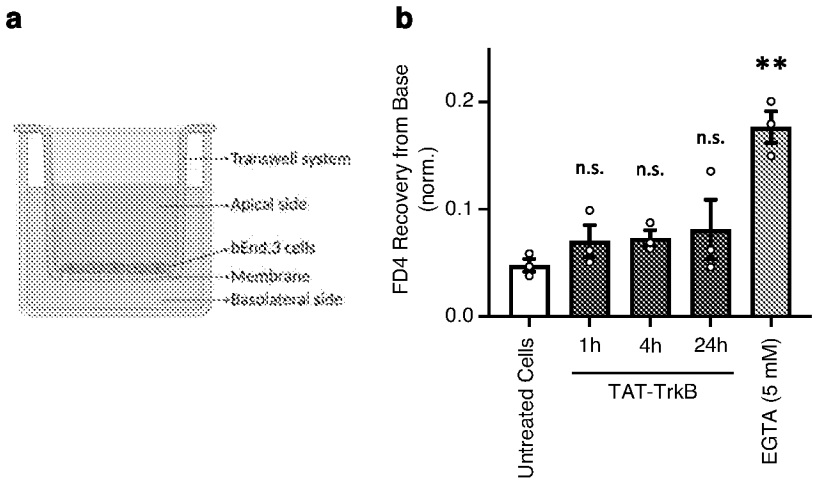

a
Transwell system
Apical side
bEnd.3 cells
Membrane
Basolateral side
b
FD4 Recovery from Base (norm.)
0.0
0.1
0.2
n.s.
n.s.
n.s.
**
Untreated Cells
1h
4h
24h
TAT-TrkB
EGTA (5 mM)

Figure 8

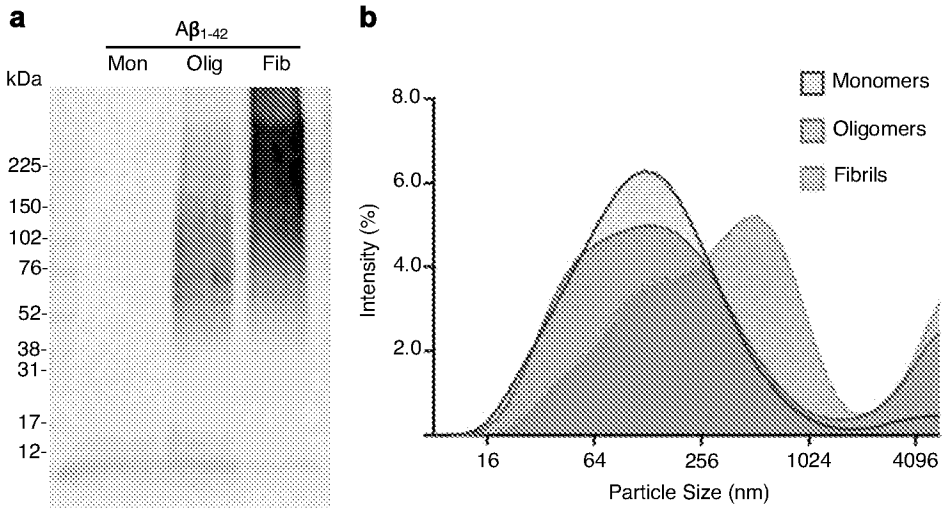

a
Aβ1-42
Mon
Olig
Fib
kDa
225-
150-
102-
76-
52-
38-
31-
17-
12-
b
Monomers
Oligomers
Fibrils
Intensity (%)
8.0
6.0
4.0
2.0
16
64
256
1024
4096
Particle Size (nm)

Figure 9

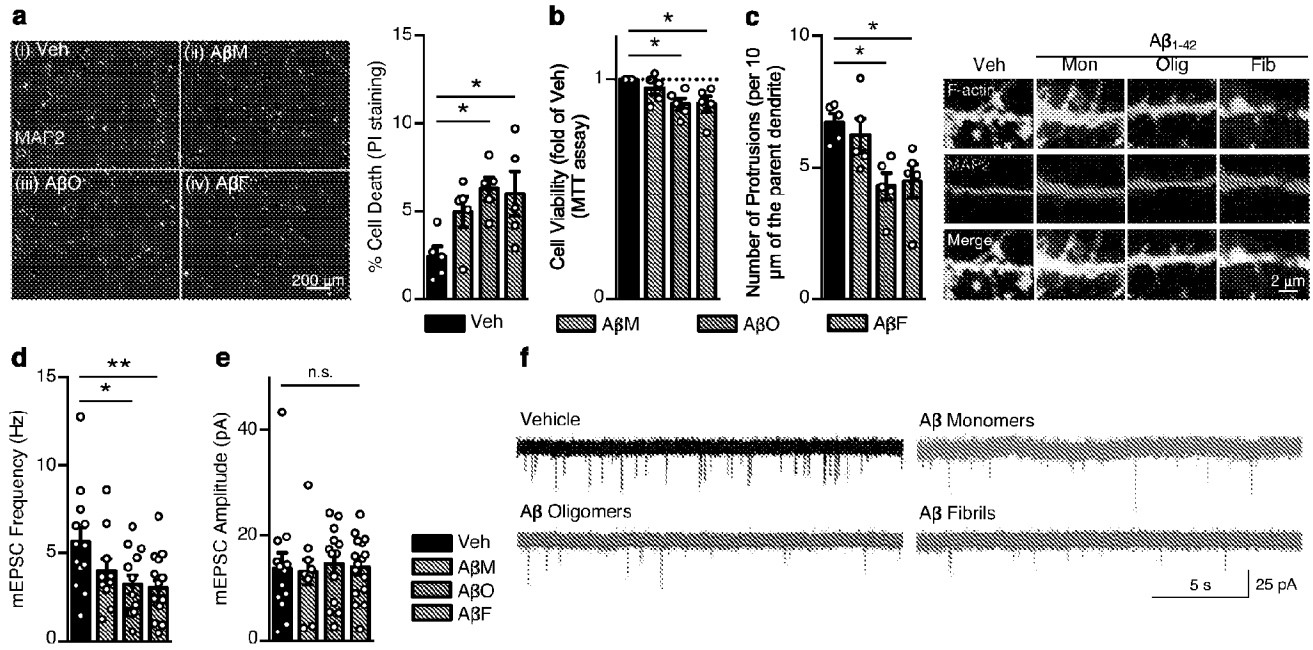

a
(i) Veh
(ii) AβM
MAP2
(iii) AβO
(iv) AβF
200 µm
% Cell Death (PI staining)
b
Cell Viability (fold of Veh) (MTT assay)
c
Number of Protrusions (per 10 µm of the parent dendrite)
Veh
AβM
AβO
AβF
Aβ1-42
Veh
Mon
Olig
Fib
F-actin
MAP2
Merge
2 µm
d
mEPSC Frequency (Hz)
e
mEPSC Amplitude (pA)
n.s.
f
Vehicle
Aβ Monomers
Aβ Oligomers
Aβ Fibrils
5 s
25 pA

Figure 10

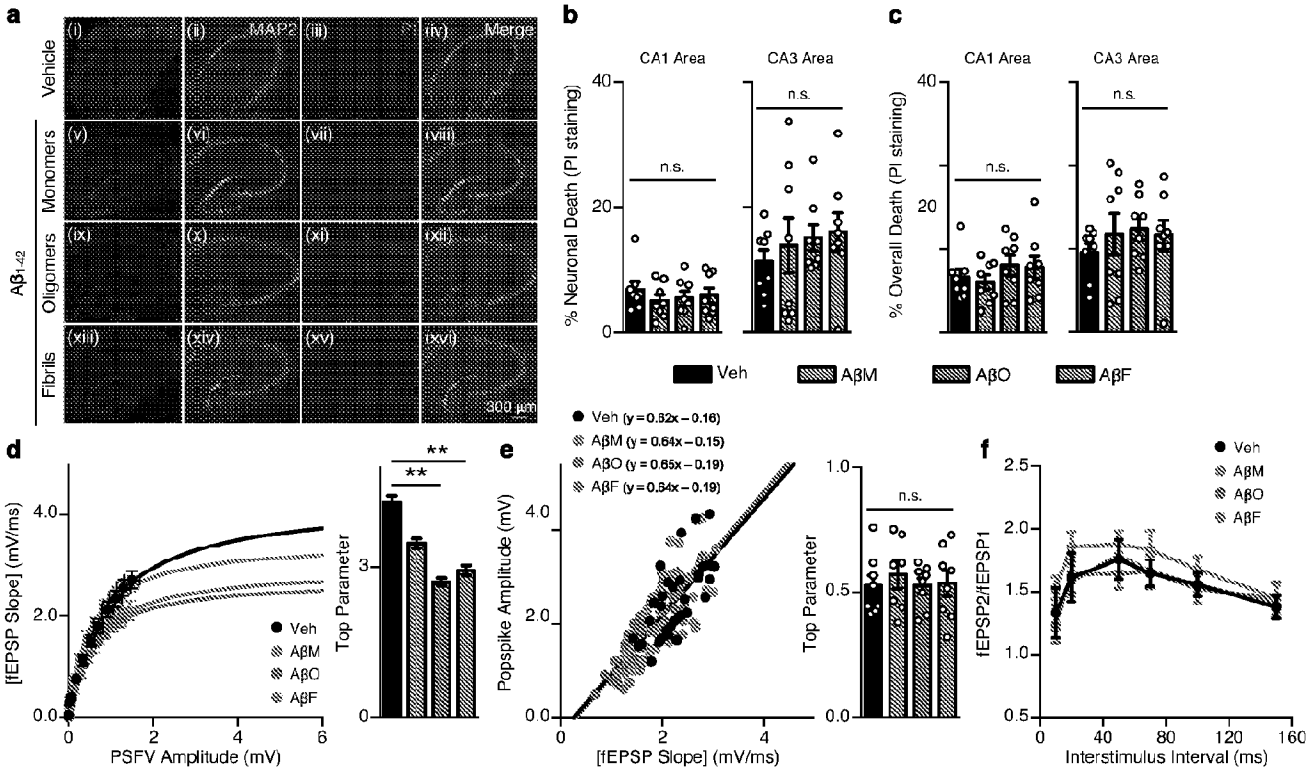

a
b
c
Vehicle
Monomers
Oligomers
Fibrils
Aβ1-42
(i)
(ii) MAP2
(iii)
(iv) Merge
(v)
(vi)
(vii)
(viii)
(ix)
(x)
(xi)
(xii)
(xiii)
(xiv)
(xv)
(xvi)
300 µm
CA1 Area
CA3 Area
% Neuronal Death (PI staining)
% Overall Death (PI staining)
n.s.
Veh
AβM
AβO
AβF
d
e
f
[fEPSP Slope] (mV/ms)
PSFV Amplitude (mV)
Top Parameter
**
Veh (y = 0.52x – 0.16)
AβM (y = 0.64x – 0.15)
AβO (y = 0.65x – 0.19)
AβF (y = 0.54x – 0.19)
Popspike Amplitude (mV)
[fEPSP Slope] (mV/ms)
fEPSP2/fEPSP1
Interstimulus Interval (ms)

Figure 11

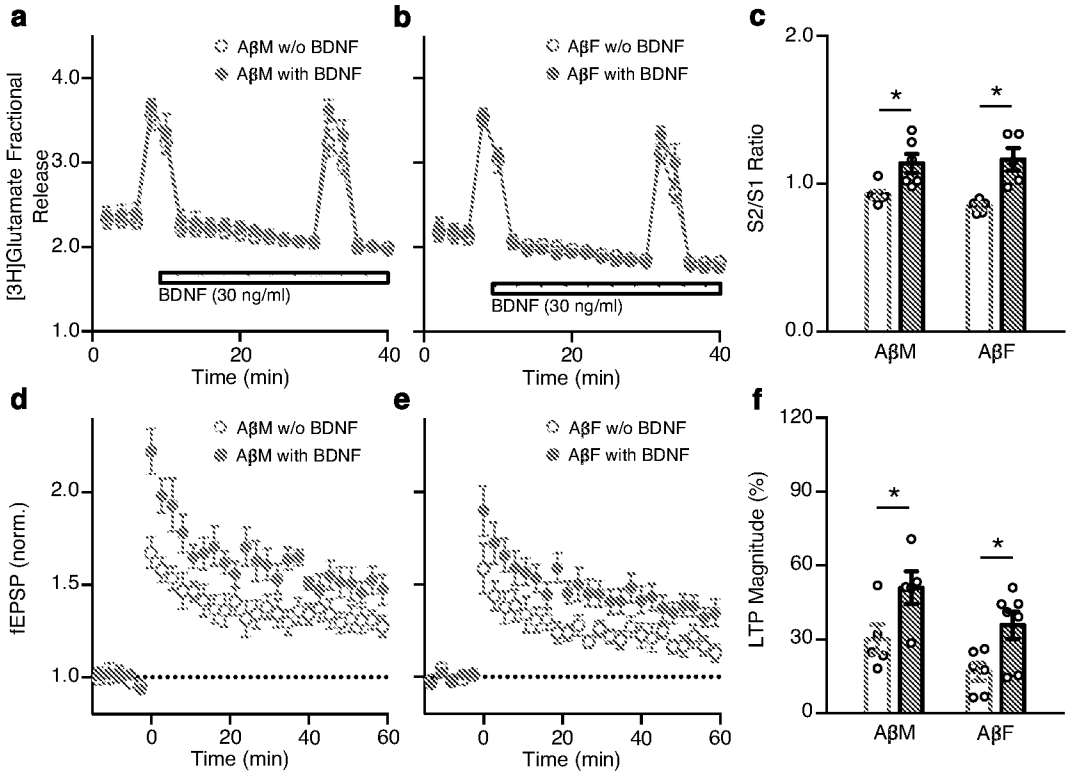

a
AβM w/o BDNF
AβM with BDNF
[3H]Glutamate Fractional Release
BDNF (30 ng/ml)
Time (min)
b
AβF w/o BDNF
AβF with BDNF
BDNF (30 ng/ml)
Time (min)
c
S2/S1 Ratio
AβM
AβF
d
AβM w/o BDNF
AβM with BDNF
fEPSP (norm.)
Time (min)
e
AβF w/o BDNF
AβF with BDNF
Time (min)
f
LTP Magnitude (%)
AβM
AβF

Figure 12

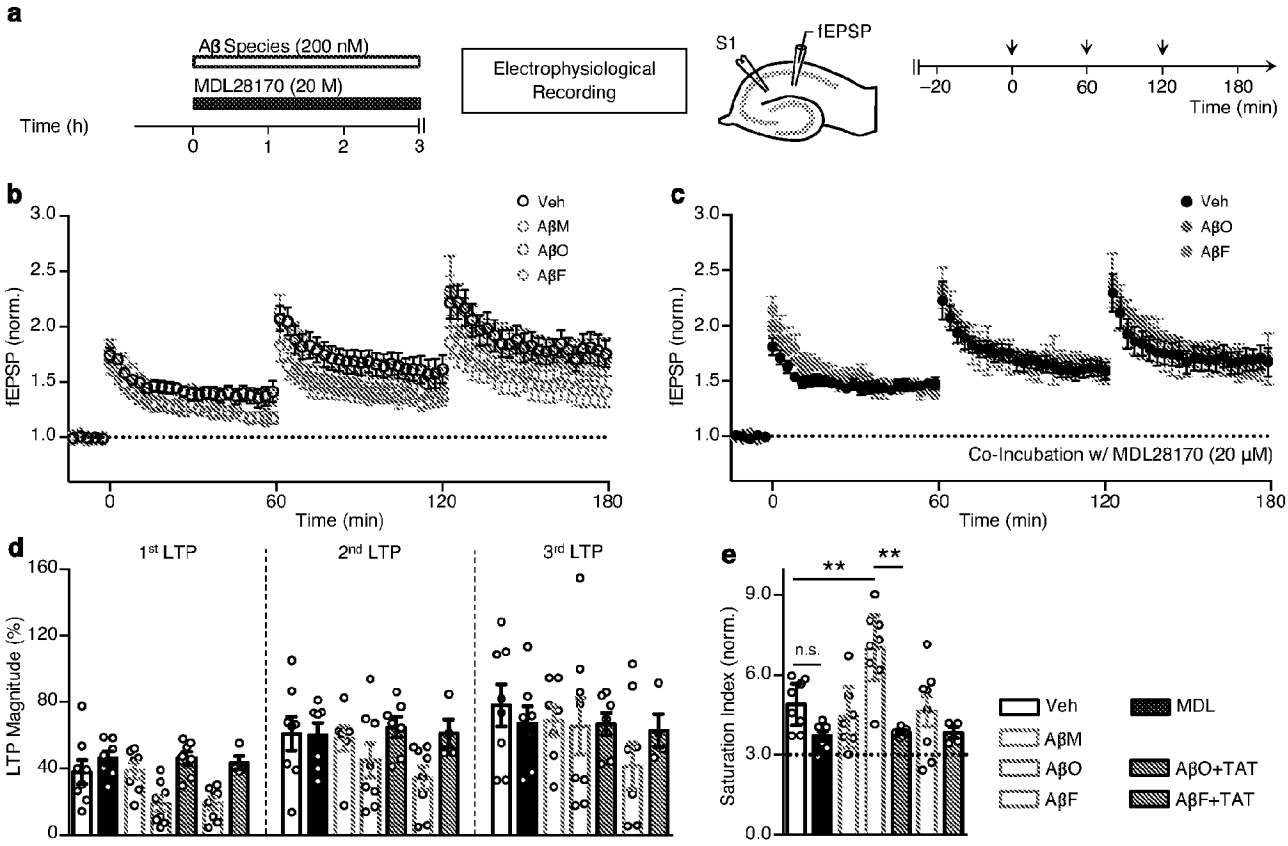

a
Aβ Species (200 nM)
MDL28170 (20 M)
Time (h)
0
1
2
3
Electrophysiological Recording
S1
fEPSP
–20
0
60
120
180
Time (min)
b
Veh
AβM
AβO
AβF
fEPSP (norm.)
Time (min)
c
Veh
AβO
AβF
fEPSP (norm.)
Co-Incubation w/ MDL28170 (20 μM)
Time (min)
d
1st LTP
2nd LTP
3rd LTP
LTP Magnitude (%)
e
Saturation Index (norm.)
n.s.
**
**
Veh
AβM
AβO
AβF
MDL
AβO+TAT
AβF+TAT

Figure 13

Figure 1a

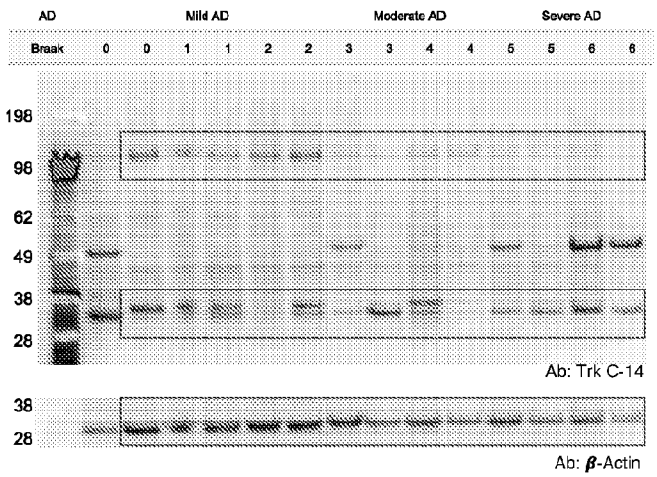


Figure 1a – 2nd WB

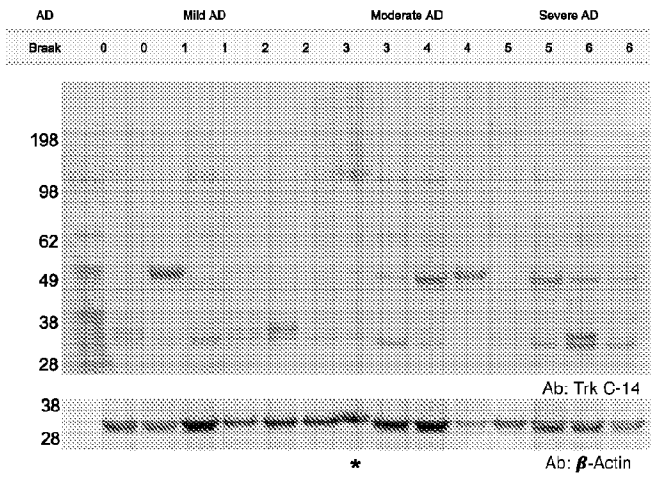


Figure 1e

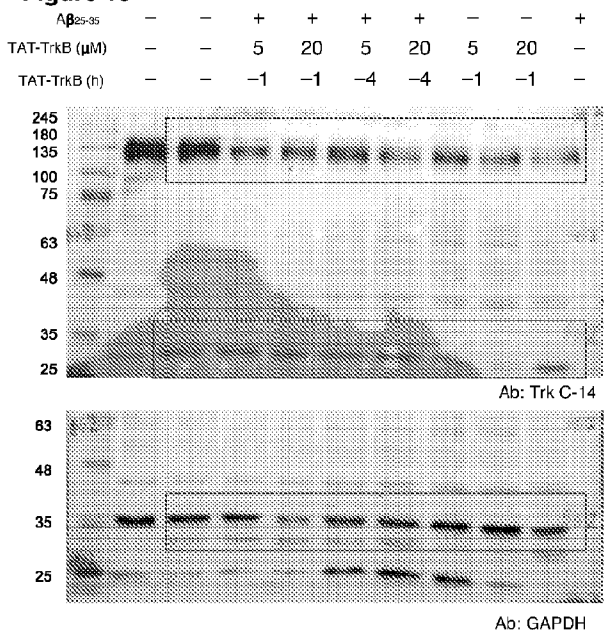


Figure 1f

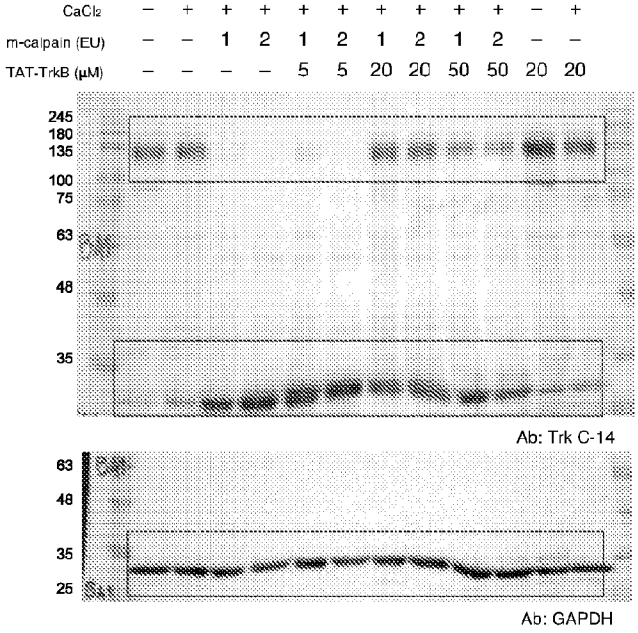


Figure S2b

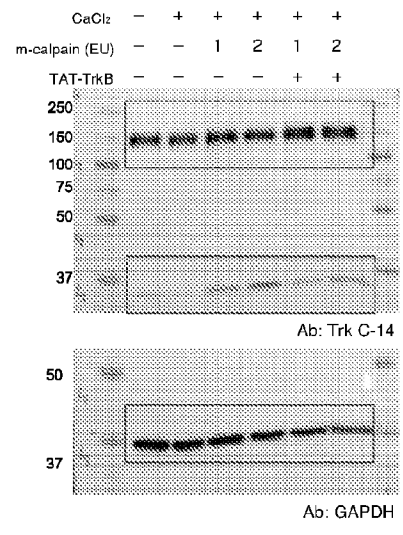


Figure S2c

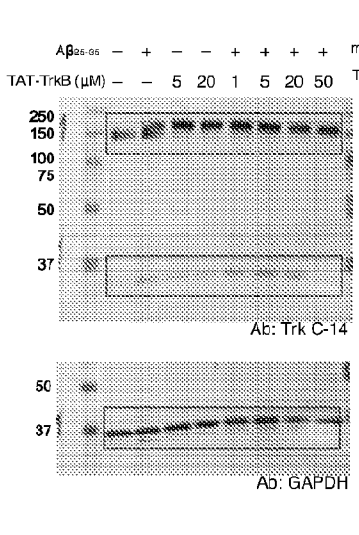


Figure S3c

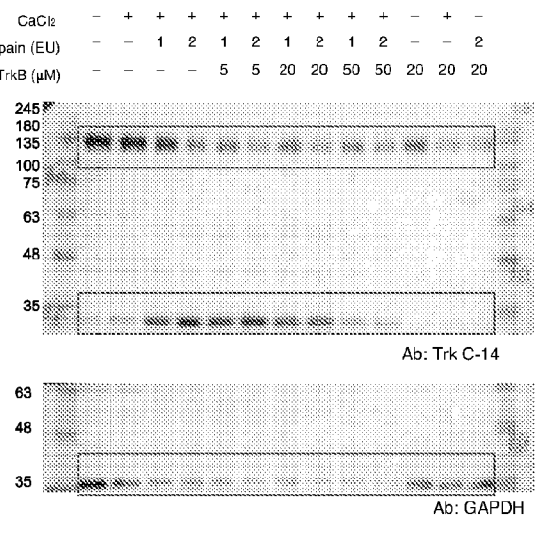


Figure 14

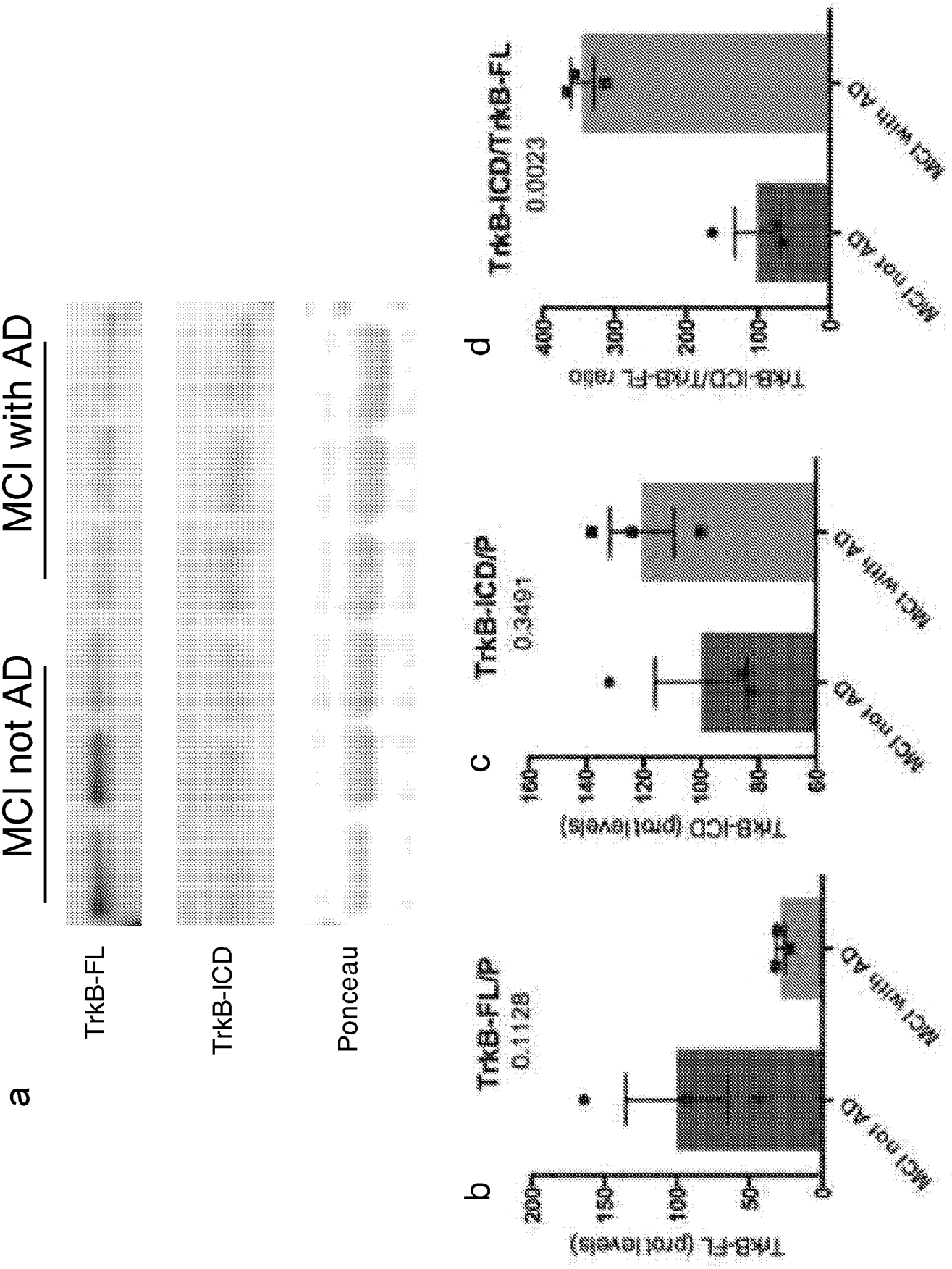

a
MCI not AD
MCI with AD
TrkB-FL
TrkB-ICD
Ponceau
b
TrkB-FL/P
0.1128
TrkB-FL (prot levels)
200
150
100
50
0
MCI not AD
MCI with AD
c
TrkB-ICD/P
0.3491
TrkB-ICD (prot levels)
160
140
120
100
80
60
MCI not AD
MCI with AD
d
TrkB-ICD/TrkB-FL
0.0023
TrkB-ICD/TrkB-FL ratio
400
300
200
100
0
MCI not AD
MCI with AD

Figure 15

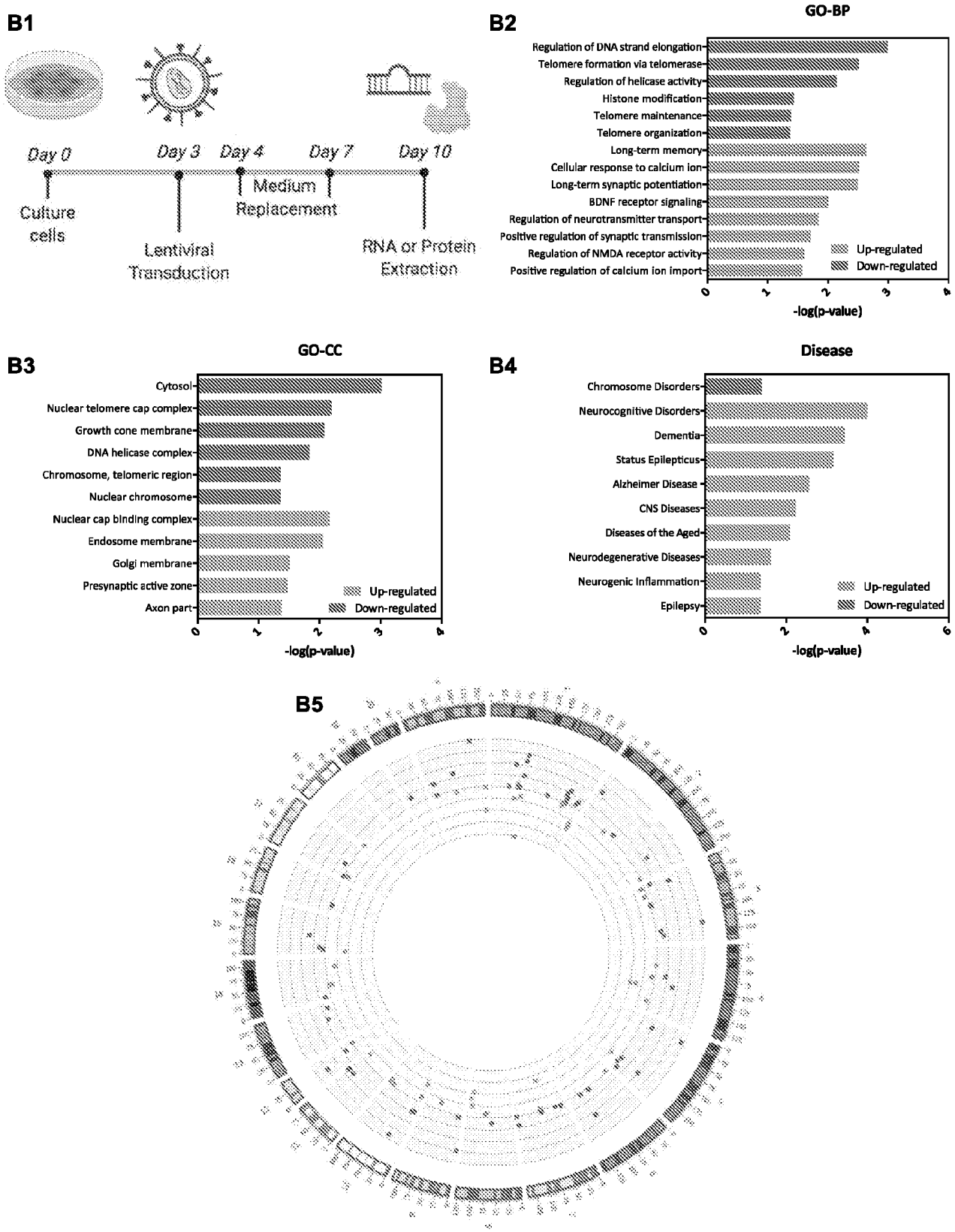

B1
Day 0
Day 3
Day 4
Day 7
Day 10
Culture cells
Lentiviral Transduction
Medium Replacement
RNA or Protein Extraction
B2
GO-BP
Regulation of DNA strand elongation
Telomere formation via telomerase
Regulation of helicase activity
Histone modification
Telomere maintenance
Telomere organization
Long-term memory
Cellular response to calcium ion
Long-term synaptic potentiation
BDNF receptor signaling
Regulation of neurotransmitter transport
Positive regulation of synaptic transmission
Regulation of NMDA receptor activity
Positive regulation of calcium ion import
Up-regulated
Down-regulated
-log(p-value)
B3
GO-CC
Cytosol
Nuclear telomere cap complex
Growth cone membrane
DNA helicase complex
Chromosome, telomeric region
Nuclear chromosome
Nuclear cap binding complex
Endosome membrane
Golgi membrane
Presynaptic active zone
Axon part
Up-regulated
Down-regulated
-log(p-value)
B4
Disease
Chromosome Disorders
Neurocognitive Disorders
Dementia
Status Epilepticus
Alzheimer Disease
CNS Diseases
Diseases of the Aged
Neurodegenerative Diseases
Neurogenic Inflammation
Epilepsy
Up-regulated
Down-regulated
-log(p-value)
B5

Figure 16

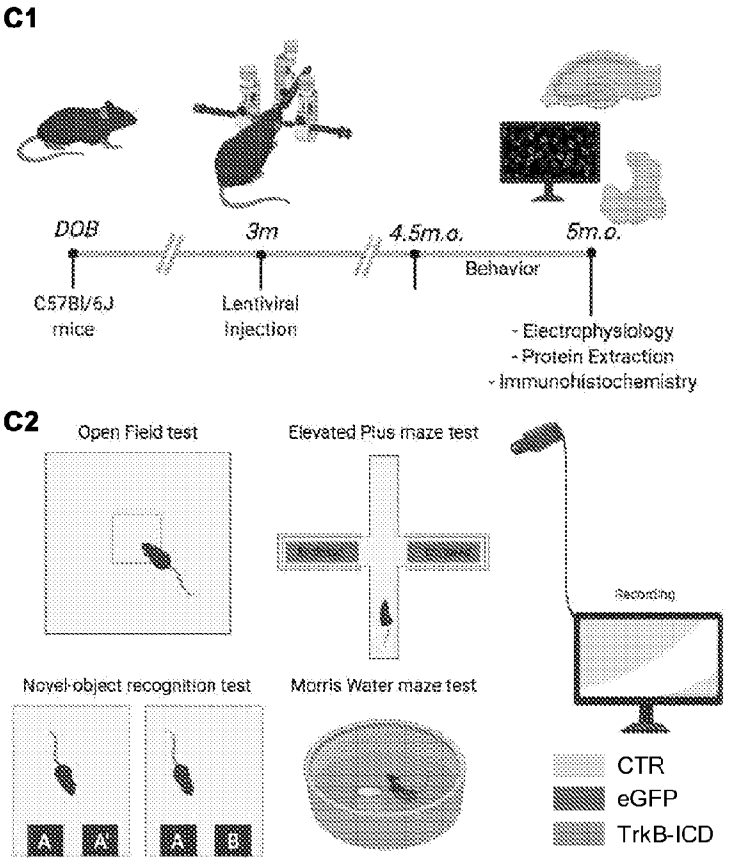

C1
DOB
3m
4.5m.o.
5m.o.
Behavior
C57Bl/6J mice
Lentiviral injection
- Electrophysiology
- Protein Extraction
- Immunohistochemistry
C2
Open Field test
Elevated Plus maze test
Novel-object recognition test
Morris Water maze test
Recording
CTR
eGFP
TrkB-ICD
C3 – OF
Mean Velocity (cm/sec)
Time on Central Zone (%)
Distance Travelled (cm)
C4 – EPM
Entries on Open Arms
Time on Open Arm (%)
C5 – MWM – Latency
Latency to target (s)
Day 1
Day 2
Day 3
Day 4
C6 – MWM – Probe Test
Number of crossings
% time in correct quadrant
C7 – NOR – Training Day
Total Time of Exploration (%) Training Day
Exploration Time (%) Training Day
n.s.
C8 – NOR – Test Day
Total Time of Exploration (%) Test Day
Exploration Time (%) Test Day
****
n.s.

Figure 17

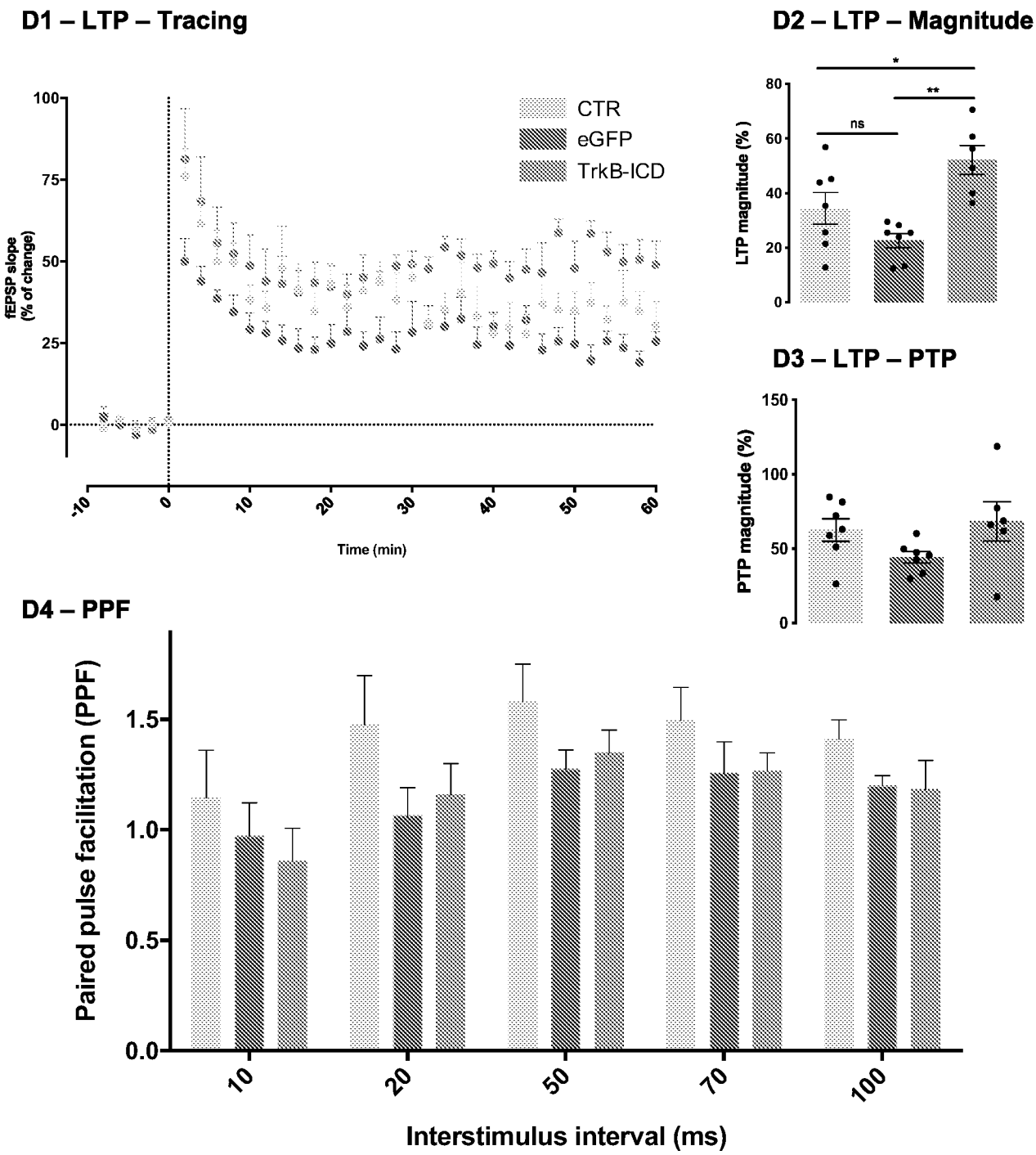
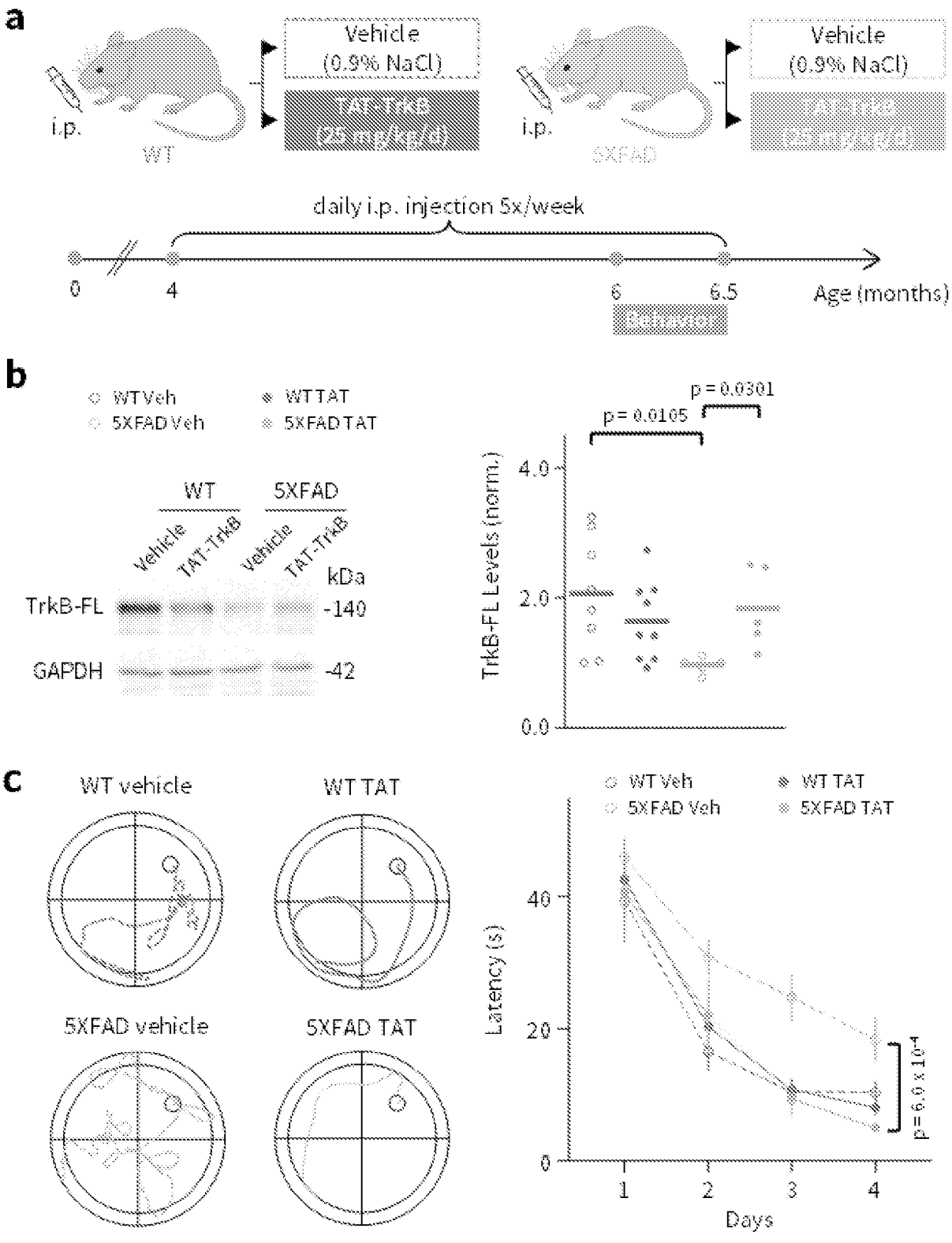

D1 – LTP – Tracing
fEPSP slope (% of change)
100
75
50
25
0
CTR
eGFP
TrkB-ICD
-10
0
10
20
30
40
50
60
Time (min)
D2 – LTP – Magnitude
LTP magnitude (%)
80
60
40
20
0
*
**
ns
D3 – LTP – PTP
PTP magnitude (%)
150
100
50
0
D4 – PPF
Paired pulse facilitation (PPF)
1.5
1.0
0.5
0.0
10
20
50
70
100
Interstimulus interval (ms)

Figure 18


a
i.p.
WT
Vehicle
(0.9% NaCl)
TAT-TrkB
(25 mg/kg/d)
i.p.
5XFAD
Vehicle
(0.9% NaCl)
TAT-TrkB
(25 mg/kg/d)
daily i.p. injection 5x/week
0
4
6
6.5
Age (months)
b
WT Veh
5XFAD Veh
WT TAT
5XFAD TAT
WT
5XFAD
Vehicle
TAT-TrkB
Vehicle
TAT-TrkB
kDa
TrkB-FL
-140
GAPDH
-42
p = 0.0301
p = 0.0105
TrkB-FL Levels (norm.)
4.0
2.0
0.0
c
WT vehicle
WT TAT
5XFAD vehicle
5XFAD TAT
WT Veh
5XFAD Veh
WT TAT
5XFAD TAT
Latency (s)
40
20
0
1
2
3
4
Days
p = 6.0 x 10-7

INTERNATIONAL SEARCH REPORT

International application No
PCT/PT2021/050011

A. CLASSIFICATION OF SUBJECT MATTER
INV. A61K38/17 A61P25/28 G01N33/50
ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
A61K G01N A61P

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
EPO-Internal, BIOSIS, Sequence Search, EMBASE, FSTA, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	JERÓNIMO-SANTOS ANDRÉ ET AL: "Dysregulation of TrkB Receptors and BDNF Function by Amyloid-[beta] Peptide is Mediated by Calpain", CEREBRAL CORTEX, vol. 25, no. 9, 1 September 2015 (2015-09-01), pages 3107-3121, XP055814286, GB ISSN: 1047-3211, DOI: 10.1093/cercor/bhu105 Retrieved from the Internet: URL:https://watermark.silverchair.com/bhu105.pdf?token=AQECAHi208BE49Ooan9kkhW_Ercy7Dm3ZL_9Cf3qfKAc485ysgAAArgwggK0BgkqhkiG9w0BBwagggKlMIICoQIBADCCApoGCSqGSIb3DQEHATAeBglghkgBZQMEAS4wEQQMT6mo3yvliTMWWNA1AgEQgIICa7CrzXZvUzGmtq1ZsiXhTzKjPpDd_B_7PQzdCX85TtwCfpSSVHWCekiyPYD2qGlC96QgeBPvsyznT7HyOdC -/--	1-54

X Further documents are listed in the continuation of Box C.

X See patent family annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
16 June 2021	18/08/2021

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Dolce, Luca

1

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
	e9QLmtUwRY> figure 1 -----	
X	TEJEDA GONZALO S ET AL: "Prevention of excitotoxicity-induced processing of BDNF receptor TrkB-FL leads to stroke neuroprotection", EMBO MOLECULAR MEDICINE, vol. 11, no. 7, 3 June 2019 (2019-06-03), XP055814263, ISSN: 1757-4676, DOI: 10.15252/emmm.201809950 Retrieved from the Internet: URL:https://onlinelibrary.wiley.com/doi/full-xml/10.15252/emmm.201809950> figure 1 -----	1-54
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1

INTERNATIONAL SEARCH REPORT

International application No.
PCT/PT2021/050011

Box No. I Nucleotide and/or amino acid sequence(s) (Continuation of item 1.c of the first sheet)

1. With regard to any nucleotide and/or amino acid sequence disclosed in the international application, the international search was carried out on the basis of a sequence listing:

   a. [X] forming part of the international application as filed:

      [X] in the form of an Annex C/ST.25 text file.

      [ ] on paper or in the form of an image file.

   b. [ ] furnished together with the international application under PCT Rule 13*ter*.1(a) for the purposes of international search only in the form of an Annex C/ST.25 text file.

   c. [ ] furnished subsequent to the international filing date for the purposes of international search only:

      [ ] in the form of an Annex C/ST.25 text file (Rule 13*ter*.1(a)).

      [ ] on paper or in the form of an image file (Rule 13*ter*.1(b) and Administrative Instructions, Section 713).

2. [ ] In addition, in the case that more than one version or copy of a sequence listing has been filed or furnished, the required statements that the information in the subsequent or additional copies is identical to that forming part of the application as filed or does not go beyond the application as filed, as appropriate, were furnished.

3. Additional comments:

INTERNATIONAL SEARCH REPORT

International application No.
PCT/PT2021/050011

Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. ☐ Claims Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

see additional sheet

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.

2. ☐ As all searchable claims could be searched without effort justifying an additional fees, this Authority did not invite payment of additional fees.

3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:

4. ☒ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

1-54

Remark on Protest

☐ The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.

☐ The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.

☐ No protest accompanied the payment of additional search fees.

FURTHER INFORMATION CONTINUED FROM PCT/ISA/ 210

This International Searching Authority found multiple (groups of) inventions in this international application, as follows:

1. claims: 1-54

   polypeptides, pharmaceutical compositions, methods of treatment based on TrkB-FL-derived polypeptides spanning the calpain cleavage site

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2. claims: 55-78

   diagnostic methods for Alzheimer's disease (AD), as well as methods for monitoring the efficacy of treatment of AD

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/PT2021/050011

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