VNIVERSITAT DE VALÈNCIA Facultat de Psicologia i Logopèdia

Programa de Doctorado en
Promoción de la Autonomía y Atención Sociosanitaria a la Dependencia

APPROACHING THE COMPREHENSION OF COGNITION IN THE OLD AGE: STUDY OF ITS ASSOCIATED FACTORS FROM A GENDER PERSPECTIVE

APROXIMACIÓN A LA COMPRENSIÓN DEL FUNCIONAMIENTO COGNITIVO DE PERSONAS MAYORES: ESTUDIO DE SUS FACTORES ASOCIADOS DESDE UNA PERSPECTIVA DE GÉNERO

TESIS DOCTORAL

Presentada por:
Irene Fernández Martínez

Dirigida por:
Dr. José Manuel Tomás Miguel
Dra. Manuela Torregrosa Ruiz

Valencia, febrero de 2023

A Ernestina

Agradecimientos

En primer lugar, quiero agradecer a mi madre Elena y a mi padre Manuel todos sus esfuerzos para ofrecerme las oportunidades que me han llevado hasta el desarrollo de esta tesis doctoral.

A mis directores de tesis. A Manuela, gracias por ser ejemplo, por animarme y apoyarme para conseguir mis objetivos. A José Manuel, gracias por creer en mí, por lo que me has enseñado y sigues enseñando, y por tu amistad.

A mi equipo de investigación, ARMAQoL. A Amparo Oliver, gracias por tu inestimable ayuda durante todos estos años, por los cuidados y por tu generosidad. A Laura y Patri, gracias por ser ejemplo a seguir y gracias por los consejos. A Sara y Zaira, es una suerte no recorrer este camino sola y es un regalo haberlo hecho de vuestra mano; gracias. Y a todo el equipo en general, porque gracias a vosotras soy mejor investigadora.

A mis amigas y amigos, les agradezco haberme acompañado durante la realización de este proyecto, uno de los más importantes de mi vida.

Acknowledgements

Irene Fernández is the recipient of grant PRE2019-089021 funded by MCIN/AEI/ 10.13039/501100011033 and by “ESF Investing in your future”. Agradecimientos también al Ministerio de Ciencia e Innovación, Agencia Estatal de Investigación y Fondos FEDER de la UE, por apoyar el proyecto de investigación “SAETA”, PID2021-124418OB-I00, del que el Prof. Tomás es IP2 y en el marco del cual se alinean los objetivos de esta tesis.

The SHARE data collection has been funded by the European Commission, DG RTD through FP5 (QLK6-CT-2001-00360), FP6 (SHARE-I3: RII-CT-2006-062193, COMPARE: CIT5-CT-2005-028857, SHARELIFE: CIT4-CT-2006-028812), FP7 (SHARE-PREP: GA N°211909, SHARE-LEAP: GA N°227822, SHARE M4: GA N°261982, DASISH: GA N°283646) and Horizon 2020 (SHARE-DEV3: GA N°676536, SHARE-COHESION: GA N°870628, SERISS: GA N°654221, SSHOC: GA N°823782, SHARE-COVID19: GA N°101015924) and by DG Employment, Social Affairs & Inclusion through VS 2015/0195, VS 2016/0135, VS 2018/0285, VS 2019/0332, and VS 2020/0313. Additional funding from the German Ministry of Education and Research, the Max Planck Society for the Advancement of Science, the U.S. National Institute on Aging (U01_AG09740-13S2, P01_AG005842, P01_AG08291, P30_AG12815, R21_AG025169, Y1-AG-4553-01, IAG_BSR06-11, OGHA_04-064, HHSN271201300071C, RAG052527A) and from various national funding sources is gratefully acknowledged (see www.share-project.org).

INDEX

RESUMEN AMPLIO

Introducción y objetivos

El envejecimiento de la población es un fenómeno mundial, y es más notable en los países desarrollados. Los aumentos en la esperanza de vida junto a las menores ratios de natalidad son responsables de este cambio demográfico (Tavares, 2022; Weber & Loichinger, 2020).

Los cambios en la estructura poblacional implican cambios económicos, dado que el consumo relacionado con el gasto público en atención sanitaria aumenta con la edad (Mason & Lee, 2022), pero la fuerza de trabajo disminuye. Adicionalmente, las mejoras en los tratamientos de enfermedades infecciosas, responsables en muchos casos de una mayor esperanza de vida, han introducido a las enfermedades crónicas entre las principales causas de muerte en gran parte de los países desarrollados (McCraken & Phillips, 2017).

De entre las 10 causas de muerte globales, la Organización Mundial de la Salud establece que la demencia ocupa la séptima posición mundial, y la segunda posición en aquellos países con altos ingresos (WHO, 2022). Aparte de las implicaciones económicas de la demencia, el deterioro cognitivo en general supone una barrera para la calidad de vida de las personas que lo sufren (Bárrios et al., 2013; Hoe et al., 2009; Lawson et al., 2016; Lawson et al., 2014; Maki et al., 2014).

Las intervenciones en estilos de vida pueden resultar una estrategia efectiva para posponer el inicio de la demencia. Vivir una mayor cantidad de años sin esta enfermedad, implicaría un aumento en la esperanza de vida saludable de la población. Dado que la demencia es el último estadio del deterioro cognitivo (Hugo & Ganguli, 2014) y que éste es normativo del proceso de envejecimiento (Steinerman et al., 2010), una alternativa es el estudio del envejecimiento cognitivo en general. El retraso del envejecimiento normativo a nivel cognitivo podría resultar ampliamente beneficioso para todo el proceso en cadena del deterioro cognitivo.

Dentro del estudio de la cognición, numerosas teorías e hipótesis ponen de manifiesto el papel explicativo de distintos factores sobre el funcionamiento cognitivo de las personas mayores. En esta línea, la teoría de la reserva cognitiva (Stern, 2002), establece que la educación, junto con otros factores, proporcionan una reserva para afrontar el deterioro asociado a la edad, de forma que este deterioro no afecta al desempeño cognitivo en el mismo grado que lo haría de no disponer de dicha reserva (Harrison et al., 2015; Stern, 2012). Numerosos estudios han puesto a prueba el efecto de la educación, o del nivel educativo, sobre la función cognitiva de los adultos mayores. La evidencia apunta hacia el papel protector de este determinante de la cognición (Bertola et al., 2019; Ding et al., 2019; Weber et al., 2014).

Otra hipótesis que proporciona base teórica a los efectos hallados entre diversos factores físicos y el funcionamiento cognitivo es la de la inflamación (Chung et al., 2001). Según esta hipótesis, con la edad avanzada los procesos inflamatorios se cronifican y dan lugar al deterioro de los sistemas biológicos (Franceschi et al., 2000). Dichos procesos conllevan alteraciones en las células y tejidos (Chung, 2019) que se han relacionado con enfermedades cardiovasculares, así como con otras enfermedades crónicas (Ferrucci & Fabbri, 2018). En esta línea, numerosos estudios señalan una asociación positiva entre la actividad física y el funcionamiento cognitivo (Beydoun et al., 2014; Blondell et al., 2014; Buchman et al., 2012; Frederiksen et al., 2015; Ku et al., 2012; Middleton, 2011; Tolppanen et al., 2015).

Por su parte, la hipótesis de depresión vascular (Alexopoulos et al., 1997) propone que las enfermedades neurovasculares asociadas a la edad podrían activar, acelerar o ser responsables de los síndromes depresivos en la edad avanzada. De la misma manera, algunos autores sugieren que la depresión puede considerarse una manifestación temprana de demencia futura (Ismail et al., 2018; Steffens, 2012; Stella et al., 2014). Numerosos estudios han reportado una asociación entre la depresión o la sintomatología depresiva y un mayor deterioro cognitivo (T. Y. Chen & Chang, 2016; Downer et al., 2017; L. Han et al., 2016; Howrey et al., 2015; Min, 2018; Yu et al., 2015).

Por último, algunos factores sociales también se han estudiado en relación al funcionamiento cognitivo. Partiendo de la hipótesis de enriquecimiento cognitivo (Scarmeas & Stern, 2003), la participación de los adultos mayores en distintas actividades conlleva situaciones demandantes a nivel cognitivo, que pueden contribuir al mantenimiento de la reserva cognitiva (Bourassa et al., 2017; Hertzog et al., 2008). De entre estas actividades, se ha estudiado especialmente el vínculo entre la participación en actividades sociales y la función cognitiva (Choi, 2020;

Fu et al., 2018; Glei et al., 2005; Hwang et al., 2018; Krueger et al., 2009; Litwin & Stoeckel, 2015; McFall et al., 2019; Miceli et al. 2018; Seeman et al., 2011; Teipel et al., 2018), aunque algunos estudios parecen indicar que la participación en actividades intelectuales podría ser también beneficiosa (Hultsch et al., 1999; Yu et al., 2015).

El principal propósito de esta tesis doctoral es establecer un marco de referencia holístico que contemple los principales factores bio-psico-sociales involucrados en el mantenimiento de la función cognitiva en la edad avanzada, y estudiar la relación entre la función cognitiva y el envejecimiento con éxito.

Para ello, se empleará el modelo Comprehensivo Preventivo y Correctivo Proactivo (PCP) propuesto por Kahana et al. (2014). Según este modelo, el envejecimiento con éxito no es únicamente un resultado, sino también un proceso. Este modelo considera que el envejecimiento exitoso se puede determinar por la consecución de una buena calidad de vida, pero también por el uso eficiente de adaptaciones comportamentales proactivas, dados los recursos internos y externos disponibles, para afrontar tanto los estresores relacionados con la edad como los acumulativos a lo largo del ciclo vital. En este contexto, se propone que el deterioro cognitivo puede considerarse un estresor relacionado con la edad que puede tener un impacto sobre los resultados del envejecimiento exitoso.

Esta tesis doctoral presenta cinco objetivos generales (OG):

OG1. Evaluar la adecuación psicométrica de los instrumentos de medidas cognitivas empleados en la encuesta Survey of Health, Aging and Retirement in Europe (SHARE).

OG2. Establecer un modelo comprehensivo para predecir el funcionamiento cognitivo desde una perspectiva bio-psico-social.

OG3. Establecer los posibles efectos explicativos de los factores más relevantes documentados en la literatura de funcionamiento cognitivo.

OG4. Examinar la relación entre la función cognitiva y los resultados de calidad de vida.

OG5. Estudiar el funcionamiento cognitivo en las personas mayores desde una perspectiva de género.

Para cada uno de estos objetivos generales, se han derivado varios objetivos específicos (OE). Al respecto del objetivo general 1:

OE1. Examinar la estructura factorial, la fiabilidad y la validez convergente del 10-Word Recall Test (10WRT), prestando especial atención a los efectos de posición serial y su papel en la relación entre la memoria reciente/retardada y la educación.

OE2. Evaluar la estructura factorial, la fiabilidad, la validez referida al criterio y la validez diagnóstica de la adaptación de SHARE del Informant Questionnaire on Cognitive Decline in the Elderly (IQCODE).

Los objetivos específicos al respecto del OG2 son:

OE3. Poner a prueba las relaciones diferenciales entre los predictores de la función cognitiva y cuatro dimensiones cognitivas (orientación temporal, memoria, cálculo aritmético y fluidez verbal).

OE4. Poner a prueba el impacto relativo de los años de educación, las enfermedades crónicas, los factores psicológicos (soledad y depresión) y la participación en actividades sociales e intelectuales sobre las dimensiones cognitivas, controlando la edad.

Los objetivos específicos relativos al OG3 son:

OE5. Establecer la forma de las trayectorias latentes de la memoria, diferenciando entre memoria reciente y retardada, y fluidez verbal.

OE6. Poner a prueba el poder explicativo del nivel educativo, la inactividad física, la depresión y la implicación social sobre la memoria y la fluidez verbal, controlando la edad.

Los objetivos específicos al respecto del OG4 son:

OE7. Estudiar las asociaciones longitudinales entre la memoria reciente y la calidad de vida, controlando por diversas covariables.

OE8. Estudiar las asociaciones longitudinales entre la memoria retardada y la calidad de vida, controlando por diversas covariables.

OE9. Estudiar las asociaciones longitudinales entre la fluidez verbal y la calidad de vida, controlando por diversas covariables.

Los objetivos específicos relativos al OG5 son:

OE10. Poner a prueba el impacto relativo del género en la orientación temporal, la memoria, el cálculo aritmético y la fluidez verbal.

OE11. Estudiar el papel explicativo del género en las trayectorias latentes de la memoria reciente y retardada, y de la fluidez verbal.

OE12. Determinar el efecto del género en la trayectoria latente de la calidad de vida.

Sobre cada uno de estos objetivos específicos, se han propuesto adicionalmente una o más hipótesis, que se detallan a continuación:

Hipótesis relativas al OE1:

1a. La memoria reciente mostrará una estructura de un factor con efectos de recencia, pero no de primacía.

1b. La memoria retardada mostrará una estructura de un factor con efectos de primacía, pero no de recencia.

1c. La escala 10-WRT presentará estimaciones de fiabilidad adecuadas, tanto para la memoria reciente como para la retardada.

1d. La existencia de efectos de posición serial distorsionará las relaciones entre memoria reciente/retardada y educación.

Hipótesis relativas al OE2:

2a. La escala IQCODE mostrará una estructura de un factor de deterioro cognitivo.

2b. La escala IQCODE presentará estimaciones de fiabilidad adecuadas.

2c. Las percepciones de los informantes sobre el deterioro cognitivo de los encuestados, medidas por la escala IQCODE, serán mayores para los encuestados con un diagnóstico autodeclarado de demencia.

2d. Habrá un punto de corte para el IQCODE que represente un equilibrio adecuado entre sensibilidad y especificidad.

Hipótesis relativas al OE3:

3. Los predictores mostrarán efectos diferenciales en las dimensiones cognitivas consideradas.

Hipótesis sobre el OE4:

4a. Los años de educación, la participación en actividades sociales, y la participación en actividades intelectuales presentarán efectos positivos y estadísticamente significativos sobre las diferentes dimensiones cognitivas consideradas.
4b. Las enfermedades crónicas, la soledad y la depresión presentarán efectos negativos y estadísticamente significativos sobre las diferentes dimensiones cognitivas consideradas.

Hipótesis relativas al OE5:

5a. La memoria reciente mostrará una trayectoria latente de deterioro lineal o cuadrático.
5b. La memoria retardada mostrará una trayectoria latente de deterioro lineal o cuadrático.
5c. La fluidez verbal mostrará una trayectoria latente de deterioro lineal o cuadrático.

Hipótesis al respecto del OE6:

6a. El nivel educativo y la implicación social tendrán efectos positivos y estadísticamente significativos en las trayectorias latentes de la memoria reciente, la memoria retardada y la fluidez verbal.
6b. La inactividad física y la depresión tendrán efectos negativos y estadísticamente significativos en las trayectorias latentes de la memoria reciente, la memoria retardada y la fluidez verbal.

Hipótesis relativas al OE7:

7. Los cambios en la memoria reciente explicarán los cambios en la calidad de vida.

Hipótesis sobre el OE8:

8. Los cambios en la memoria retardada explicarán los cambios en la calidad de vida.

Hipótesis sobre el OE9:

9. Los cambios en la fluidez verbal explicarán los cambios en la calidad de vida.

Hipótesis sobre el OE10:

10. Las mujeres presentarán niveles estadísticamente mayores de memoria en general y de fluidez verbal que los hombres.

Hipótesis sobre el OE11:

11a. Las mujeres presentarán niveles estadísticamente más bajos de deterioro de la memoria reciente y de la fluidez verbal que los hombres a lo largo del tiempo.

11b. Las mujeres presentarán niveles estadísticamente más altos de deterioro de la memoria retardada a lo largo del tiempo.

Hipótesis sobre el OE12:

12. Las mujeres presentarán niveles estadísticamente más altos de deterioro de la calidad de vida que los hombres.

Metodología

Para satisfacer cada uno de los objetivos generales propuestos, y más concretamente cada uno de los objetivos específicos, se emplearon diversas técnicas estadísticas con datos procedentes de la encuesta Survey of Health, Aging and Retirement in Europe (SHARE; Börsch-Supan et al., 2013). SHARE constituye una infraestructura de investigación única que contiene información longitudinal sobre salud, datos socioeconómicos, entorno y redes sociales de ciudadanos tanto europeos como israelíes con edades igual o superior a 50 años.

Para el estudio de las propiedades psicométricas de la escala 10-WRT, se empleó una muestra de 37143 individuos que participaron en la ola 2 (Börsch-Supan, 2022a).

Para el estudio de las propiedades psicométricas de la escala IQCODE, se empleó una muestra de 1059 familiares de los participantes objeto de estudio de SHARE, procedente de la ola 8 (Börsch-Supan, 2022b).

Para el estudio de los predictores de las distintas dimensiones cognitivas, se empleó una muestra de 45475 personas participantes en la 8ª ola de SHARE (Börch-Supan, 2022b), que fueron capaces de responder a todas las pruebas cognitivas.

Por último, para el estudio longitudinal del funcionamiento cognitivo, sus determinantes y sus consecuentes asociados, se emplearon datos procedentes de las olas 4 (Börsch-Supan, 2022c), 5 (Börsch-Supan, 2022d), 6 (Börsch-Supan, 2022e), 7 (Börsch-Supan, 2022f) y 8 (Börsch-Supan, 2022b) de la encuesta SHARE. Se incluyeron a todos los participantes de la ola 4 de SHARE independientemente de su participación posterior en el estudio, lo que dio lugar a una muestra de 56616 individuos.

Respecto a los instrumentos, se emplearon medidas de funcionamiento cognitivo, concretamente de memoria reciente y retardada, orientación temporal, fluidez verbal, cálculo aritmético y la percepción externa de deterioro cognitivo.

La memoria reciente y retardada se evaluó mediante el 10-Word Test Recall (10-WTR). En este test, se leen 10 palabras a los participantes, y se les pide que digan todas las que recuerden inmediatamente (memoria reciente) y tras 10 minutos de habérselas leído (memoria retardada). El número total de palabras recordadas inmediatamente y tras el lapso de 10 minutos constituyen la puntuación del participante en memoria reciente y memoria retardada, respectivamente.

La orientación temporal se midió con cuatro indicadores que reflejaban la orientación del encuestado al respecto del mes, año, día de la semana y fecha. Cada indicador se registró como correcto (1) o incorrecto (0). Mayores puntuaciones indicaron mejor orientación temporal.

La fluidez verbal se empleó como una medida de función ejecutiva (Dewey & Prince, 2005). En esta prueba, los participantes deben nombrar tantos animales distintos como sea posible durante 60 segundos. El número total de indicadores se registra como indicador de la fluidez verbal de cada participante.

El cálculo aritmético también se empleó como medida de la función ejecutiva (Cragg & Gilmore, 2014; Dewey & Prince, 2005) y fue medido mediante una secuencia de cinco preguntas recursivas en las que el participante debía restar 7 unidades, empezando en 100. Las preguntas se codificaban como correctas (1) o incorrectas (0).

La percepción externa de deterioro cognitivo se evaluó mediante la versión adaptada de la escala 16-Item Informant Questionnaire on Cognitive Decline in the Elderly (IQCODE; Jorm, 1994), de la cual se emplearon siete ítems. Esta escala va dirigida a los familiares de las personas mayores y evalúa el deterioro cognitivo percibido por los mismos. Adicionalmente a la reducción de ítems, el marco temporal empleado para el cambio en la habilidad cognitiva se redujo a dos años en lugar de los 10 años de la versión original, y la escala de respuesta empleada presentó tres anclajes de respuesta en lugar de los cinco originales.

Adicionalmente, se contemplaron diversos antecedentes de la función cognitiva como son la edad, el género, el nivel educativo, el número de enfermedades crónicas, la inactividad física, la participación en actividades sociales y en actividades intelectuales, la depresión, la soledad y la implicación social. Estas variables se introdujeron bien como predictores en el modelo correlacional, bien como covariables determinantes en los modelos longitudinales.

Asimismo, la calidad de vida de los adultos mayores fue empleada como indicador de envejecimiento exitoso, tal y como propone el modelo Comprehensivo PCP de Kahana et al. (2014).

Respecto a los análisis, la estructura factorial de las escalas 10-WRT y IQCODE se examinó mediante Análisis Factorial Confirmatorio (AFC). Las estimaciones de fiabilidad se calcularon empleando el coeficiente omega (McDonald, 1999). Las relaciones entre memoria reciente/retardada y el nivel educativo en presencia y ausencia de efectos de posición serial se estudió mediante correlaciones, estimadas dentro de los modelos de AFC. La validez referida al criterio de la escala IQCODE se examinó mediante la comparación de las puntuaciones medias en la escala entre las personas cuyo familiar dijo tener un diagnóstico de Alzheimer o demencia general, y las personas cuyo familiar dijo no tenerlo. Por último, se emplearon áreas bajo la curva (Receiver Operating Curve; ROC) para determinar el punto de corte que optimizaba los valores de sensibilidad y especificidad.

Para establecer un modelo holístico de predicción se puso a prueba un Modelo de Ecuaciones Estructurales (MEE) con las variables dependientes de funcionamiento cognitivo comentadas anteriormente (orientación temporal, memoria, fluidez verbal y cálculo aritmético) y con los siguientes predictores de la función cognitiva: nivel educativo, número de enfermedades crónicas, inactividad física, depresión, soledad, participación en actividades sociales y participación en actividades intelectuales. Los efectos de estos predictores sobre las distintas dimensiones de función cognitiva fueron adicionalmente controlados por la edad y el género.

Para el estudio de las trayectorias longitudinales de memoria reciente, memoria retardada y fluidez verbal se pusieron a prueba Modelos de Crecimiento Latente (MCL). Primero se examinó la forma de las trayectorias de cada uno de los dominios cognitivos considerados. Una vez se retuvo el modelo de mejor ajuste, se probó un modelo adicional con los efectos de las covariables género, edad, nivel educativo, inactividad física, depresión e implicación social, sobre las interceptas y las pendientes del modelo retenido para cada una de las dimensiones cognitivas.

Finalmente, para el estudio de los efectos longitudinales de la memoria reciente, la memoria retardada y la fluidez verbal sobre la calidad de vida, se establecieron Modelos de Procesos Paralelos de Crecimiento Latente. En estos modelos se contemplaron también los efectos de las covariables introducidas en los MCLs.

En caso de variables categóricas, como son los ítems de las escalas 10-WRT y IQCODE, se empleó el método de estimación Mínimos Cuadrados Ponderados con Medias y Varianzas corregidas (WLSMV, por sus siglas en inglés). En el caso de variables cuantitativas, se empleó el método de estimación de Máxima Verosimilitud Robusto (MLR, por sus siglas en inglés).

El ajuste de los modelos de evaluó mediante los índices de ajuste recomendados en la literatura (Kline, 2016; Tanaka, 1993): estadístico chi-cuadrado (χ^2), Comparative Fit Index (CFI), Root Mean Squared Error of Approximation (RMSEA), y Standardized Root Mean Square Residual (SRMR). Generalmente, se asume un buen ajuste de los modelos con valores de CFI iguales o superiores a .90, y valores de RMSEA/SRMR de .08 o inferiores. En el caso de la escala 10-WRT, se calcularon las diferencias de chi-cuadrado ($\Delta\chi^2$) y las diferencias de CFI (ΔCFI) entre los modelos anidados para determinar el de mejor ajuste. Para los modelos competitivos longitudinales, adicionalmente se tuvieron en cuenta el Criterio de Información de Akaike (AIC, por sus siglas en inglés) y el Criterio de Información Bayesiano (BIC, por sus siglas en inglés).

En todos los modelos, el tratamiento de datos faltantes se llevó a cabo empleando Full Information Maximum Likelihood (FIML), una técnica adecuada ante mecanismos de datos faltantes aleatorios o completamente aleatorios (MCAR y MAR). Esta técnica no elimina o imputa observaciones faltantes, sino que crea subconjuntos de datos que comparten el mismo patrón de datos faltantes, de la que extrae la información para calcular las estimaciones de los parámetros de los modelos (Enders, 2010; Kline, 2016). Los análisis se llevaron a cabo empleando R (R Core Team, 2022) y Mplus 8.7 (L. K. Muthén & Muthén, 1998-2017).

Discusión y conclusiones

Los resultados derivados del trabajo se interpretaron en el contexto del objetivo general que satisfacían en cada caso. La única excepción fue el objetivo general 5, estudiar el funcionamiento cognitivo en las personas mayores desde una perspectiva de género. Este objetivo es transversal a cualquier otro del trabajo, ya que la consecución de una perspectiva de género se logra mediante la consideración de las relaciones específicas del género con cualquier otro fenómeno, cosa que se ha realizado a lo largo de todo el trabajo.

Respecto a los resultados de este trabajo, se ha encontrado evidencia sobre la aparición de efectos de posición serial en una escala para evaluar la memoria. Aunque estudios previos parecen indicar que la influencia de dichos efectos no es muy relevante para la medición de variables latentes (Cernat et al., 2022), en este trabajo se examinó la relación de la variable latente con un criterio externo y se encontraron diferencias estadísticamente significativas entre las estimaciones de la correlación considerando y sin considerar este efecto de método, aunque dicha diferencia fue pequeña.

Por otro lado, el estudio psicométrico de la escala IQCODE adaptada en el contexto SHARE mostró evidencias de adecuadas propiedades psicométricas en términos de validez factorial, fiabilidad, valides referida al criterio y validez diagnóstica. Estos resultados proporcionan evidencia sobre la adecuación de esta versión adaptada de la escala como una aproximación a la medición del deterioro cognitivo cuando no es posible evaluar a la persona directamente.

Respecto al objetivo general 2, los resultados de este trabajo muestran un modelo con un acercamiento holístico al estudio de la cognición desde una perspectiva bio-psico-social y considerando la heterogeneidad de los efectos sobre diferentes dominios cognitivos. En dicho modelo tuvieron un impacto especialmente relevante la depresión, la participación en actividades sociales y la participación en actividades intelectuales.

En cuanto a las trayectorias longitudinales de memoria reciente, memoria retardada y fluidez verbal, todas ellas mostraron una forma cuadrática y negativa. Es decir, en los tres dominios cognitivos se observó un deterioro inicial seguido de un deterioro posterior más acusado. Las covariables explicaron en cierto grado la varianza de las interceptas y en mucho menor grado la varianza de las pendientes lineales y cuadráticas en los tres casos.

Finalmente, el estudio longitudinal de la memoria reciente, la memoria retardada y la fluidez verbal junto con la calidad de vida, entendida como un indicador de resultados de envejecimiento exitoso, mostraron evidencias sobre el poder explicativo de los niveles iniciales de la memoria reciente y la memoria retardada sobre el grado de disminución de la calidad de vida. Concretamente, mayores niveles iniciales explicaban una menor disminución de la calidad de vida de los adultos mayores. A raíz de estos resultados, y dado que no se hallaron efectos estadísticamente significativos de los niveles iniciales de calidad de vida sobre la memoria reciente ni sobre la memoria retardada, se infirió que estos resultados pudieran ser evidencia de la relación causal entre la memoria y la calidad de vida. Esto no fue así para la fluidez verbal, para la que no se encontraron estos efectos. En el caso de la fluidez verbal, se encontró evidencia de una relación positiva entre los niveles iniciales de ésta y los niveles iniciales de calidad de vida, así como también de una relación positiva entre el grado de deterioro de la fluidez verbal y el grado de la disminución de calidad de vida. Estos resultados se interpretan como evidencia sobre el carácter dinámico de la relación entre fluidez verbal y calidad de vida.

El propósito principal de esta tesis doctoral ha sido establecer un marco holístico para el estudio de la cognición en la edad avanzada y sus implicaciones para el envejecimiento exitoso de los adultos mayores.

A lo largo de todo este trabajo se ha utilizado el marco teórico ofrecido por el modelo de Comprehensivo PCP (Kahana et al., 2014). En general, los resultados de este trabajo apoyan las evidencias previas sobre la importancia de factores clave para el mantenimiento de la capacidad cognitiva, diferenciando entre memoria reciente, memoria retardada y fluidez verbal. Además, los resultados también proporcionan evidencia para el modelo Comprehensivo PCP y el efecto de la cognición, como un factor estresante relacionado con la edad, en los resultados de envejecimiento exitoso de los adultos mayores.

A continuación, se destacan las principales conclusiones de este trabajo:

- Se puede considerar que las escalas cognitivas empleadas en SHARE presentan propiedades psicométricas adecuadas. No obstante, la memoria reciente, medida mediante la escala 10-Word Recall Test, presenta efectos de primacía y recencia que podrían estar causando una subestimación de las relaciones entre la memoria reciente y otras variables.
- La participación en actividades sociales e intelectuales están significativamente asociada a diferentes componentes de la cognición. Sin embargo, se necesitan más estudios longitudinales para dilucidar la direccionalidad de estos efectos.
- La capacidad cognitiva debería estudiarse a nivel de dominio. Los predictores de la cognición muestran heterogeneidad en la magnitud, e incluso en la aparición, de los efectos sobre diferentes dominios cognitivos.
- El declive cognitivo no es exclusivo de la vejez. Los adultos ya empiezan a experimentar declive en distintos dominios cognitivos. Podrían desarrollarse intervenciones para fomentar la cognición en la edad adulta, con el fin de prevenir el declive cognitivo posterior.
- El deterioro de la memoria, tanto reciente como retardada, pueden considerarse factores estresores relacionados con la edad que afectan a la calidad de vida de las personas mayores.
- El estudio de la cognición y sus resultados asociados difiere entre hombres y mujeres. Por tanto, la investigación y la intervención deben incorporar una perspectiva de género.

1. INTRODUCTION

1.1. Contextualization

Ageing of the population is a worldwide phenomenon, and it is the most notorious in developed countries. Higher life expectancies combined with lower birth rates are responsible for this demographic change (Tavares, 2022; Weber & Loichinger, 2020). In Europe, birth rates have decreased from 10.4 births per thousand persons in 2010 to 9.3 in 2019, while life expectancy at age 65 has increased from 19.4 years in 2010 to 20.2 years in 2019 for both males and females (Eurostat, 2022). However, since the past century, a clear tendency for women to live longer than men has been observed (Oksuzyan et al., 2010; Thorslund et al., 2013). Segregated by gender, life expectancy at age 65 has augmented from 17.4 years in 2010 to 18.3 years in 2019 in the case of males, and from 21.0 years in 2010 to 21.8 years in 2019 in the case of females (Eurostat, 2022).

Although in 2020 life expectancies decreased, this was probably due to the outbreak of the COVID-19 pandemic, whose fatal consequences were most tangible for older adults (Biswas et al., 2021; J. T. Wu et al., 2020). This was a rather unusual event, as life expectancy projections indicate a positive trend towards higher life expectancy (Cao et al., 2020; Janssen et al., 2021). For example, the study by Janssen et al. (2021) projected life expectancy across Europe to increase to 90.5 years for men and 92.8 years for women in 2065. This demographic transition towards more enduring societies can be explained by acquired knowledge about risk and protective health factors. In fact, Janssen et al. (2021) argue that the tightening of the gap between men's and women's life expectancy is partially due to the acquaintance of healthier life habits by men (*e.g.* diminution of smoking and alcohol consumption).

Changes in the age structure of the population entail global economic changes. Mason and Lee (2022) show that "consumption tends to rise with age, primarily as a result of public spending on health care and long-term care" (p. 54) in high-income countries, but low labour income is also observed at older age in these countries. Economic growth will come to a standstill as a result of demographic change, as the global working-age population decreases (Liu & McKibbin, 2022). Moreover, with improvements in treatment of communicable diseases, noncommunicable –or chronic– diseases (NCDs) have become the main cause of death in most developed countries (McCracken & Phillips, 2017). NCDs include, but are not limited to, cardiovascular diseases, dementia, chronic respiratory diseases and cancer.

Among the top 10 causes of death globally, the World Health Organization (WHO, 2022) reported ischaemic heart disease as the leading cause of death in 2019, followed by stroke and chronic obstructive pulmonary disease. Dementia occupied the seventh position in the ranking. According to the income group, for high-income countries, nine out of the 10 leading causes of death were NCDs (dementia ranking in second position), whereas only three out of ten were degenerative diseases for countries classified as low income. Finally, after the outbreak of the pandemic, COVID-19 became one of the top 10 causes of death globally (World Health Statistics, 2022), which is linked to the aforementioned reduction in life expectancy. With the development and implementation of vaccination policies, reduction in COVID-19-related deceases has already been observed (Huang & Kuan, 2022) and therefore, these are not considered as constituting a general tendency.

Chronic diseases have a global impact on macro-economic productivity (Chaker et al., 2015) and nations' healthcare expenditure (Muka et al., 2015), but also on impoverishment of households (Jaspers et al., 2015). Regarding healthcare systems, cardiovascular diseases stand for the highest healthcare expenditure (Muka et al., 2015). Estimates show that the cost of dementia is also considerable (El-Hayek et al., 2019), being comparable to that of cancer or heart diseases (Hurd et al., 2013). In this line, a study by Doblhammer et al. (2022) estimated that dementia will become the most prevalent cause of death for German women and the second one for German men. Overall, dementia presents substantial economic hardship (Cantarero-Prieto et al., 2020; Sontheimer et al., 2021).

Besides the economic consequences of dementia, cognitive impairment, in general, poses a burden on the quality of life (QoL) of individuals who suffer from it (Bárrios et al., 2013; Hoe et al., 2009; Lawson et al., 2016; Lawson et al., 2014; Maki et al., 2014). Mechanisms underlying the association between cognitive impairment and reduced quality of life are complex, probably due to the broad definition of QoL.

There is no general consensus on the definition of QoL, and it is likely that the term's meaning will evolve along time (Noll, 2021). In addition, the use of the concept "health-related quality of life" (HRQoL) has interfered with the understanding of QoL, without offering a clear differentiation from the latter. Authors recommend not using the term HRQoL, as it is essentially equivalent to self-perceived health (Karimi & Brazier, 2016). The WHO offers a definition of QoL as "individuals' perception of their position in life in the context of the culture and value systems in which they live and in relation to their goals, expectations, standards and concerns" (WHOQOL Group, 1995, p. 1405). Generally, QoL is understood as a subjective measure of one's well-being comprising the physical, psychological, social and spiritual dimensions. Given that quality of life is considered a key element for successful ageing (Cheng, 2014; Rowe & Kahn, 2015; Wahl et al., 2016), even a marker of this "success" (Kahana et al., 2014), the preservation of cognitive ability is of paramount importance for the ageing process.

Moreover, increases in life expectancy do not necessarily entail that those extra years are lived in good health. The term "healthy life expectancy" is used to refer to the amount of years a person can expect to live in good health. The difference between both is understood as a period of time spent in an unhealthy or disabled state due to disease. A study by Cao et al. (2020) examined life expectancy, healthy life expectancy, and the difference between both, referred to as GAP, during the period 1995-2017. Their results showed increases in life expectancy, healthy life expectancy and GAP, meaning that the increase in healthy life expectancy is not proportional to the increase in life expectancy. Moreover, they observed different scenarios for males and females. Females presented higher initial estimates of life expectancy and healthy life expectancy than males, but the observed growth rate was slower for females than for males. This indicates that the gender gap is tightening, which was further supported by the results in Janssen et al. (2021). Moreover, females presented a higher GAP, which implies that they spent more time in a disabled state. The GAP growth rate was, however, slower in the case of females than in the case of males. Cao et al. (2020) also provided life expectancy, healthy life expectancy and GAP projections for the period 2017-2025, which indicated that, globally, most regions would continue experiencing increases in all of them. Increases in GAP imply that people will spend more years with disability and diminished quality of life, as life expectancy increases at a faster rate than healthy life expectancy.

There are a few studies, however, that report that factors such as socioeconomic status and healthy lifestyle influence life expectancy (Janssen et al., 2021; Y. Li et al., 2018; Pan et al., 2020; Y. B. Zhang et al., 2022). More specifically, smoking, inactivity, unhealthy diets, BMI, alcohol intake and socioeconomic status have been associated with higher levels of mortality and less life expectancy. A recent study by Dhana et al., (2022) focused on the effects of lifestyle factors on the life expectancy of people with dementia. Results suggested that adherence to healthy lifestyles was associated with higher life expectancy as well as to less risk of developing dementia. Another study by K. L. Harrison et al. (2022) also showed that functional and clinical characteristics, such as physical limitations or depression, to be associated with diminished life expectancy among people with dementia.

Therefore, there is emerging evidence pointing towards lifestyle interventions as an effective strategy for the postponement of the onset of dementia. Living more years free of dementia would imply an increase in healthy life expectancy. Considering that dementia is the ultimate form of cognitive impairment (Hugo & Ganguli, 2014) and that some degree of cognitive impairment is normative of the ageing process (Steinerman et al., 2010), an additional alternative is to tackle cognitive ageing in general. The delay of normative ageing at the cognitive level could be most beneficious for the whole chain process of cognitive deterioration.

1.2. Cognition across time

To approach the study of cognition, it is essential to examine it across time. Normative cognitive ageing is the expected decline in cognition due to usual deterioration of biological systems that starts to manifest in the behaviour of older individuals, which can be considered a normal phenomenon in ageing (Harada et al., 2013; Steinerman et al., 2010). Yet some older adults experience more severe, non-normative, declines in cognition that do not affect their functional abilities, known as Mild Cognitive Impairment (MCI; Bermejo-Pareja et al., 2021). If MCI continues to progress until a point in which it affects individuals' functional abilities, a diagnosis of dementia is raised (Murman, 2015).

There are several studies analysing cognitive trajectories along time. However, different approximations to the longitudinal study of cognition have been used, both in terms of the analytic strategy, and the operationalisation of cognition. Across the reviewed literature examining cognitive trajectories, the most prevailing conceptualisation and analysis of cognitive ability is considering a global component (T. Y. Chen & Chang, 2016; Downer et al., 2017; Espeland et al., 2018; L.

Han et al., 2016; Hayden et al., 2011; Howrey et al., 2015; Lee & Jean Yeung, 2019; Min, 2018; Park et al., 2017; Teipel et al., 2018; Terrera et al., 2010; Tu et al., 2020; Z. Wu et al., 2021; Yu et al., 2015; W. Zhang et al., 2022). Two of these studies, however, did also consider specific components of cognition: semantic memory (Teipel et al., 2018) and executive function, episodic memory and psychomotor speed (Z. Wu et al., 2021). Some other authors have conceptualised cognition by focusing on one or more components of interest, the most common being memory (Bertola et al., 2019; Ding et al., 2019; Johnson et al., 2012; Liampas et al., 2022; Lin et al., 2017; McFall et al., 2019; Williams et al., 2022; Yam et al., 2014), but also executive function (Johnson et al., 2012; Lin et al., 2017; Williams et al., 2022), processing speed (Johnson et al., 2012; Yam et al., 2014), language and attention (Johnson et al., 2012). All in all, studies do not share a common approximation to the construct, and this may be influencing the results.

Regarding the analytic strategy, most studies employed a person-centred approach, which assumes that population heterogeneity can be clustered into different sub-populations based on their responses (J. Wang & Wang, 2012). Among studies employing person-centred techniques that used a global score of cognition, seven studies reported three distinct trajectories (T. Y. Chen & Chang, 2016; Downer et al., 2017; Hayden et al., 2011; Howrey et al., 2015; Teipel et al., 2018; Terrera et al., 2010; Tu et al., 2020). Sample characteristics and specific labelling and size of trajectories is available in Table 1. In general, a group of good performers was found in all studies, followed by a trajectory of slow decline that identifies the normative cognitive agers, and by a group with acute cognitive decline that could be representing non-normative decline. This latter trajectory was the smallest one in five out of seven studies. Different characteristics of the samples used in studies could be accounting for different sample sizes of trajectories. For example, participants in the study by Terrera et al. (2010) were aged 75 and over, while the rest of the studies employed samples aged 65 years old or older. Therefore, the big proportion of acute decliners found by Terrera et al. (2010) could be due to the higher-aged sample. Finally, three of these studies were carried out in the USA, two in Asia (Taiwan and China), one in the United Kingdom, and one in France.

Three additional studies that operationalised cognition as a global component reported four trajectories (Lee & Jean Yeung, 2019; Z. Wu et al., 2021; Yu et al., 2015) and another three studies reported five trajectories (Espeland et al., 2018; L. Han et al., 2016; Park et al., 2017). These trajectories are described for each study in Table 2. Among these studies, in general, groups of high performers, relatively stable performers and decliners are found. High performers' cognition is maintained during time, while performers that remain relatively stable over time are characterised by some cognitive decline during the study period. This decline could be considered normative of the ageing process. Decliners are individuals whose cognitive abilities decreased considerably over the years or individuals whose baseline cognition was already impaired. Some trajectories were identified that do not comply with the expected developmental trends. Namely, Yu et al. (2015) found a trajectory of heterogeneous decliners that accounted for 7.9% of the sample that presented large within-subject variability whilst following a general decline trend. Moreover, Espeland et al. (2018) found a group of relative improvers that represented almost a quarter of the sample. These individuals were characterised by presenting less decline than other decliners. Most of these studies employed samples from the USA, with one study also including an Australian sample (Z. Wu et al., 2021) and the study by Lee and Jean Yeung (2019) that employed a Korean sample.

Table 1

Characteristics of studies reporting three trajectories of global cognition.

Study	Sample features	Trajectories
T. Y. Chen & Chang (2016)	Older adults from the Taiwan Longitudinal Study on Aging (Taiwan)	High-stable (17.4%) Start high and decline (51.8%) Start low and decline (30.8%)
Downer et al. (2017)	Older adults from the Hispanic Established Population for the Epidemiologic Study of the Elderly (USA)	Persistent high (31.3%) Decline but high (52.9%) Decline to low (15.8%)
Hayden et al. (2011)	Older adults from the Religious Orders Study (USA)	Slow decline (64.6%) Moderate decline (27.1%) Fast decline (8.3%)
Howrey et al. (2015)	Older adults from the Hispanic Established Population for the Epidemiologic Study of the Elderly (USA)	Stable (27.1%) Slow decline (55.6%) Rapid decline (17.3%)
Teipel et al. (2018)	Cognitively healthy older adults from the INSIGHT-preAD study (France)	High (32.7%) Medium (65.4%) Low-declining (1.9%)
Terrera et al. (2010)	Older adults from the Cambridge City over 75 Cohort Study (United Kingdom)	High-linear decline (41%) Medium-linear decline (5%) Medium-quadratic decline (54%)
Tu et al. (2020)	Older adults from the Chinese Longitudinal Healthy Longevity Survey (China)	Stable function (81.5%) Slow decline (14.0%) Rapid decline (4.5%)

Finally, only the study by Min (2018) reported two different trajectories of global cognition among Korean older adults. One trajectory of stable cognitive function, that the majority of the sample followed (93.3%), and another trajectory of sharp cognitive decline (6.7% of the sample).

Some research employing person-centred techniques focused on the cognitive domain of memory (Ding et al., 2019; Lin et al., 2017; McFall et al., 2019; Teipel et al., 2018; Williams et al., 2022; Z. Wu et al., 2021). The study of Ding et al. (2019) differentiated among cognitively-healthy subjects and MCI subjects from the Alzheimer's Disease Neuroimaging Initiative in the USA. Among cognitively-healthy individuals, six trajectories were reported: High-stable, medium-stable, starting medium with linear decline, starting low with linear decline, slow curvilinear decline and mild curvilinear decline. For MCI subjects, four trajectories of linear decline with different baseline level of memory and one quadratic trajectory of decline that further represented a floor effect were identified.

Moreover, Lin et al. (2017) analysed the joint trajectories of episodic memory and executive function in a sample of cognitively-healthy older adults from the Alzheimer's Disease Neuroimaging Initiative in the USA. They distinguished three different groups of individuals. One group presented high levels of both cognitive domains that declined over time (21.2% of the sample), another group also displayed high initial levels of episodic memory and executive function with maintenance of the former and increase of the latter (40.7%), and a final group was depicted by stable episodic memory and lower initial levels of executive function that further declined over time (38.1% of the sample).

Regarding the other studies employing memory to portray different trajectories, each reported a different number of trajectories. McFall et al. (2019) employed a sample of older adults from the Victoria Longitudinal Study (Canada) and defined three trajectories of episodic memory: Stable memory ageing (31.3%), normal memory ageing (47.1%) and declining memory ageing (21.6%), which resemble the developmental stages documented in the cognitive research arena. Teipel et al. (2018) used a measure of semantic memory and reported four quadratic trajectories of decline among cognitively-healthy older adults from the INSIGHT-preAD study (France): high (18.1%), high to medium (39.5%), medium (36.0%) and low (6.4%). These trajectories imply an initial decline that is followed by steeper future decline. The study by Williams et al. (2022) examined trajectories of episodic memory among older adults participating in the English Longitudinal Study of Aging and described two trajectories, similarly to Min (2018) employing a global measure of cognition: Gradual decline (91.5%) and rapid decline (8.5%). Finally, the aforementioned mentioned research by Z. Wu et al. (2021) did also consider additional cognitive domains other than global cognition, one of them being episodic memory. For this domain, Z. Wu et al. (2021) identified seven distinct trajectories, according to initial level and trend: Very high/stable (8.5%), high/increase (23.0%), high-medium/increase (28.8%), medium/stable (23.6%), medium-low/minor decline (11.8%), low/major decline (3.1%) and high-medium/major decline (1.2%).

Table 2

Characteristics of studies reporting four and five trajectories of global cognition.

Study	Sample features	Trajectories
	Four trajectories	
Lee & Jean Yeung (2019)	Individuals aged 55 to 84 from the Korean Longitudinal Study of Aging (Korea)	High-maintaining (20.3%) Moderate-stable (44.2%) Low-decreasing (23.0%) Moderate/severe (12.5%)
Z. Wu et al. (2021)	Older adults from the Aspirin in Reducing Events in the Elderly (Australia & USA)	High/stable (65.6%) Medium/stable (26.3%) Low/minor decline (6.8%) Low/major decline (1.2%)
Yu et al. (2015)	Deceased participants from the Religious Orders Study and the Rush Memory and Aging Project (USA)	Nondecliners (44.4%) Moderate decliners (34.7%) Severe decliners (13.0%) Heterogeneous decliners (7.9%)
	Five trajectories	
Espeland et al. (2018)	Older women from the Women's Initiative Memory Study (USA)	Consistently high (20.3%) Relative improvement (24.8%) Decline to median (19.1%) Decline to low (18.3%) Consistently low (17.5%)
L. Han et al. (2016)	Older adults from the Yale Precipitating Events Project (USA)	No decline (32.5%) Minimal decline (40.6%) Moderate decline (16.6%) Progressive decline (8.4%) Rapid decline (2.8%)
Park et al. (2017)	Older adults from the Health and Retirement Study (USA)	Stable high (15.4%) High to moderate (20.1%) Moderate to low (8.3%) Stable moderate (52.6%) Stable low (3.6%)

Lastly, among studies that employed person-centred techniques, and aside from the study by Lin et al. (2017), some other research that has been already mentioned also contemplated the cognitive domain of executive function in its own. More concretely, the study by Williams et al. (2022) distinguishes between a gradual decline trajectory (90.0% of the sample) and a rapid decline trajectory (10.0% of the sample). These results were similar to those found for the episodic memory domain in the same study (Williams et al., 2022), and to those found by Min (2018) using a measure of global cognition. In its part, Z. Wu et al. (2021) identify five trajectories of executive functioning over time: high/increase (1.6%), high medium/increase (10.3%), medium/increase (29.9%), medium-low/increase (40.3%) and low/stable (17.9%).

All these studies share the person-oriented analytical approach to study cognition across time. These person-centred techniques assume that the sample arises from a heterogeneous population that can be distinguished into a finite number of homogeneous subpopulations of individuals (Collins & Lanza, 2009). Two related but different person-oriented approaches were used among the studies. Some studies (Hayden et al., 2011; Lee & Jean Yeung, 2019; Lin et al., 2017; Min, 2018; Terrera et al., 2010; Williams et al., 2022; Yu et al., 2015) employed Growth Mixture Modelling (GMM). These models capture variability in latent growth trajectories that correspond to different groups or classes, representing the subpopulations (van der Nest et al., 2020). Within each trajectory, however, variability is also modelled.

A fair amount of studies (T. Y. Chen & Chang, 2016; Ding et al., 2019; Downer et al., 2017; Espeland et al., 2018; L. Han et al., 2016; Howrey et al., 2015; McFall et al., 2019; Park et al., 2017; Teipel et al., 2018; Tu et al., 2020; Z. Wu et al., 2021) applied either Latent Class Growth Analysis (LCGA) or Group-Based Trajectory Modelling (GBTM). LCGA is a special case of GMM, in which within-trajectory variability is assumed to be zero but within class error variance is acknowledged and allowed to vary across classes (van der Nest et al., 2020). That is, in each trajectory, every individual classified in that trajectory is assumed to share the same growth trajectory (J. Wang & Wang, 2012). In the case of GBTM, growth parameters are also held constant within the class but error variance is further assumed to be constant across classes and over time (Nagin & Tremblay, 2001). Constraining growth parameters to be equal for all individuals within a given class implies that deviations from the estimated parameter are treated as error (van der Nest et al., 2020).

Moreover, deciding on the number of classes to retain is sometimes problematic (Nagin, 1999) and may result in model misspecification. Assuming all individuals within a class share the same average trajectory may provoke deviant individuals to be modelled as belonging to another subpopulation (*i.e.* class), which in turn may generate multiple classes that do not represent substantially different trajectories but slight variations from a general trend (B. O. Muthén, 2004). In the wider GMM context, authors also warn about the perils of assuming substantive meaning of latent trajectory classes (Bauer & Curran, 2003). Throughout the reviewed literature using person-centred approaches, reported results generally represent different variations of a general trend. For example, in studies that reported a three-class trajectory solution as best representing the data, they typically describe high, medium and low trajectories of cognitive function decline (see, for example: Hayden et al., 2011; Howrey et al., 2015; Teipel et al., 2018;

McFall et al., 2019). The same happens in the other studies reporting different number of classes. These studies mainly capture slight variations in cognition, rather than substantive trajectories. For instance, Z. Wu et al. (2021) employed GBTM to examine trajectory classes of global cognition, vocabulary/executive function, episodic memory and attention/psychomotor speed. For episodic memory, they reported up to seven different trajectories (very high/stable, high/increase, high-medium/increase, medium/stable, medium-low/minor decline, low/major decline and high-medium/major decline), that represented slight, minor variations in intercept and/or slope rather than different developmental trends. As another example, among the trajectories reported by Yu et al. (2015) using GMM, there was a trajectory of moderate decliners and another one of heterogeneous decliners. The latter trajectory was different from the former in that individuals within this class presented large error variance, although both presented the same declining trend. This illustrates the problem of growth parameter constriction, as well as over extraction of classes.

Lastly, B. O. Muthén (2004) insists on the importance of including model covariates when specifying the GMM or LCGA/GBTM, as they influence class proportions, the number of classes and class membership. Therefore, the unconditional model may entail model misspecification. Moreover, covariates ought not only affect the latent class but also the growth factors (B. O. Muthén, 2004). Across the reviewed literature, the mainstream approach is to estimate the unconditional model employing either technique and later test the effect of covariates on class membership only (see, for example: Hayden et al., 2011; Lee & Jean Yeung, 2019; McFall et al., 2019; Park et al., 2017; Teipel et al., 2018). As Bauer and Curran (2003) state “growth mixture models are more typically used in an exploratory mode, with post hoc interpretations of the class trajectories" (p. 359).

Given the above-mentioned reasons, the person-centred approach does not appear to be the most appropriate approximation to modelling of longitudinal cognitive data. An alternative set of techniques are the variable-centred ones, in which the focus is in the relationship among the variables (Howard & Hoffman, 2017). Some authors argue that these techniques fail to acknowledge population heterogeneity (Laursen & Hoff, 2006). However, variable-centred techniques such as Linear Mixed Modelling (LMM) or Latent Growth Modelling (LGM) do contemplate inter- and within-individual variation. Moreover, these same authors (Laursen & Hoff, 2006) state that this approach suits longitudinal research of developmental trajectories, if these are thought to be similarly experienced by individuals.

As mentioned before, studies that employed these alternative, variable-centred, techniques also presented diversity in their conceptualisation of cognition. One study (W. Zhang et al., 2022) employed a measure of global cognition, while two other (Bertola et al., 2019; Liampas et al., 2022) focused on the memory domain. Besides these, some authors examined more than one component of cognition. Yam et al. (2014) contemplated four different components (inductive reasoning, processing speed, memory and vocabulary), and Johnson et al. (2012) considered up to five different dimensions (memory, executive functioning/processing speed, visuospatial ability, language and attention). Furthermore, the specific technique employed also varies across studies. Some did multi-group LGM (Bertola et al., 2019), parallel LGM (Johnson et al., 2012) or general LGM (Yam et al., 2014), while others employed multilevel generalised LMM (W. Zhang et al., 2022) or Generalized Estimating Equations (GEE; Liampas et al., 2022).

Regarding their results, W. Zhang et al. (2022) report a linear trajectory of global cognitive decline, and Bertola et al. (2019) and Liampas et al. (2022) report a trajectory of linear memory decline over time. In its part, Johnson et al. (2012) tested parallel trajectories of memory with the other specific cognitive domains and further examined differences between individuals with MCI and healthy controls. They found that both groups displayed linear trajectories of memory decline in all cases, although the impaired group displayed more acute decline. Only cognitively impaired individuals additionally showed linear trajectories of decline in the other cognitive domains. Finally, Yam et al. (2014) examined latent trajectories of inductive reasoning, processing speed, episodic memory and vocabulary separately, and found that in all cases a quadratic trajectory of decline best represented the data. With the exception of Johnson et al. (2012), using data from the Alzheimer's Disease Neuroimaging Initiative in the USA, the rest of studies employed samples of healthy older adults. Two of the samples were also from the USA (Bertola et al., 2019; Yam et al., 2014), one was from Greece (Liampas et al., 2022) and the other one was from China (W. Zhang et al., 2022).

In general, a lot of heterogeneity is observed in the longitudinal cognitive literature, both regarding the approximation to cognition and the methods used to approach its study. Regarding the measurement of cognition, Steinerman (2010) argues that using a measure of global cognition to characterise patterns of cognitive performance across the lifespan may fail to capture subtle age-related changes. In fact, some authors report lack of sensitivity in such general scores (Floden et al., 2015) and additional evidence shows that cognitive domains are more adequate in predicting functional decline and mortality than a general measure of cognition (Johnson et al., 2007). Indeed, across the reviewed studies, some of those that contemplated more than one cognitive domain found different class solutions for each domain (Teipel et al., 2018; Z. Wu et al., 2021). Moreover, as will be discussed in the next section, the conceptualisation of cognition as constituted by different domains shows differential effects of predictors onto the different cognitive domains.

Cognitive domain differentiation also presents difficulties on its own. As Harvey (2019) claimed, the conceptualisation of cognitive ability domains can be done in several ways, either using process or brain functional regions as criteria. In this work, based on the reviewed literature, a domain-based approach to the study of cognition will be adopted. The proposed differentiation of cognitive ability into domains will be that of the Diagnostic and Statistical Manual of Mental Disorders (DMS-5-TR; American Psychiatric Association, 2022).

The DSM-5-TR establishes six main neurocognitive domains that make up cognition: complex attention, executive function, learning and memory, language, perceptual motor skills and social cognition. Complex attention includes sustained attention, divided attention, selective attention and processing speed (American Psychiatric Association, 2022). It is considered to be a required precedent for executive function and memory (Ruthruff & Lein, 2017). Attention implies the ability to focus cognitive activity in determined stimuli or task intentionally and for a variant length of time (Staub et al., 2013).

Executive function includes planning, decision-making, working memory, responding to feedback/error correction, overriding habits/inhibition and mental flexibility (American Psychiatric Association, 2022). These functions allow the person to adapt to changing environmental demands (Unger & Karbach, 2017) and are considered especially relevant in ambiguous, unknown or complex situations (Jurado & Rosselli, 2007).

Learning and memory include immediate memory, recent memory and very-long-term memory (American Psychiatric Association, 2022). They are difficult to distinguish, but memory is considered a subsystem of learning (Lu et al., 2018; Rast, 2017; Walsh & Lovett, 2016), given that memory is the process by which a certain experience is registered and retrieved and learning is a process of behavioural change produced by such experience.

Language includes expressive language and receptive language (American Psychiatric Association, 2022), with several specific neural networks interacting in both language production and language comprehension (Shafto & Tyler, 2014).

Perceptual and motor functions include visual perception, visuoconstructional, perceptual-motor coordination, praxis and gnosis (American Psychiatric Association, 2022). All these processes allow the individual to interact with the world (L. Wang et al., 2015).

Finally, social cognition includes recognition of emotions and theory of mind (American Psychiatric Association, 2022). According to Natelson-Love et al. (2015), social cognition is also a way to interact with the world and thus depends on the perceptual-motor domain, given that social signals need to be perceived and processed in a determined context.

1.3. Correlates of cognition

In this section, relationships between cognition and other variables will be extensively reviewed, both at the cross-sectional and at the longitudinal level. First, relationships between sociodemographic variables and cognition will be discussed. Then, literature on the association between physical dimensions of the individual, such as physical activities, chronic disorders or smoking, and cognition will be examined. After that, this section will cover correlates of cognition related to the psychological sphere, as for example depression, frailty or loneliness. Finally, social factors potentially related to cognitive functioning will be reviewed.

1.3.1. Sociodemographic variables

As mentioned earlier, the study of cognition in old age is of relevance because in this specific developmental stage individuals' cognitive abilities start to decline, following normative cognitive ageing, whose severity could progress to a point where MCI, or ultimately dementia, are considered. Deterioration of humans' biological systems is well known across the life cycle and its manifestation are especially evident in the old age (Harada et al., 2013). In this regard, the impact of age on the different cognitive abilities has received great empirical support.

Be that as it may, other sociodemographic characteristics of individuals are thought to also have an effect on cognition as they age. One of these is education, which is seen as a protective factor against cognitive decline. According to the cognitive reserve theory (Stern, 2002), former education received by an individual, among other phenomena, is thought to provide a cognitive reserve to cope with age-related decline, so that this decline does not affect cognitive performance to the same degree (Harrison et al., 2015; Stern, 2012).

There is a considerable amount of research that provides evidence about the relationship between this sociodemographic factor and cognition. For example, Weber et al. (2014) found education to be positively related to cognition. Results from the correlational study by Lourenco et al. (2018) showed that higher age and lower educational level were associated with a lower level of cognitive abilities, namely executive function and perceived memory. Bertola et al (2019), in its part, considered educational level as a moderator variable and reported that initial levels of cognition as well as race had an effect on memory on high-educated individuals but not among lower-educated ones.

Among studies employing person-centred techniques, Ding et al. (2019) showed that higher education significantly increased the odds of being classified in the class of less memory decline in both cognitively-healthy and MCI subjects. In turn, Espeland et al. (2018) reported that participants classified in the less favourable cognitive trajectory presented lower levels of education. This association of higher educational attainment to trajectories of less cognitive decline over time has been repeatedly observed in studies using the aforementioned approach (L. Han et al. 2016; Howrey et al., 2015; McFall et al., 2019; Min, 2018; Park et al., 2017; Teipel et al., 2018; Terrera et al., 2010; Tu et al., 2020; Williams et al., 2022; Z. Wu et al., 2021)

Another frequently studied factor is socioeconomic status, comprised by the social and economic assets of the individual. According to the cognitive enrichment hypothesis (Scarmeas & Stern, 2003), exposure to enriched, demanding contexts offer the opportunity to make use of cognitive abilities that, in turn, aid maintenance of the cognitive reserve. In this context, the amount of social and economic resources an individual has is seen as a marker of the cognitive enrichment potential their environment has (Migeot et al., 2022).

In this line, one study examining the longitudinal association of socioeconomic status, measured as family assets and years of education, with executive function and memory showed a positive relationship between the socioeconomic status and these cognitive domains, both at the same time and after a four-year delay (Miceli et al., 2019). Work by Cadar et al. (2017) also focused on the longitudinal effects of education and family income, among others, on memory in a sample of older adults from 10 European countries. Higher levels of both family income and education exerted a positive effect on recent and delayed memory, although family income only displayed a positive relationship to initial memory and not to its rate of change.

In turn, Bourassa et al. (2017) employed LGM to study the effect of age and family income, among other factors, on memory and executive function. Results reported in this study show that higher age had an effect on lower initial levels of these cognitive abilities as well as worse performance over time. On the other side, family income only explained higher initial levels of ability but had no effect over time.

Furthermore, person-centred approaches also contemplated age, gender and socioeconomic status in their analysis of latent cognitive trajectory classes. In general, older age is associated with a higher probability of belonging to the group with worse cognitive performance over time (Ding et al., 2019; Downer et al., 2017; Howrey et al., 2015; Min, 2018; Park et al., 2017; Teipel et al., 2018; Tu et al., 2020; Z. Wu et al., 2021). Seemingly, Park et al. (2017) provide some evidence of the association between lower socioeconomic status at childhood and at adulthood and a less favourable cognitive trajectory.

Regarding the effect of gender on cognition, evidence is somewhat mixed. A study by Lundervold et al. (2014) reported lower levels of memory decline among women. Female gender has further been associated with more favourable trajectories of recent memory (Ding et al., 2019; Lin et al., 2017; McFall et al., 2019; Z. Wu et al., 2021), executive function (Lin et al., 2017; Z. Wu et al., 2021) and global cognition (Howrey et al., 2015; Min, 2018; Z. Wu et al., 2021) in studies employing a person-centred approach. However, some other studies have found female gender to be associated with higher odds of belonging to less favourable groups, in terms of delayed memory (Liampas et al., 2022) and global cognition (Terrera et al., 2010; Tu et al., 2020).

Therefore, it seems that gender may have a differential effect depending on the cognitive component that is considered.

Finally, Lavrencic et al. (2018) studied the effect of the years of education received by an individual to their attention, executive function, memory, social cognition and perceptual motor skills. In line with the cognitive reserve theory, they found education to present an effect in attention, memory and executive function but not in the other domains. This study provides evidence on the differential behaviour of cognitive reserve on different cognitive domains, as also did previous findings (Ritchie et al., 2015; Roldán-Tapia et al., 2012).

1.3.2. Physical variables

Evidence shows that, in old age, chronic inflammatory processes account for the observed deterioration of biological systems, a condition known as inflammaging (Franceschi et al., 2000) or inflammation hypothesis (Chung et al., 2001). These processes entail alterations in cells and tissues (Chung, 2019) and have been related to cardiovascular disorders as well as to other chronic disorders such as cancer, osteoporosis, depression and dementia (Ferrucci & Fabbri, 2018). Additionally, some physical factors such as exercise or diet restriction have anti-inflammatory effects that are beneficial for older individuals (Weyh et al., 2020). From this theoretical perspective, the difference between normative ageing and pathological ageing relies on chronic inflammation. Therefore, inflammaging can be considered a marker of accelerated physiological ageing.

Among physical variables, literature has often focused in physical activity. Several studies report a positive relationship between physical activity and cognition (for example: Beydoun et al., 2014; Blondell et al., 2014; Buchman et al., 2012; Frederiksen et al., 2015; Ku et al., 2012; Middleton, 2011; Tolppanen et al., 2015). In the same fashion, physical inactivity or sedentariness have been considered risk factors for the development of cognitive impairment (Hessel et al., 2018; Lourenco et al., 2018). Indeed, some studies that examined trajectories of global cognition observed that individuals who engaged in fewer physical activities present a higher probability of being in the trajectory with sharper cognitive decline (Min, 2018; Yu et al., 2015).

Regarding specific cognitive domains, research reports the effects of physical (in)activity on executive function (Baker et al., 2010; Dai et al., 2013; Lourenco et al., 2018; Nagamatsu et al., 2013;), memory (Hessel et al., 2018; Miller et al., 2012; Suzuki et al., 2013) and attention (Baker et al., 2010; Lam et al., 2011; Nagamatsu et al., 2013; Yágüez et al., 2011), as well as on global cognition (Lam et al., 2011; Lautenschlager et al., 2008; Suzuki et al., 2013; Vreugdenhil et al., 2012).

All in all, the amount of physical activity individuals perform in their daily routines is one of the predictive factors of cognition the literature has most frequently examined, and its explanatory effect on cognition has also been established across time (Blondell et al., 2014; Ku et al., 2012; Lam et al., 2011; Miller et al., 2012; Suzuki et al., 2013).

Other factors related to the physical dimension of the individual that have received attention are cardiovascular risk factors, such as obesity, hypertension, diabetes, smoking, stroke and heart attack. As previously mentioned in section 1.1, noncommunicable diseases are the main cause of death for developed countries (McCracken & Phillips, 2017) and most of these are derived from the aforementioned factors. However, some authors have further studied the relationship between these factors and cognition.

Obesity and diabetes have been associated with cognitive impairment (Crane et al., 2013; Hessel et al., 2018). Regarding the evidence about the association of diabetes and cognition, one study reported diabetes to be associated with lower odds of being classified in a cognitive trajectory of high cognitive maintenance over time (T. Y. Chen & Chang, 2016), while other study reported higher presence of Type II diabetes among less favourable cognitive trajectories (Espeland et al., 2018). The relationship between weight and cognition appears to be less clear, as longitudinal research reports a higher Body Mass Index (BMI) to be associated with better cognitive progression (McFall et al., 2019; Tu et al., 2020). One possibility is that, when inflammation takes place, both the digestive system and the nervous system start to deteriorate and, consequently, weight loss and cognitive impairment take place simultaneously. Recent work by Norman et al. (2021) argues that initial sedentariness and obesity lead to ectopic fat accumulation, which in turn eases the occurrence of inflammaging, that contributes to malnutrition, one of whose outcomes is diminished BMI.

Other studies considered stroke and argued that it is one of the most important cardiovascular risk factors in relation to cognitive decline (Lourenco et al., 2018), and a relationship between stroke and Alzheimer's Disease was established in a meta-analytic study by Zhou et al. (2014). On the other hand, the study by Lourenco et al. (2018) also showed that smoking was associated with higher odds of impairment in the cognitive domains of memory and executive function. A similar study by T. Y. Chen and Chang (2016) using a measure of global cognition also reported smoking to be associated with a lower probability of being in the high-stable cognitive group. In this line, some authors claim that neurotoxins associated with tobacco can have a detrimental effect on functioning of some cognitive domains (Gorelick et al., 2011; Sabia, 2008).

Finally, chronic disorders in general have been also related to worse cognitive functioning. In fact, the number of chronic disorders is considered a marker of exposure to vascular risk factors for the development of cognitive impairment (Gorelick et al., 2011; Lim et al., 2016; Lourenco et al., 2018). Research on cognitive trajectories also supports the negative impact of chronic disorders on cognition. Namely, Park et al. (2017) and Tu et al. (2020) report a higher initial number of chronic conditions to be positively associated with higher probabilities of belonging to the impaired cognitive group.

1.3.3. Psychological variables

Among the psychological dimension of the individual, depression among older adults is an important phenomenon, as evidence shows that it presents negative associated outcomes for the lives of older individuals and is often underdiagnosed (T. Hu et al., 2022; Zenebe et al., 2021). This, together with the increasing trend of the prevalence of depression (Moreno-Agostino et al., 2021), make it a frequently studied phenomenon in geriatric research. Depression can be defined as a mood disorder that produces alterations in sleep, appetite, energy levels and it is often accompanied by feelings of sadness and negative thoughts (Potter & Steffens, 2007). Moreover, depressive symptomatology has been related to changes in cognition (McDermott & Ebmeier, 2009).

Evidence shows that the risk of dementia duplicates among older individuals with a diagnosis of depression, and some have argued that this mood disorder can be considered a risk factor for the development of Alzheimer's Disease (Green et al., 2003; Ownby et al., 2006). Additionally, Major Depression Disorder has been labelled an important risk factor for the development of future dementia (R. Chen et al., 2008).

In fact, depressive symptomatology includes problems in concentration (American Psychiatric Association, 2022), which could also be considered an early indicator of cognitive impairment. In this regard, some authors suggest that depression could be considered a prodromal manifestation of future dementia (Ismail et al., 2018; Steffens, 2012; Stella et al., 2014). According to vascular depression hypothesis (Alexopoulos et al., 1997), age-related neurovascular disease may activate, accelerate or be responsible for depressive syndromes in old age, or so-called late-life depression. Moreover, evidence shows (Taylor et al., 2013) that neurovascular deterioration usually affects prefrontal and frontal regions of the brain, which has also been observed in cognitive impairment (Steffens, 2012). Finally, neurovascular disease entails inflammation which has further been observed in relation to cognitive decline (Ferrucci & Fabbri, 2018).

In this regard, several studies have analysed the effect of depression or depressive symptomatology in individuals' cognitive trends along time. For example, T. Y. Chen and Chang (2016), employing a person-centred approach, reported that depression was associated with a lower likelihood of being classified in a high stable group of global cognition. Other studies employing seminal analytical approaches also conceptualised cognition as a global element (Downer et al., 2017; L. Han et al., 2016; Howrey et al., 2015; Min, 2018; Yu et al., 2015) and findings from these studies also showed depressive symptomatology to be related to less favourable trajectories of cognition. In addition, McFall et al. (2019) focused on the memory domain specifically and reported similar results. It is worth noting that none of the studies focused in the executive function domain. Studying the effects of depression on this particular domain becomes especially relevant, as it involves frontal lobe activation (Otero & Barker, 2014; Stuss, 2011) and this is the brain region often affected by neurovascular deterioration (Taylor et al., 2013).

Another factor that has been examined in relation to cognition is loneliness (Boss et al., 2015; Cacioppo & Hawkley, 2009; McDermott & Ebmeier, 2009), which is also associated with depression (Kong et al., 2018). Loneliness is understood as a subjective experience of lack of fulfilling human relationships (Tilvis et al., 2012) and is considered a risk factor for the behavioural and psychological symptoms of dementia (Sun et al., 2021).

There are three tentative explanations for the association between cognitive impairment and loneliness. One of them argues that loneliness could lead to bad life habits (Baumgart et al., 2015; Berkman et al., 2000; Golden et al., 2009). Another one suggests that biological correlates of loneliness could impact on cognitive functions (Berkman et al., 2000; Boss et al., 2015). Lastly, the third hypothesis suggests that loneliness implies a state of social deprivation in which individuals may lack the benefits that social relationships have for cognition, which in turn rises the risk for cognitive impairment (Berkman et al., 2000; Fratiglioni et al., 2004). Work by Kong et al. (2018) reports an association between loneliness and cognitive impairment, but the association dissipated when considering depression. Authors from this work suggest that loneliness and depression affect cognition simultaneously. However, another possibility is that the relationship between loneliness and cognition is often confounded by depression.

Lastly, frailty has also been studied in relationship to older adults' cognition (Brigola et al., 2015; Godin et al., 2017; Godin et al., 2018). Considered a geriatric syndrome, there is no consensus about the exact definition of frailty. The most common way to understand this syndrome is, however, the one proposed by Fried et al. (2001). These authors argue that frailty is made up by five criteria: feelings of fatigue, involuntary weight loss, reduced grip strength, slowness and physical inactivity.

In general, correlational studies examining the association between frailty and cognition agree that higher levels of frailty are often accompanied by higher levels of cognitive impairment (Ávila-Funes et al., 2011; E. S. Han et al., 2014; Kulmala et al., 2014; Macuco et al., 2012; Moreira & Lourenço, 2013; Yassuda et al., 2012). Longitudinal studies also bolster this relationship over time (Alencar et al., 2013; Auyeung et al., 2011; Boyle et al., 2010; Godin et al., 2017; Gray et al., 2013).

Among the aforementioned studies, not all of them employed Fried et al.'s (2001) approach to the conceptualisation of frailty. Some research considered other alternative operationalisations of frailty as a physical and psychological syndrome (Godin et al., 2017). Additional studies conceptualised frailty as a physical syndrome using alternative criteria (Auyeung et al., 2011; Boyle et al., 2010; Kulmana et al., 2014; Macuco et al., 2012; Yassuda et al., 2012). All in all, the definition of frailty is not universal. Additional conceptualisations have also referred to cognitive frailty as a state of physical frailty accompanied by MCI (Kelaiditi et al. 2013), but some authors (Facal et al., 2019) argue that this term lacks specificity both in terms of its concept and of its operationalisation. In this line, and building on previous evidence on the longitudinal association of frailty and cognition, cognitive frailty status may be understood as the result of two differentiated events: enduring frailty along time and developing cognitive impairment.

1.3.4. Social variables

Although not new, some research that has received increased attention in recent years is that of social participation in relation to cognitive impairment. Social participation can be understood as individuals' involvement in social activities such as religious groups, volunteering, sports or social clubs or community-related organizations (Bourassa et al., 2017; Miceli et al., 2019). Evidence shows that social activity is related to cognition along the life cycle, but that this relationship becomes more evident in the old age (James et al., 2011; Seeman et al., 2011).

In the context of the cognitive enrichment hypothesis (Scarmeas & Stern, 2003), older adults' engagement in different activities may offer cognitive-demanding scenarios that contribute to the maintenance of cognitive reserve (Bourassa et al., 2017; Hertzog et al., 2008). Research has mainly focused in social activities specifically and both correlational

(Choi, 2020; Fu et al., 2018; Krueger et al., 2009; Litwin & Stoeckel, 2015) and longitudinal evidence (Glei et al., 2005; Hwang et al., 2018; McFall et al., 2019; Miceli et al. 2018; Seeman et al., 2011; Teipel et al., 2018) suggests that greater engagement in social activities implies higher levels of cognitive functioning. Some other studies have focused in intellectual activity participation and also report a positive longitudinal association between higher engagement in this kind of activities and less cognitive impairment over time (Hultsch et al., 1999; Yu et al., 2015).

Among studies that contemplated both types of activities simultaneously, Fernández et al. (2023) found social and intellectual activity participation to be positively related to different cognitive domains, namely verbal fluency, memory, numeracy and temporal orientation. These authors reported, however, that both activities did not equally influence these domains, and intellectual activity participation generally presented larger effect sizes. Moreover, while engagement in intellectual activities presented meaningful effects for all aforementioned domains, engagement in social activities was relevant for memory and verbal fluency in particular. Other study that differentiated among social and intellectual activity participation reported higher levels of engagement in both types of activities to be associated with the most cognitively-healthy trend over time (H. Li et al., 2020). Nevertheless, these authors employed a measure of global cognition, so information regarding specific effects of participation in different activities on different cognitive domains is not available longitudinally.

Finally, Litwin and Stoeckel (2016) report a positive association of social participation with memory, as well as with social network.

When this latter association was contemplated, the relationship between social participation and memory decreased. In light of these results, the authors argue that social activity participation may serve as a form of social contact, that is positively associated with memory. In this regard, some research examined the relation of social network and cognition. Social network is understood as the system of individuals surrounding the individual and it is operationalised in terms of size, kind of relationship and contact frequency (Kelly et al., 2017). Generally, results point to a positive effect of social network on cognitive maintenance (for example: Barnes et al., 2004; Béland et al., 2005; Kimura et al., 2017).

Finally, research has also examined the effects of social support in relation to cognition, with unalike results. On the one hand, Yeh and Liu (2003) found a positive relationship between social support and cognitive function. Some other authors (Rashid et al., 2016) reported older adults with low social support to present threefold chances of developing cognitive impairment. On the other hand, findings from the study by Sims et al. (2014) showed a negative association between social support and cognition, which implies higher levels of social support to be associated with a higher number of cognitive problems, in terms of memory and inhibition. Additional evidence reported different findings as a function of gender and the type of social support considered (Liao & Scholes, 2017; Murata et al., 2019). A possible explanation for these results could rely in the way social support was measured across these studies. For example, the study by Sims et al. (2014) conceptualised social support as perceived availability of social support in activities from different areas of the individual, as also did the study by Murata et al. (2019). Other authors, in turn, employed more subjective indicators, such as understanding one’s feelings or perceiving there is someone to rely on when problems arise (Liao and Scholes, 2017; Rashid et al., 2016; Yeh & Liu, 2003). Other authors (Haber et al., 2007) also point to a difference between specific perceived supportive behaviours and general availability of support, and argue that it is the latter that presents implications for health.

1.4. A holistic approach

Robert J. Havighurst is considered the forefather of successful ageing (SA) research. In his seminal work, Havighurst (1961) established the first approximation to the operationalisation of SA theories. He defined a theory of SA as “a statement of the conditions of individual and social life under which the individual person gets a maximum of satisfaction and happiness” (p. 8). In this work, Havighurst summarized previous procedures for SA measurement and concluded that the most appropriate one relied in the measurement of what he called “individual’s life satisfaction”. He went on to propose a five-dimensional model of satisfaction with life. These dimensions and their meaning are available in Table 3.

Another seminal work within the gerontological research arena was the one by Rowe and Kahn (1987). These authors suggested that lifestyle factors could account for age-related declines, and therefore proposed an additional differentiation within non-pathological ageing into successful and usual ageing. This differentiation was also intended to serve as an explanation of the heterogeneity observed within the normative agers. According to these authors, factors such as diet, exercise or nutrition moderated the ageing process. Regarding cognition in particular, Rowe and Kahn (1987) stated that “much of the cognitive loss in late middle life that has been considered intrinsic to ageing is caused in part by extrinsic factors and may therefore be preventable” (p. 145).

Table 3

Satisfaction with life dimensions proposed by Havighurst (1961)

Dimension	High	Low
Zest vs. Apathy	Involvement in meaningful activities	Apathy as well as meaningless, unenjoyed, hyper-activity
Resolution and fortitude	Accepting personal responsibility for his life	Feelings of resignation, intropunitive and extrapunitive attitudes
Goodness of fit between desired and achieved goals	Self-realization with one’s goals	Feelings of regret about past missed opportunities
Positive self-concept	Good concept of self with regard to physical and psychological attributes	Negative feelings and perceptions towards self
Mood tone	Feelings of pleasure for life, optimism and affection	Displaying sad mood, irritability, helplessness or feelings of loneliness

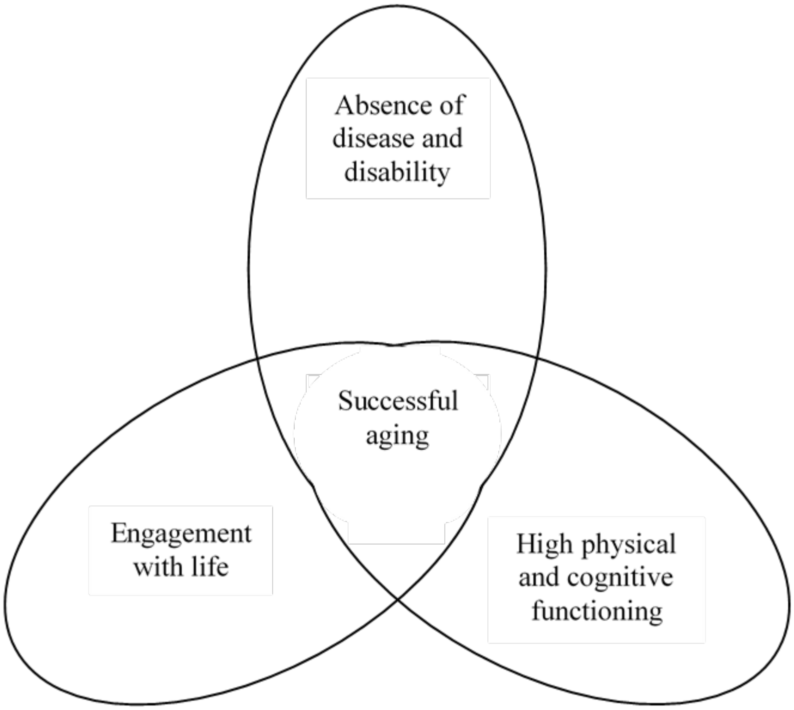
A few years later after the establishment of the distinction between usual and successful ageing, Rowe and Kahn (1997) proposed a conceptual framework for SA. This theoretical framework comprises three hierarchical components: absence or low risk of disease and disability, high physical and cognitive functioning and active engagement with life. The two first components are subordinated to the third one, as these authors claim that absence of disease and disability imply high levels of functioning at the physical and cognitive level, and both allow for engagement with interpersonal relationships and productive activity – paid or not. Figure 1 displays the theoretical model of SA according to Rowe and Kahn (1997). Therefore, according to this theoretical paradigm, these are the three conditions that the individual ought to fulfil in order to age successfully.

It should be noted that Rowe and Kahn's model of SA emerged at a time in which the World Health Organization had just made a shift from the notion of health as absence of disease towards the positive, dynamic and empowering concept of health promotion (WHO, 1984). In this sense, these authors merit the credit for being pioneers in considering individuals' extrinsic factors as enhancers of health in the old age. All in all, the Rowe-Kahn paradigm has been greatly acknowledged in the gerontological literature and numerous scholars reflected on this theoretical framework to advance knowledge in ageing research (Rowe & Kahn, 2015).

Although a very progressive theory, some criticisms have been raised around Rowe and Kahn's (1997) model of SA. In 2015, *The Gerontologist* released a special issue in which the most prominent scholars in the SA arena contributed with different topics around the reformulation and possible upgrades and expansions of the model.

Figure 1

Rowe and Kahn's (1997) theoretical model of successful ageing



One of these contributions was a systematic review of the critiques received by the model over the years (Martinson & Berridge, 2015). In this study, the authors differentiated the critiques into four categories that will be employed here to guide the discussion about the model's limitations. The first category referred to the narrowness of SA criteria. In this sense, Cheng (2014) also signalled the excessive biomedicalization of ageing made by Rowe and Kahn's model. Namely, the model of SA suggests absence of disease and disability, or low risk of such, to be a requisite for success. As argued by Cheng (2014), some diseases do not limit individuals' functional capacities at all and therefore do not pose a burden for ageing successfully. All in all, among the proposed criteria to be added to the definition of SA, the most prevailing in the literature concerns social elements at the micro- and macro-levels (Katz & Calasanti, 2015; Martinson & Berridge). Other authors have also suggested embedding Rowe and Kahn's model in a life-course perspective that takes into account the historical, cultural and social contexts of the individual, and lessens the strain of individual agency as the only determinant of SA (Stowe & Cooney, 2015).

The second category of critiques was also related to SA criteria, but such criticism focused on the need to include individuals' subjective assessments of their success (Martinson & Berridge, 2015). Overall, prevalence estimates of SA according to Rowe and Kahn's criteria are systematically lower than those established according to individuals' subjective assessments. Already by the time Havighurst (1961) discussed the different operationalisations of SA, he noted that no operational definition of the construct should assume there is only one desirable condition. In Rowe and Kahn's model of SA there is a clear standard, as these authors suggest that avoidance of disease and high functioning are desirable because they allow the individual to keep engaged with life, assuming that engagement is the desirable condition. Criticism argues that SA does not present a universally shared meaning and that disparity in prevalence of estimates may be due to a failure to include subjectively defined criteria that allows cultural and inter-individual variability in the conceptualisation of SA (Cheng, 2014; Wahl et al., 2016).

Further criticisms point to the individualistic essence of the model and the stigmatization of those who do not manage to age successfully and a bias towards more genetically predisposed individuals (Martinson & Berridge, 2015). Regarding individualism, Rubinstein and de Medeiros (2015) developed a critique on the similarities between the model and neoliberalism, given that both focus on the individual as the main agent of change. Moreover, work by Stowe and Cooney (2015) suggested that taking a life course approach to SA would also permit relaxing the strain on individual agency, as these authors argued that Rowe and Kahn's model relied excessively on the individual. They also claimed that acknowledging inter-individual heterogeneity in the ageing process as the outcome of different developmental patterns would also help avoid stigma around those individuals that do not manage to age successfully in terms of the model (Stowe & Cooney, 2015). Additionally, Rubinstein and de Medeiros (2015) made several remarks about the perils the Rowe-Kahn paradigm of SA had for unsuccessful agers and the failure of the model to identify successful agers despite disability, for example Stephen Hawking or Mother Theresa.

The fourth category of critiques claimed for the reconceptualisation of successful ageing towards a more holistic paradigm of ageing that acknowledges losses and social and spiritual dimensions, not considered before (Martinson & Berridge, 2015). Academics within this perspective attempted to offer alternative models that made up for Rowe and Kahn's model deficiencies.

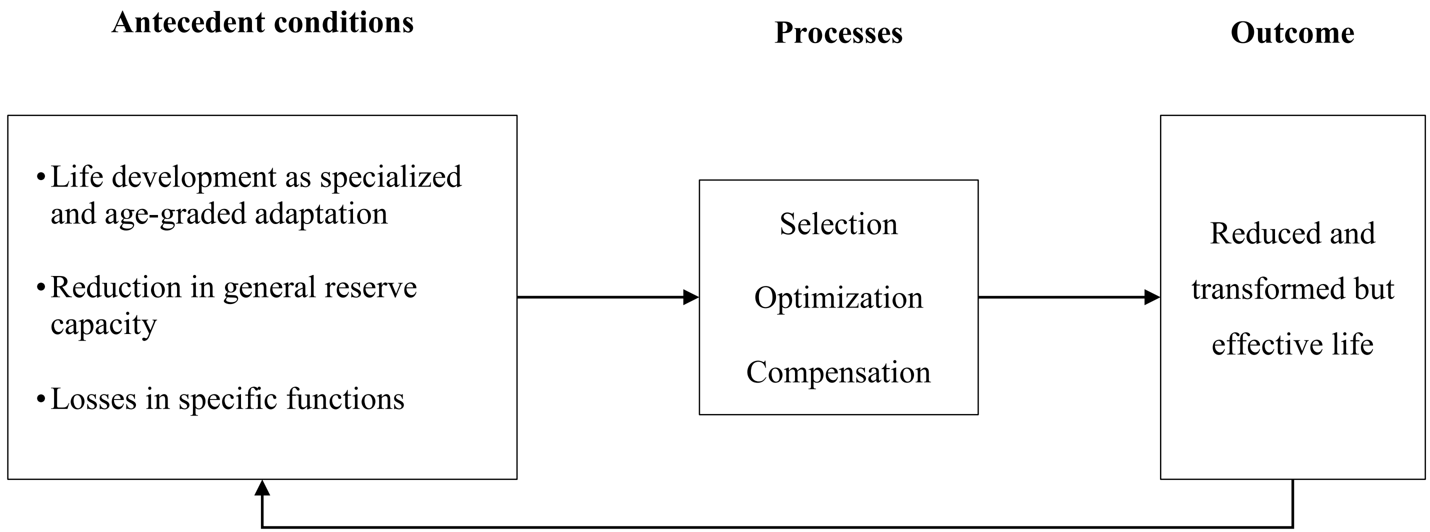
Such alternative models include the Selective Optimization with Compensation (SOC) model by Baltes and Baltes (1990), that approaches the study of SA from a life-course perspective that is consistent with the SA framework. Moreover, in contrast with previous theoretical propositions, the model acknowledges inter-individual variability as well as social and contextual circumstances. Based on the notions of variability and plasticity, the authors argue that ageing is an adaptive process constituted by the three main components of selection, optimization and compensation, that are derived from the following seven propositions about the essence of ageing:

i. Differences exist among normal, optimal and pathological ageing.
ii. A lot of heterogeneity is observed in the ageing process.
iii. There is substantial unobserved reserve capacity.
iv. There is age-related loss of reserve capacity.
v. Reserve's age-related declines can be moderated by knowledge and technology.
vi. Gains and losses achieve a balance with ageing.
vii. Individuals remain resilient in old age.

From these propositions, Baltes and Baltes (1990) suggest a general process of adaptation by which the individual navigates their age-related gains and losses. Selection involves focusing on the domains of functioning of high priority, taking into account individuals' motivations and environmental demands. This allows for the adjustment of expectations so they can be fulfilled giving rise to the subjective experience of satisfaction. Optimization implies the focus of individuals' energy on actions that can enhance their reserves and maximize the domains of high priority. Finally, compensation makes reference to the replacement of loss or diminished behavioural capacity by other mental capacities or technology, that make up for the deficiency. By doing this, the individual minimizes age-related declines and maximizes gains to obtain a more positive balance. A graphical representation of the model, adapted from Baltes and Baltes (1990) is available in Figure 2.

Figure 2

Selective Optimization with Compensation model, adapted from Baltes and Baltes (1990)



Although this model was proposed as a general model of successful development, it was deemed especially relevant for the old age. Nonetheless, Freund and Baltes (2002) hypothesized a decline in SOC behaviours due to age-related functional losses, following the previous study's findings of a decrease in SOC behaviours with increasing age (Freund & Baltes, 1998). These authors also argued that older individuals that continue using SOC strategies also display higher levels of functioning (Freund & Baltes, 2002). In this line, evidence from Carpentieri et al. (2017) showed that older individuals who engaged in SOC behaviours displayed higher levels of well-being despite their levels of physical function but the inverse was not true, and concluded that SOC behaviours could mediate the relationship between physical function and well-being.

All in all, the SOC model offers a valuable perspective on adaptive processes that allow the maximization of individuals' potential throughout the life cycle. However, there are some shortcomings related to the measurement of SOC (see Moghimi et al., 2019) and the model's approximation to successful ageing. As a process model, the emphasis of the model relies in SOC behavioural strategies, and success is defined as the employment of such strategies regardless of the outcome.

An alternative model that focuses on ageing exclusively while maintaining a holistic and inclusive approach is the Preventive and Corrective Proactivity (PCP) model by Kahana and Kahana (1996). This model was developed in response to the lack of theoretical frameworks addressing the antecedents of successful ageing not considering older adults as passive respondents of their environments. The model "explores ways in which older adults shape their armamentarium of resources and enhance their late-life well-being as they prepare to confront and actually face normative stresses of aging" (p. 19; Kahana & Kahana, 1996).

This model agrees with Baltes and Baltes's (1990) contribution in that the older individual interacts with external and internal resources to reduce their vulnerability while also shaping their priorities. However, Kahana and Kahana's (1996) approximation to successful ageing is not limited to these behavioural strategies but considers challenges specific to the ageing process without excluding genetic and socio-structural factors, as they are contemplated in older adults' resources and stressors. The PCP model implies a forward leap in complexity that better achieves to represent the complex reality of ageing.

According to the PCP model (Kahana & Kahana, 1996), individuals face stressors that may impact in their capacity to age successfully, as defined by positive affect, meaning in life and maintenance of activities and relationships. Nonetheless, individuals also have external resources that can buffer the negative impact of stressors onto successful ageing. Affecting these external resources and also impacting on the stress-success relationship, there are preventive and corrective adaptations individuals can endorse in order to age successfully. Psychological dispositions are defined as internal resources for successful ageing and constitute the antecedents of both adaptation components. Finally, socio-structural influences are acknowledged as having an effect on every element of the model (control variables), to represent that the individual is embedded within a social context. A graphical representation of all these components of the model is shown in Figure 3.

Figure 3

Preventive and Corrective Proactivity (PCP) model, adapted from Kahana and Kahana (1996)

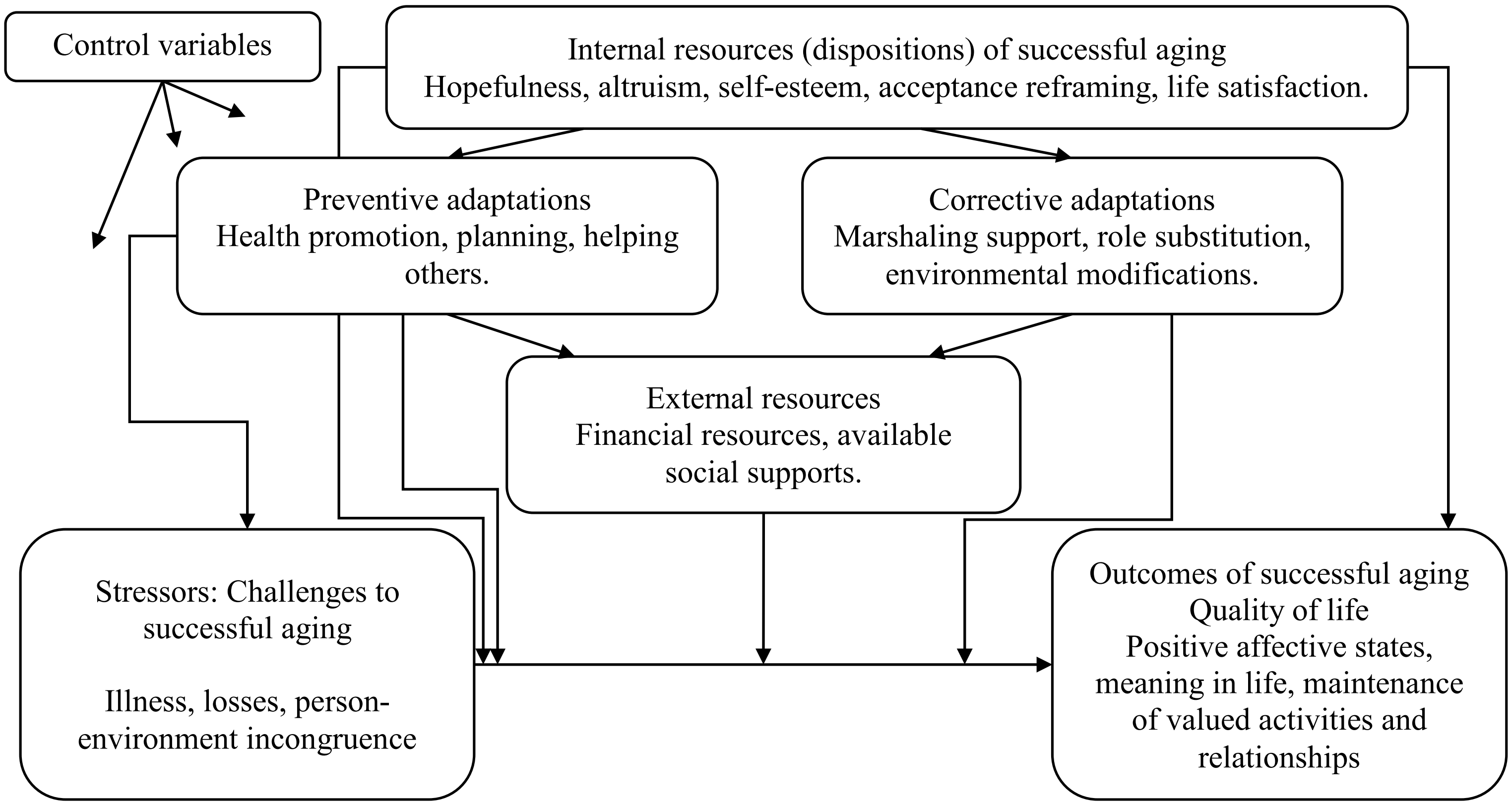
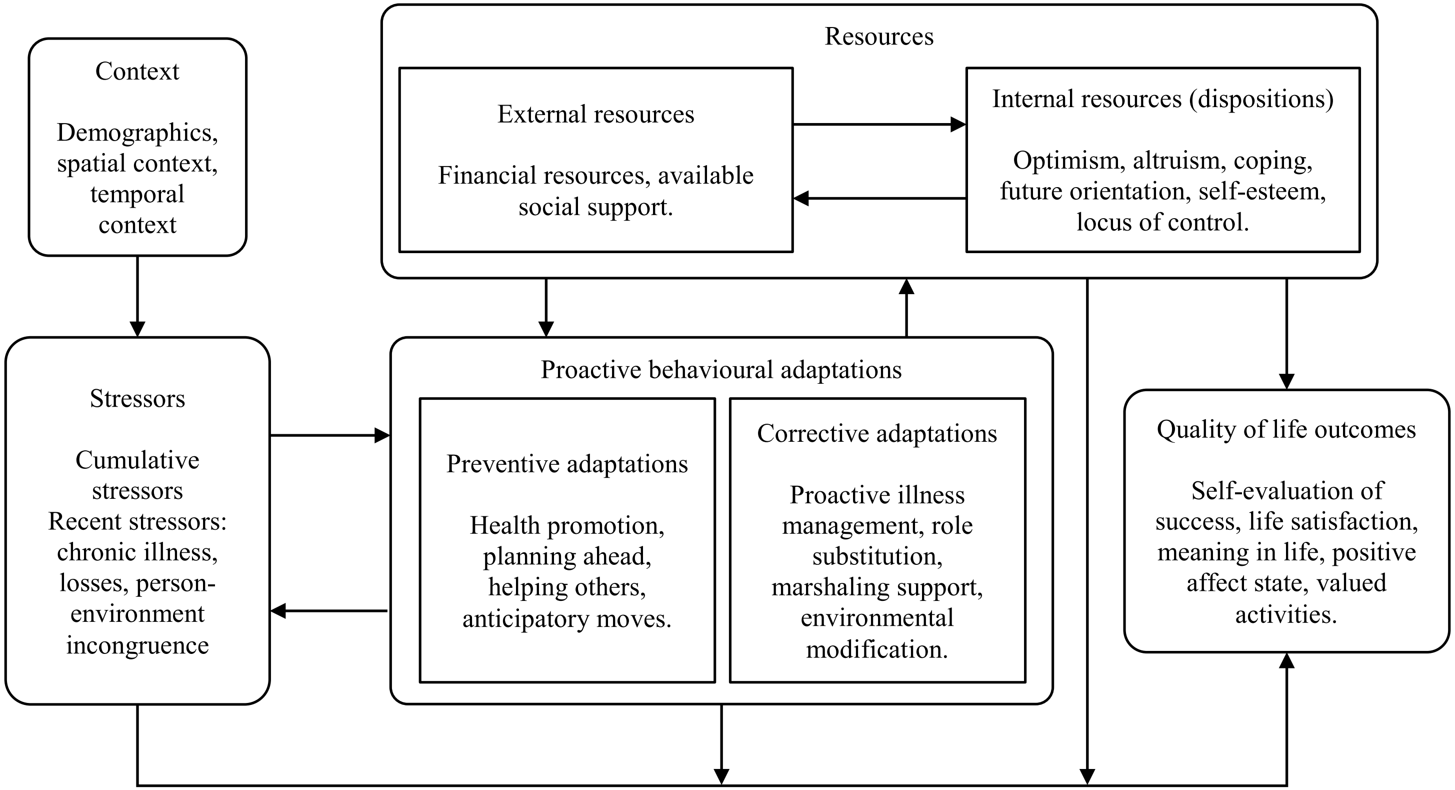


Figure 4

Comprehensive Preventive and Corrective Proactivity (PCP) model, adapted from Kahana et al. (2014)



This model has received empirical support (for example: Kahana et al., 2002; Kahana et al., 2005; Kahana et al., 2012) and offers a holistic theoretical framework that focuses in both the process and the outcomes of successful ageing, with tangible components that can be operationalised. A few years later, however, Kahana et al. (2014) offered a revised version of the PCP model, the Comprehensive PCP model. This second model included not only late-life stressors such as health problems, social losses and person-environment incongruence, but also cumulative stressors like social discrimination or financial resources' access inequality. The Comprehensive PCP model is shown in Figure 4

Moreover, regarding outcomes of successful ageing, in the Comprehensive PCP model these are equated to quality of life (QoL) outcomes and include life satisfaction, which was considered as a disposition in the original model. Additionally, the revised Comprehensive PCP model clearly excludes physical health and functionality as outcomes of SA and contemplates them as stressors.

Regarding internal and external resources, these are considered at the same level, and their role is not mediated by adaptations as in the original model. Within external resources, special emphasis is given to financial resources and available social support while internal resources, that is, dispositions promoting adaptations, are expanded to further include future orientation and internal locus of control.

Proactive adaptations, in their part, comprise both preventive and corrective actions. Preventive behaviours are considered as prior to stressors although they can also serve corrective purposes. Corrective behaviours, instead, appear in the presence of stressors in order to lessen the negative impact of age-related stressors onto QoL outcomes. The four specific preventive adaptations include health promotion, planning ahead, offering help and taking anticipated moves. Health promotion makes reference to engagement in healthy lifestyles that postpone or reduce the onset of chronic disorders. Planning ahead refers to preparing for late-life changes and accommodating new activities, social networks or contexts. Offering help consists in providing informal assistance to others, which is suggested to have a positive effect on the self's well-being. Finally, anticipatory moves include actions to potentiate social support and resources in future late-life and this, together with the person-environment incongruence stressor, make up for the ecological dimensions of SA.

Corrective behaviours aimed at lessening the effects of stressors can be grouped under four different themes. Role substitution comprises actions directed towards finding new social roles after the individual's social dimension is affected by retirement or loss of a relative. Marshalling support implies help-seeking skills to solve problematic situations. Environmental modification includes all changes made to overcome environmental limitations that pose a threat to the person-environment fit. Proactive illness management concerns active health management once disorders appear and the desire to involve oneself in healthcare services to minimize health loss.

Finally, the model contemplates contextual influences, as it acknowledges that the individual is embedded in socio-structural contexts that present different stressors and resources to different individuals within a society, depending upon their age, gender, marital status, educational level and race. Moreover, the model also acknowledges the spatial context of the individual regarding their living surroundings and their location, which may present particularities that ultimately impact in their SA. These contextual factors are thought to impact every component of the Comprehensive PCP model.

Regarding cognition, the Comprehensive PCP model argues that –lack of– functionality constitutes a stressor, so cognitive decline can be considered an aged-related stressor that impacts on QoL outcomes. This stressor would be, at the same time, affected by the individual's context and by corrective and preventive adaptations, that can both protect against cognitive decline and buffer the detrimental effects of cognitive decline on QoL. However, the contrary would also be true. Namely, cognitive decline would be capable of impacting on behavioural adaptations, which concurs with the idea by Freund and Baltes (2002) that SOC strategies diminish with age.

Overall, there have been numerous attempts to provide a theoretical framework of SA that represents the complex reality of the ageing process. From all these theoretical proposals, the three reviewed in this section were chosen because they are considered especially notorious in the SA arena. Be that as it may, conceptual and methodological limitations have also been raised. In the case of Kahana and Kahana's (1996) PCP model, the own authors restated the model to overcome these limitations, giving rise to the Comprehensive PCP model (Kahana et al., 2014). Perhaps, the most evident criticism to this latter model is its extraordinary complexity, given the amount of components contemplated and the inter-connections amongst them. Nonetheless, that could also be considered its main strength, as every sphere of the older individual is acknowledged.

There are three main contributions of the Comprehensive PCP model that make it appealing for the study of human ageing. First, it confers proactive behavioural adaptations upon the individual, suggesting that the person is capable of shaping their own successful ageing. Second, the model poses the ageing process as multidimensional by incorporating both processes and outcomes of ageing. Third, the inclusion of contextual and socio-structural factors acknowledges that the person is embedded within a larger reality that can impede or bolster their actions towards success. Finally, the interconnection between all features of the model allows different processes to give rise to the same outcomes. In conclusion, the Comprehensive PCP model offers a holistic, flexible-enough, framework for the study of ageing.

1.5.The Survey of Health, Aging and Retirement in Europe

The Survey of Health, Aging and Retirement in Europe (SHARE; Börsch-Supan et al., 2013) constitutes a unique research infrastructure accommodating longitudinal information about health, socio-economics, environment and social networks of European and Israeli citizens (50 years old or older). In this section, SHARE's main features will be discussed, including a listing of the structural actors involved in the project and their roles, a brief summary of the study's design, and SHARE's specific and general questionnaires.

There are five main agents involved in each wave of SHARE. First, the project is centralized by the SHARE Central Coordination Team, which supervises the survey process across all participating countries. SHARE Central has five units: European Relations and International Management, Financial Affairs, Survey Methodology, Operations and Database Management. At the country-level, each participating country has its own Country Team, composed by a Country Team Leader (CTL) and, at least, by a Country Team Operator (CTO) that supports the CTL. Moreover, Area Coordinators are responsible for scientific supervision and coordination of each of the five areas of content considered in the SHARE questionnaire: Income and Wealth, Health, Health Care, Work and Retirement, and Social Networks. Fourth, the software needed for the Computer Assisted Personal Interview (CAPI) method employed in SHARE is developed and maintained by CentERdata, who also process and archive the data. Finally, the CAPI interviews are done by professional trained interviewers that belong to a Survey Agency contracted by either SHARE Central or a Country Team following a public procurement process. SHARE presents ex-ante harmonization, which implies that all participating countries use the same instruments, software and protocol for data acquisition.

SHARE data follows a longitudinal panel design that employs probabilistic-based sampling at each wave of data and includes refreshment samples. The sampling protocol follows a four-stage process, described in Bethmann et al. (2019). In general, first the Country Team and the Survey Agency, in cooperation with SHARE Central, determine a sample frame and specify the sampling procedure to be used. Second, the sample is drawn to produce a gross sample file. Third, SHARE Central supervises and authorises the file. Fourth, CentERdata and SHARE Central distribute the gross sample data through a software, onto which the Country Team later uploads the sample's addresses. Therefore, sample frames and sampling procedures can vary by country. In the event that the sampling procedure is a non-equal probability selection method (EPSEM), design weights are computed to correct any bias associated with the sampling procedure.

Table 4

Overview of participating countries in each wave of SHARE

	Wave 1	Wave 2	Wave 3	Wave 4	Wave 5	Wave 6	Wave 7	Wave 8	SCS1	SCS2
Austria	X	X	X	X	X	X	X	X	X	X
Belgium	X	X	X	X	X	X	X	X	X	X
Bulgaria							X	X	X	X
Croatia						X	X	X	X	X
Cyprus							X	X	X	X
Czech Republic		X	X	X	X	X	X	X	X	X
Denmark	X	X	X	X	X	X	X	X	X	X
Estonia				X	X	X	X	X	X	X
Finland							X	X	X	X
France	X	X	X	X	X	X	X	X	X	X
Germany	X	X	X	X	X	X	X	X	X	X
Greece	X	X	X			X	X	X	X	X
Hungary				X			X	X	X	X
Ireland		X	X					X	X	X
Israel	X	X			X	X	X	X	X	X
Italy	X	X	X	X	X	X	X	X	X	X
Latvia							X	X	X	X
Lithuania							X	X	X	X
Luxembourg					X	X	X	X	X	X
Malta							X	X	X	X
Netherlands	X	X	X	X	X	X	X	X	X	X
Poland		X	X	X		X	X	X	X	X
Portugal				X		X	X	X	X	X
Romania							X	X	X	X
Slovakia							X	X	X	X
Slovenia				X	X	X	X	X	X	X
Spain	X	X	X	X	X	X	X	X	X	X
Sweden	X	X	X	X	X	X	X	X	X	X
Switzerland	X	X	X	X	X	X	X	X	X	X

SCS1 = SHARE Corona Survey 1; SCS2 = SHARE Corona Survey 2.

Regarding SHARE waves, since 2004 one wave of data has been collected every two years, with participating countries varying across waves. Summary information of participating countries per wave is displayed in Table 4. The last wave of data available is SHARE Wave 8, which collects data from all countries of the European Union and Israel. Two additional surveys, SHARE Corona Survey 1 and 2, were also designed as a consequence of the outbreak of the COVID-19 pandemic.

It should be noted that SHARE Wave 3, also known as SHARELIFE, constitutes a retrospective life histories study and hence does not include the usual measures (Schröder, 2011). This was also done in SHARE Wave 7, but only for those respondents that had not participated in SHARELIFE. In SHARE Wave 7, the regular questionnaire was fully administered to respondents that participated in SHARE since Wave 3 or before, and it was partially administered for any other respondent, which resulted in very high rates of missing data for some of the questionnaire's modules (Bergmann et al., 2019). Be that as it may, SHARELIFE was initially designed to provide researchers with information about the respondents' life events prior to the baseline year of the study. More specifically, the interviewer asks the respondent to locate in a calendar children's year of birth, partner history, and job and retirement history. The respondent is also asked about their living situation at the age of ten, as well as about financial assets, their health during childhood and adulthood, and the use of healthcare. Finally, respondents are also questioned about meaningful periods of their life, both positive and negative (Schröder, 2011).

Furthermore, as shown in Table 4, two additional surveys focusing on the consequences of the COVID-19 pandemic, SHARE

Corona Survey 1 and 2, also took place soon after the procurement of Wave 8 data. In mid-March 2020, fieldwork of SHARE Wave 8 had to be suspended due to the outbreak of the COVID-19 pandemic and its incompatibility with face-to-face CAPI. Consequently, the SHARE Corona Survey 1 was administered between June and September 2020 as a Computer-Assisted Telephone Interview (CATI) to gather data about the COVID-19 impact on the living situation of adults aged 50 or more. A second SHARE Corona Survey was administered between June and August 2021 to study the long-term impact of the pandemic (Scherpenzeel et al., 2020). The Corona Surveys collect data in line with the standard SHARE questionnaire but shortened to the CATI format and focusing on COVID-19 related aspects. Table 5 displays a summary of the content included in the Corona questionnaires.

Table 5

Summary of the content of the Corona Survey 1 and 2, adapted from Scherpenzeel et al. (2020)

Area	Measures
Health and health behaviours	General health before and after the COVID-19 outbreak, practice of safety measures.
Mental health	Anxiety, depression, sleeping problems, and loneliness before and after the COVID-19 outbreak.
Infections and healthcare	COVID-19 related symptoms, SARS-CoV-2 testing and hospitalization, forgone medical treatment, satisfaction with treatments.
Changes in work and economic situation	Unemployment, business closures, working from home, changes in working hours and income, financial support.
Social networks	Changes in personal contacts with family and friends, help given and received, personal care given and received.

The regular SHARE questionnaire is organized in modules grouping conceptually-similar measures. Not all modules were present at the beginning of the project and not all modules are administered in all waves. Table 6 displays the relation of modules included in each wave of the study, excluding Wave 3, in which only the aforementioned SHARELIFE questionnaire was administered. The modules shown in Table 6 are considered the regular ones, but SHARE further includes some special questionnaire modules. All the information regarding SHARE modules can be consulted in the latest version of the release guide, available at the SHARE website (www.share-eric.eu).

In addition to the modules presented in Table 6, there are a set of screening questions, usually referred to as the coverscreen module, that are asked in every wave of the study to eligible and non-eligible members of the household. Furthermore, small variations between waves are done to the questionnaire modules, including or excluding certain questions. This implies that for example, although the same module could have been asked in all waves, the information contained in the module at each wave is not exactly the same. Nonetheless, the general trend is not to dismiss questions within a module but to add new questions and measures.

Regarding specific measurement instruments employed in SHARE, the Scales and Multi-Items Indicators manual (Mehrbrodt et al., 2021) includes the description of all scales and tests used at any wave of SHARE. Of special interest are cognitive function measures. More specifically, four cognitive domains have been assessed as part of the regular SHARE questionnaire protocol since the beginning of the project: temporal orientation, numeracy, memory and verbal fluency.

Table 6

Overview of questionnaire modules administered across waves

	W1	W2	W4	W5	W6	W7	W8
Demographics	X	X	X	X	X	X	X
Social networks			X		X		X
Children	X	X	X	X	X	X	X
Physical health	X	X	X	X	X	X	X
Behavioural risks	X	X	X	X	X	X	X
Cognitive function	X	X	X	X	X	X	X
Mental health	X	X	X	X	X	X	X
Health care	X	X	X	X	X	X	X
Employment and pensions	X	X	X	X	X	X	X
Computer use				X	X	X	X
Mini childhood				X			
Grip strength	X	X	X	X	X	X	X
Walking speed	X	X					
Chair stand		X		X			
Blood sample					X		
Peak flow		X	X		X		
Social support	X	X	X	X	X	X	X
Financial transfers	X	X	X	X	X	X	X
Housing	X	X	X	X	X	X	X
Household income	X	X	X	X	X	X	X
Consumption	X	X	X	X	X	X	X
Assets	X	X	X	X	X	X	X
Activities	X	X	X	X	X	X	X
Expectations	X	X	X	X	X	X	X
Saving regrets							X
Time expenditure							X
Interviewer observations	X	X	X	X	X	X	

Temporal fluency is measured with four indicators that correspond to four of the 10 items tapping temporal orientation in the

Mini-Mental State Examination (MMSE; Folstein et al., 1975). Namely, the respondent is asked about year, date, day of the week and month. Likewise, numeracy is assessed employing the corresponding test from the MMSE, in which the respondent is asked to count backward from 100 in sevens, five times. Four additional numeracy items are used to assess respondents' percentage calculation skills, and their content is available in Mehrbrodt et al. (2021).

To assess respondents' verbal fluency, participants are instructed to name as many different animals as possible during 60 seconds. This semantic category, animals, is considered adequate across languages and cultures (Ardila et al., 2006; Henley, 1969). Finally, memory is measured with a word recall test. This test contains 10 words. Respondents are asked to remember the words immediately after having them read and after a brief period of time. In waves 1 and 2 the same word list was employed for every respondent. From wave 4, one of four different lists is randomly assigned to each participant. Word lists across SHARE waves are displayed in Table 7.

Employing word lists to measure memory performance raises the question of whether serial position effects may be playing a role in respondents' probability of remembering some words versus others. Serial positions effects have been documented since the end of the 19th century (Ebbinghaus, 1913) and consist of a higher probability of recalling the first items (primacy effect) and the latter items (recency effect) of a word list (Murdock, 1962).

Several instruments designed for memory assessment employ word lists. For example, the California Verbal Learning Test (CVLT; Delis et al., 1987), a revised version of the CVLT, known as CVLT-II

(Delis et al., 2000), the Telephone Interview for Cognitive Status (TICS; Brandt et al., 1988), the modified TICS (TICS-m; Welsh et al., 1993) or the Rey Auditory Verbal Learning Test (RAVLT; Rey, 1964). Moreover, some more general neuropsychological batteries also employ word list as part of their protocol, as is the case of the Consortium to Establish a Registry for Alzheimer's Disease (CERAD; Morris et al., 1988) and the aforementioned MMSE (Folstein et al., 1975).

Table 7

Word lists employed in the 10 Word Recall Test (10-WRT) across SHARE waves

Word #	Waves 1 & 2	Waves 4, 5, 6, 7 & 8			
		List 1	List 2	List 3	List 4
1	Butter	Hotel	Sky	Woman	Water
2	Arm	River	Ocean	Rock	Church
3	Letter	Tree	Flag	Blood	Doctor
4	Queen	Skin	Dollar	Corner	Palace
5	Ticket	Gold	Wife	Shoes	Fire
6	Grass	Market	Machine	Letter	Garden
7	Corner	Paper	Home	Girl	Sea
8	Stone	Child	Earth	House	Village
9	Book	King	College	Valley	Baby
10	Stick	Book	Butter	Engine	Table

Even though these measurement instruments are widely used in both research and practice, there is little evidence about the potential impact of serial position effects on the assessment of memory performance. The only documented study is that of Millis (1995), that examined the psychometric properties of the CLVT (Delis et al., 1987). In this study, Millis applied principal component analysis to examine the factor structure of the test, although this practice has been criticised in factor analysis, as it assumes the absence of measurement error (Widaman, 1993). Be that as it may, the novelty in Millis' findings relied in the appearance of one component that he labelled "Serial Position", which represented both primacy and recency effects. Therefore, although evidence seems to suggest that serial position effects do occur in these memory instruments, there is a lack of studies analysing the presence of such effects as well as their impact on relationships between memory, as measured by word recall, and other variables from its nomological network.

According to the Dual-Store Model (Atkinson & Shiffrin, 1968), recent recall is affected by the recency effect, as the recall request triggers retrieval from the short-term store (STS) that contains the most recent information (Osth & Farrell, 2019). When the recall request is postponed, information is no longer available in the STS and therefore recency effects do not occur in delayed recall. Primacy effects are, however, expected to occur in delayed recall trials, as former items of a list are available for a longer period of time in the STS and hence they are more likely to be encoded in the long-term store (LTS; Leicht, 1968). In this line, some studies have found evidence of primacy effects in delayed recall trials (Tan & Ward, 2000).

Besides the original cognitive tests included in SHARE since the beginning of the project, from wave 8 new cognitive measures have been integrated into the regular SHARE questionnaire (Bergmann & Börsch-

Supan, 2021). These tests were included mainly for the purpose of offering a higher level of harmonization with the Health and Retirement Study (HRS), and tap cognitive domains not covered by the other measures: self-rated change in memory, backward count, object naming and drawing exercises. In addition, a proxy measure was included to assess cognitive function of individuals that were not capable of answering cognitive tests themselves. In particular, an adapted version of the Informant Questionnaire on Cognitive Decline in the Elderly (IQCODE; Jorm & Korten, 1988) was employed.

The IQCODE was originally developed as a 26-item informant-based screening test of cognitive decline, and latter shortened to 16 items by Jorm (1994). The scale measures the informant's perception about the ability of a target individual to perform everyday cognitive tasks. Proxy measures are considered useful for measuring early cognitive decline when the individual cannot be directly tested (Jorm, 2004). This scale in particular is widely used in clinical practice as a screening tool, and the psychometric properties of both the original and the shortened versions have been examined extensively. Proof of this are the systematic reviews of the scale's adequacy for the detection of dementia carried out for different contexts, namely for studies applying the scale in primary-care settings (Burton et al., 2021a), in secondary-care settings (Burton et al., 2021b) and in community-dwelling populations (Quinn et al., 2021). Generally speaking, results point to optimal functioning for the 26- and the 16-item versions of the IQCODE.

These studies were carried out from the clinical perspective. Regarding the research context, the 16-item version of the IQCODE entered the Harmonized Cognitive Assessment Protocol (HCAP), a substudy within the HRS (Langa et al., 2020) in 2016, transcending clinical practice, as from that moment it was also employed as a research instrument. A few years later, it was also included in the 8th wave of SHARE, as noted before, but subtle modifications were made to shorten administration time (Bergmann & Börsch-Supan, 2021). SHARE's version of the IQCODE presents three modifications from the original 16-item IQCODE: a reduction in the number of items to seven, a shift in the response scale form a 5-point Likert scale to a 3-point Likert scale, and a change in the time frame of reference for cognitive change from 10 years to 2 years. After implementation of this SHARE-IQCODE scale, however, no report of psychometric properties has been provided.

All in all, the SHARE project provides high-quality longitudinal panel data on very diverse topics surrounding individuals' wellbeing and health in the ageing process. Using SHARE data, researchers around the world are able to develop very different studies about human ageing. Evidence of SHARE's great contribution to ageing research is reflected in the great amount of research published using its data as well as its impact in policy-making (Openen & Coscia, 2022). In this dissertation, SHARE data will be used for empirical hypothesis-testing. Moreover, psychometric properties of some of cognitive instruments employed in SHARE will be examined, namely the 10-word recall test and SHARE's adaptation of the IQCODE.

1.6. Aim and objectives

The main aim of this dissertation is to establish a holistic framework that accounts for the main bio-psycho-social factors involved in the maintenance of cognitive function in the old age, and to study the relationship between cognitive functions and successful ageing outcomes. This research is rooted in a wider theoretical framework, namely that of successful ageing.

Section 1.4 reviewed the different successful ageing theories that emerged since Havighurst's (1961) early work. After Havighurst's first approximation to the conceptualisation of successful ageing, Rowe and Kahn's model of successful ageing (Rowe & Kahn, 1997) was described. Although a very pioneering model, numerous scholars highlighted the theoretical limitations of the model in the conceptualisation of successful ageing.

An alternative model was that of Selective Optimization with Compensation (SOC; Baltes & Baltes, 1990), that focused on the processes underlying successful ageing. Although this model offered valuable insight on the processual aspect of ageing, it presented deficiencies related to standardized measurement of the processes involved in ageing successfully. Moreover, this model did not provide any theoretical ground regarding the outcomes of successful ageing.

Finally, Kahana and Kahana's (1996) Preventive and Corrective Proactivity (PCP) model of successful ageing was described. This model presented an advantage over Rowe and Kahn's model of successful ageing in that it acknowledged the socio-structural context in which the individual is embedded as well as it provided a non-medicalized conceptualisation of successful ageing while still considering physical health factors. In addition, Kahana and Kahana's (1996) model overcomes Baltes and Baltes' model limitations by providing clearly defined operationalisations of both processes and outcomes of successful ageing. In this sense, the model achieves an optimal compromise between the outcome- and process-focused study of successful ageing. The later upgrade of the model into the Comprehensive PCP (Kahana et al., 2014) further included cumulative stressors, providing a holistic paradigm of successful ageing.

Kahana et al.'s (2014) Comprehensive PCP model will be employed as the theoretical background of this doctoral dissertation. Within this model, cognitive decline is identified as an age-related stressor that can impact successful ageing outcomes. Below, general objectives, specific objectives and the hypothesis proposed according to previous literature are described.

1.6.1. General objectives (GO)

GO1. To assess psychometric adequacy of measurement instruments tapping cognition employed in the Survey of Health, Aging and Retirement in Europe (SHARE).

GO2. To establish a comprehensive model that predicts cognitive functioning from a bio-psycho-social perspective.

GO3. To establish the possible explicative effects of the most relevant factors documented in the literature on cognitive functioning.

GO4. To examine the relationship between cognitive function and successful ageing outcomes.

GO5. To study cognitive functioning in older adults from a gender perspective.

1.6.2. Specific objectives (SO)

The specific objectives regarding GO1 are:

SO1. To examine factor structure, reliability and convergent validity of the 10-Word Recall Test (10-WRT), paying special attention to serial position effects and their role in the relationship between recent/delayed recall and education.

SO2. To assess factor structure, reliability, criterion-related validity and diagnostic validity of SHARE's adaptation of the Informant Questionnaire on Cognitive Decline in the Elderly (IQCODE).

The specific objectives regarding GO2 are:

SO3. To test the differential relationships between predictors of cognition and four cognitive dimensions (temporal orientation, memory, numeracy and verbal fluency).

SO4. To test the relative impact of years of education, chronic disorders, physical inactivity, psychological factors (loneliness and depression), and social and intellectual activity participation on the cognitive dimensions, controlling for age.

The specific objectives regarding GO3 are:

SO5. To establish the shape of the latent trajectories of memory, differentiating between recent and delayed recall, and verbal fluency.

SO6. To test the explicative power of educational attainment, physical inactivity, depression and social engagement on memory and verbal fluency, controlling for age.

The specific objectives regarding GO4 are:

SO7. To study the longitudinal latent associations between recent recall and quality of life, controlling for covariates.

SO8. To study the longitudinal latent associations between delayed recall and quality of life, controlling for covariates.

SO9. To study the longitudinal latent associations between verbal fluency and quality of life, controlling for covariates.

The specific objectives regarding GO5 are:

SO10. To test the relative impact of gender on temporal orientation, memory, numeracy and verbal fluency.

SO11. To study the explicative role of gender in latent trajectories of recent and delayed memory, and verbal fluency.

SO12. To determine the effect of gender in the latent trajectory of quality of life.

1.6.3. Hypotheses

Hypotheses regarding SO1:

1a. Recent recall will display a one-factor structure with recency, but not primacy, effects.

1b. Delayed recall will display a one-factor structure with primacy, but not recency, effects.

1c. The 10-WRT will present adequate reliability estimates, both for recent and delayed recall.

1d. The existence of serial position effects will distort the relationships between recent/delayed recall and education.

Hypotheses regarding SO2:

2a. The IQCODE will display a one-factor structure of cognitive decline.

2b. The IQCODE will present adequate reliability estimates.

2c. Informants' perceptions of respondents' cognitive decline, as measured by the IQCODE, will be higher for respondents with a self-reported diagnosis of dementia.

2d. There will be a cut-off point for the IQCODE that represents an adequate balance between sensitivity and specificity.

Hypothesis regarding SO3:

3. The predictors will display differential effects on the cognitive dimensions considered.

Hypotheses regarding SO4:

4a. Years of education, social activity participation and intellectual activity participation will present positive and statistically significant effects on the different cognitive dimensions considered.
4b. Chronic disorders, physical inactivity, loneliness and depression will present negative and statistically significant effects on the different cognitive dimensions considered.

Hypotheses regarding SO5:

5a. Recent recall will display either a linear or a quadratic latent trajectory of decline.
5b. Delayed recall will display either a linear or a quadratic latent trajectory of decline.
5c. Verbal fluency will display either a linear or a quadratic latent trajectory of decline.

Hypotheses regarding SO6:

6a. Educational attainment and social engagement will have positive and statistically significant effects in the latent trajectories of recent memory, delayed memory and verbal fluency.
6b. Physical inactivity and depression will have negative and statistically significant effects in the latent trajectories of recent memory, delayed memory and verbal fluency.

Hypothesis regarding SO7:

7. Changes in recent recall will explain changes in quality of life.

Hypothesis regarding SO8:

8. Changes in delayed recall will explain changes in quality of life.

Hypothesis regarding SO9:

9. Changes in verbal fluency will explain changes in quality of life.

Hypothesis regarding SO10:

10. Females will present statistically higher levels of global memory and verbal fluency than males.

Hypotheses regarding SO11:

11a. Females will present statistically lower levels of recent memory and verbal fluency decline than males over time.

11b. Females will present statistically higher levels of delayed memory decline over time.

Hypothesis regarding SO12:

12. Females will present statistically higher levels of decline in quality of life than males.

2. METHODOLOGY

2.1. Psychometric properties of cognitive scales in SHARE

2.1.1. Sample and procedure

2.1.1.1. 10-Word Recall Test

For this study, data from SHARE Wave 2 was used (Börsch-Supan, 2022a). Nowadays, SHARE holds eight waves of panel data that have been collected bi-annually between 2004 and 2021.

Data from Wave 2 was used for two main reasons, related to the way the instrument was administered across SHARE waves. First, waves 1 and 2 employed the same scale for all respondents. Other waves started using four parallel scales that were randomly assigned to respondents. The presence of four scales raised the question of word equivalence among lists, which requires more in-depth study in its own. Second, item-level data used in the analyses was not readily available in SHARE data releases, as it is considered metadata. As such, an application process had to be initiated to access raw data and, in such process, it was observed that the way in which the storage of such metadata in the waves using four parallel scales had been done, made it impossible to find out which exact words had been correctly recalled, but only the amount of them.

The sample was formed by 37143 individuals aged between 15 and 105 years old (*M* = 65.2, *SD* = 10.4) and there were slightly more female respondents (55.9%). Although the project's target population are adults aged 50 or older, partners living in the household are also eligible regardless of age, which explains why the sample includes younger individuals. Fifteen European countries were represented in the data: Austria (3.2%), Germany (7.1%), Sweden (7.5%), Netherlands (7.2%), Spain (6.5%), Italy (8.0%), France (8.0%), Denmark (7.1%), Greece (9.2%), Switzerland (4.0%), Belgium (8.7%), Israel (6.6%), Czech Republic (7.4%), Poland (6.6%), and Ireland (2.8%).

2.1.1.2. Informant Questionnaire on Cognitive Decline in the Elderly

Data used for this study was that from Wave 8 of SHARE (Börsch-Supan, 2022b). A total of 1137 respondents who were not able to answer the questions related to their cognitive state were selected. Only in this case, the IQCODE was administered to an informant. From these, 78 cases did not answer the IQCODE and were thus dismissed. The final sample was composed by 1059 participants that informed about the cognitive state of the target respondents. Regarding these target respondents, their average age was 79.26 years old (SD= 10.53), 510 (48.2%) were female and 549 (51.8%) were male.

2.1.2. Instruments

The 10-Word Recall Test (10-WRT) measures memory performance. Respondents were asked to remember a list of 10 words immediately (recent recall) and 10 minutes (delayed recall) after having them read. They were instructed to say, in any order, as many words as they could recall. The ordered words presented to respondents were: 1) butter, 2) arm, 3) letter, 4) queen, 5) ticket, 6) grass, 7) corner, 8) stone, 9) book and 10) stick. Words were dichotomously classified as recalled (1) or not recalled (0) for each individual.

The adapted version of the 16-item Informant Questionnaire on Cognitive Decline in the Elderly (IQCODE; Jorm, 1994) used seven items from the original 16-item version. Moreover, the time frame referred to for change in cognitive ability was changed to 2 years instead of 10, and a 3-point response scale was used instead of a 5-point one. Responses were coded as 1 (Improved), 2 (Not much changed) and 3 (Gotten worse). Item content of the original 16-item version of the IQCODE are displayed in Table 8, and items employed in SHARE's adaptation of the instrument are 1, 2, 3, 5, 10, 13 and 14.

Additionally, the self-reported diagnosis of Alzheimer's disease or senility was employed as a dichotomous variable (0 = No, 1 = Yes) for criterion-related validity and sensitivity/specificity analyses of the IQCODE.

Educational level according to International Standard Classification of Education-1997 (ISCED; Schneider, 2008) was employed as the operationalisation of cognitive reserve to study the potential impact of serial position effects on relationships between the 10-WRT and cognitive reserve. Associated labels to each of the ISCED levels were: level 0 "Pre-primary education", level 1 "Primary education or first stage of basic education", level 2 "Lower secondary education or second stage of basic education", level 3 "Upper secondary education", level 4 "Post-secondary non-tertiary education", level 5 "First stage of tertiary education", and level 6 "Second level of tertiary education".

Table 8
Item content of the 16-item IQCODE

	Compared with 10 years ago how is this person at…
1	Remembering things about family and friends e.g. occupations, birthdays, addresses.
2	Remembering things that have happened recently.
3	Recalling conversations a few days later.
4	Remembering his/her address and telephone number.
5	Remembering what day and month it is.
6	Remembering where things are usually kept.
7	Remembering where to find things which have been put in a different place from usual.
8	Knowing how to work familiar machines around the house.
9	Learning to use a new gadget or machine around the house.
10	Learning new things in general.
11	Following a story in a book or on TV.
12	Making decisions on everyday matters.
13	Handling money for shopping.
14	Handling financial matters e.g. the pension, dealing with the bank.
15	Handling other everyday arithmetic problems e.g. knowing how much food to buy, knowing how long between visits from family or friends.
16	Using his/her intelligence to understand what's going on and to reason things through.

2.1.3. Statistical analyses

Factor structure of the scales was tested by means of Confirmatory Factor Analysis (CFA). In the case of the 10-WRT, a set of four nested CFAs were tested for both recent and delayed recall. First, a one-factor model was specified. This model served as the baseline model onto which additional models were compared. Then, three more models were specified. One model that acknowledged primacy effects by correlating the three former words; one that acknowledged recency effects by correlating the three latter words; and one that considered both recency and primacy effects by including all the aforementioned correlations. For the IQCODE, a one-factor model of cognitive decline was tested to examine whether this structure fitted the data, as was the case with other versions of the IQCODE. The models were estimated using Weighted Least Squares Mean and Variance corrected (WLSMV), given that the data were not multivariate normal and some of the indicators or variables were ordinal (Finney & DiStefano, 2006).

In both cases, model fit was assessed using the fit indexes recommended in the literature (Kline, 2016; Tanaka, 1993): the chi-square statistic (χ^2), the Comparative Fit Index (CFI), the Root Mean Squared Error of Approximation (RMSEA), and the Standardized Root Mean Square Residual (SRMR). Models are generally assumed to fit the data when CFI is of at least .90 and RMSEA/SRMR are under .08 (L. T. Hu & Bentler, 1999; Marsh et al., 2004). For the 10WRT, relative fit among the models was further assessed using chi-square difference ($\Delta\chi^2$) tests and CFI differences (ΔCFI), as the former have been documented to display too much power with big sample sizes (Cheung & Resvold, 2002). As a criterion for relative fit among the models, a cut-off point of CFI deterioration no bigger than .01 was taken.

In case serial position effects were detected, the impact of these effects on the relationships between recall and cognitive reserve, operationalised by means of education, was examined. To do this, education was included in the model with and without serial position effects and the correlation between education and recent and/or delayed recall was estimated. Then, to determine whether there were statistically significant variations in the size of the correlations, 95% confidence intervals were computed. Criterion-related validity was tested comparing the mean score of the IQCODE between individuals who reported an Alzheimer's diagnosis and those who did not, and Receiver Operating Characteristic (ROC) curves were used to assess the diagnostic validity of the tool and the most optimal cut-off point.

Finally, estimates of internal consistency were computed from the best-fitting model for recent and delayed recall, as well as for the IQCODE, using coefficient omega (McDonald, 1999), as it has been proved to overcome the problems encountered when using coefficient alpha (Deng & Chang, 2017). Analyses were done in Mplus 8.7 (L. K. Muthén & Muthén, 1998-2017) and R (R Core Team, 2022).

2.2. A holistic model of cognition

2.2.1. Sample and procedure

Data from the 8th wave of SHARE (Börsch-Supan, 2022b) also was employed. However, in this case, all individuals capable of answering cognitive function tests were considered, which resulted in a total of 45475 respondents, aged between 32 and 103 years old, and their sociodemographic characteristics are presented in Table 9.

2.2.2. Instruments

Cognitive function was operationalised by means of temporal orientation, memory, numeracy and verbal fluency. Temporal orientation was measured with four indicators reflecting the respondent's orientation to month, year, day of week and date. Each indicator was dichotomously measured as correct (1) or incorrect (0). Higher scores indicate better temporal orientation.

Memory was measured by the 10-Word Recall Test. However, in this case, four parallel tests were randomly assigned to participants, each containing a different set of wordlists, which can be consulted in Table 7 from section 1.5. Answers were coded on a scale from 0 to 10, representing the number of correctly evoked words on each occasion.

Table 9

Descriptive characteristics of the sample

Characteristics	Mean ± SD or *n* (%)
Age (years)	70.04 ± 9.32
Gender (women)	26264 (57.8%)
Marital status	
Married and living with spouse	26108 (57.4%)
Widow/widower	6945 (15.3%)
Divorced	3320 (7.3%)
Other	2907 (6.4%)
Missing	6195 (13.6%)
Years of education	11.30 ± 4.13
Activity participation	
Volunteerism	7301 (16.1%)
Educational/training course	4625 (10.2%)
Sport/social/other clubs	12095 (26.6%)
Political/community organizations	2736 (6.0%)
Read books/magazines/newspapers	32648 (71.8%)
Number games	19605 (43.1%)
Play cards/chess/similar	12621 (27.8%)

Verbal fluency was employed as a measure of executive function (Dewey & Prince, 2005). In this test, respondents are instructed to name as many different animals as they can think of in 60 seconds. This instruction is repeated if no response is elicited in 15 seconds.

Participants that stopped before time were encouraged to find more words. The total amount of animals elicited by the participant was recorded.

Numeracy was also used as another measure of executive function (Cragg & Gilmore, 2014; Dewey & Prince, 2005) and was measured with a sequence of five questions in which the participant was asked to subtract 7, starting at 100. The starting question was: “Now let’s try some subtraction of numbers. One hundred minus 7 equals what?”. After the respondent’s answer, he or she was asked “And 7 from that?” four consecutive times. Answers were coded as correct (1) or incorrect (0).

Activity participation considered participation during the 12 months prior to the interview. Activities were differentiated according to its nature in intellectual activity participation (books/magazines/ newspapers, word or number games and cards/chess/similar) and social (voluntary/charity work, educational/training courses, sport/social/other clubs, and political/community-related organization) activity participation. For each type of activity, the number of activities in which the individual participated was used as an indicator of that kind of activity participation in the model.

Physical health was operationalised by the respondents’ number of chronic diseases and by a measure of physical inactivity. Chronic diseases considered were heart attack, high blood pressure, high blood cholesterol, stroke, diabetes, chronic lung disease, cancer, stomach/duodenal ulcer, Parkinson’s disease, cataracts, hip/femoral fracture, other fractures, Alzheimer’s disease/dementia, other affective/emotional disorders, rheumatoid arthritis, osteoarthritis or other rheumatism, and chronic kidney disease.

Physical inactivity was measured as an indicator of individual's performance of activities requiring a moderate level of energy such as gardening, cleaning the car, or doing a walk. Responses were recorded using a 4-point Likert scale being 1 "More than once a week", 2 "Once a week", 3 "One to three times a month", and 4 "Hardly ever, or never".

Depressive symptomatology was measured with the EURO-D scale (Prince et al., 1999), that records the total number of depressive symptoms experienced by the respondent from a list of 12, containing: depressed mood, pessimism, suicidality, guilt, sleep, lack of interest, irritability, loss of appetite, fatigue, lack of concentration, lack of enjoyment and tearfulness. Hence, responses could vary between 0 and 12. The study by Tomás et al. (2022) provided evidence on the psychometric properties of this scale using SHARE data.

Loneliness was assessed using the Three-Item Loneliness scale (Hughes et al., 2004), a short version of the R-UCLA Loneliness Scale (Russell et al., 1978; Russell et al., 1980) that covers lack of companionship, feeling left out and feelings of isolation. Responses are coded in a 3-point Likert scale. The total score was computed as the sum of the three indicators, with higher scores indicating higher loneliness.

Additional measures on sociodemographic features included in the model were age, gender (0 = female, 1 = male) and years of education.

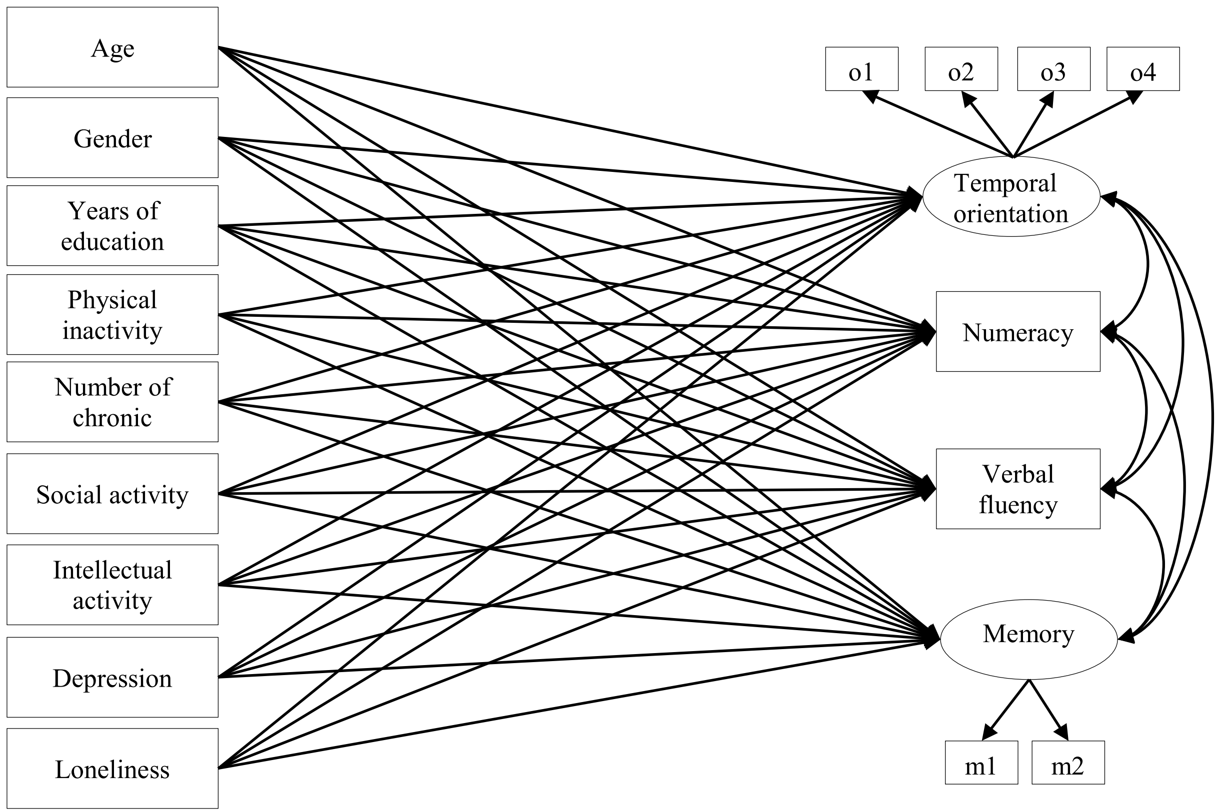
2.2.3. Statistical analyses

A Structural Equation Model (SEM) to predict cognitive functioning was tested. Outcome measures of the model consisted in four different cognitive dimensions, namely temporal orientation, memory, numeracy and verbal fluency. The predictors considered in the model were education, physical inactivity, chronic diseases, social activity participation and intellectual activity participation. The effects of the predictors onto the outcome variables was controlled by gender and age. The initially proposed model is displayed in Figure 5.

The model was estimated using Weighted Least Squares Mean and Variance corrected (WLSMV), given that the data were not multivariate normal and some of the indicators or variables were ordinal (Finney & DiStefano, 2006). Model fit was assessed with the aforementioned fit indexes: the chi-square statistic (χ^2), the Comparative Fit Index (CFI), the Root Mean Error of Approximation (RMSEA), and the Standardized Root Mean Residual (SRMR). Again, good fit of the model to the data was considered when the CFI is higher than .90, and the RMSEA and the SRMR are lower to 0.08, while excellent fit is considered with CFI over .95 and RMSEA/SRMR lower than .05 (L. T. Hu & Bentler, 1999; Marsh et al., 2004). Analyses were performed using Mplus 8.7 (L. K. Muthén & Muthén, 1998-2017).

Figure 5

Theoretical a priori holistic model of cognition. Correlations among exogenous variables not shown for clarity



2.3. Longitudinal study of cognition and its associated outcomes

2.3.1. Sample and procedure

For the longitudinal study of cognition, waves 4 (Börsch-Supan, 2022c), 5 (Börsch-Supan, 2022d), 6 (Börsch-Supan, 2022e), 7 (Börsch-Supan, 2022f) and 8 (Börsch-Supan, 2022b) of the SHARE study were used. Since the beginning of the project in 2004, SHARE has collected eight waves of data. However, wave 3 of SHARE consisted of a retrospective study and hence did not include the usual measures (Schröder, 2011). Since wave 4, the same panel study, albeit with rotating in and out of certain variables and questionnaire modules, as well as the inclusion of additional countries, has taken place every two years.

Individuals that had participated in wave 4 of SHARE and that were aged 50 years or older at that moment were included in this study. The resulting baseline sample was composed of 56616 individuals, 44.0% of which were male and 56.0% were female. Age at wave 4 ranged between 50 and 103 years (M = 65.93, SD = 10.01). Regarding marital status, most respondents were married (66.8%) at the time of the wave 4 interview, followed by widowed (14.8%) and divorced (8.6%). In total, 16 European countries were represented in the study: Austria (8.8%), Germany (2.8%), Sweden (3.5%), Netherlands (4.9%), Spain (6.4%), Italy (6.2%), France (10.0%), Denmark (3.9%), Switzerland (6.5%), Belgium (9.1%), Czech Republic (9.5%), Poland (3.0%), Hungary (5.3%), Portugal (3.4%), Slovenia (4.8%) and Estonia (11.9%). Participation rates across the waves is displayed in Table 10.

Table 10

Participation rates across waves considered in the study

# of wave	*n (%)*	
	Participation	Dropout
4	56616 (100.0)	0 (0.0)
5	38066 (67.2)	18550 (32.8)
6	34017 (60.1)	22599 (39.9)
7	31439 (55.5)	25177 (44.5)
8	19571 (34.6)	37045 (65.4)

2.3.2. Instruments

Memory was measured using the 10-Word Recall Test, already described in section 2.1.2. Recent and delayed recall were considered separately, and the number of correctly evoked words in each case was used as the measure of recent and delayed memory.

Semantic verbal fluency was measured at each time point using the enumeration of semantic category of animals, given its clarity across languages and cultures (Ardila et al., 2006; Henley, 1969). The total number of correctly-stated animals was employed as the measure of individuals' verbal fluency.

Additional covariates included in the models were socio-demographical variables (age, gender and level of education), and several bio-psycho-social variables (physical inactivity, depressive symptomatology and social engagement). All employed covariates were measured at the time of the SHARE wave 4 interview.

Level of education was measured across countries using the International Standard Classification of Education (ISCED) coding 1997 version (Schneider, 2008).

Physical inactivity, as described in section 2.1.2., was recoded as a binary indicator that recorded whether the individual performed moderate physical exercise, such as gardening or doing a walk, at least weekly (0) or not (1).

Depressive symptomatology was measured with the EURO-D scale (Prince et al., 1999), as described in section 2.1.2. The total number of depressive symptoms was employed as an indicator of respondents' level of depressive symptomatology.

Finally, social engagement considered the number of social network contacts with at least weekly interaction, and could range between 0 and 7. This measure of social engagement was employed because it was considered to represent an adequate compromise between social network and social network contact.

Quality of life (QoL) was measured with the CASP-12, a modified version of the original CASP-19 (Hyde et al., 2003). This scale considers four dimensions of QoL (control, autonomy, self-realization and pleasure) and contains 12 items, three tapping each dimension. Items are answered following a 4-point Likert scale from 1 “never” to 4 “often”. The modified scale’s psychometric properties were examined in the study by Oliver et al. (2021) and the authors concluded that it could be used as a global score of QoL or as a four-dimensional measure. In this study, the global score, computed as the sum of the 12 items, will be used.

2.3.3. Statistical analyses

Firstly, sample statistics for the variables in the study were calculated to provide a general overview of the data. Then, using Latent Growth Modelling (LGM), change over time in recent memory, delayed memory and verbal fluency was examined separately. Both linear and quadratic latent trajectories were tested for each cognitive dimension. When quadratic terms were included, time scores were centred at mean time to deal with collinearity issues. Latent growth models assume that individuals are drawn from a single population but acknowledge population heterogeneity by modelling the variance of the intercept and slope (J. Wang & Wang, 2012). Once the best growth trajectory was found, a second model was specified testing the effects of covariates onto the latent intercept and latent slope(s) in each case. The covariates considered in the models were age, gender, educational level, physical inactivity, depression and social engagement. All models were estimated using Robust Maximum Likelihood (MLR).

To study the relationship between cognition and successful ageing, operationalised by means of QoL, LGM was also employed. Namely, three Parallel Process Latent Growth Models (PP-LGM) with linear trends were specified, one for each cognitive measure (recent memory, delayed memory and verbal fluency), along with the global score of QoL. The model included the aforementioned covariates, measured at the first time considered in the analysis (SHARE wave 4).

Model fit was also assessed with fit indexes mentioned in section 2.1.3: the chi-square statistic (χ^2), the Comparative Fit Index (CFI), the Root Mean Squared Error of Approximation (RMSEA), and the Standardized Root Mean Square Residual (SRMR). Furthermore, model comparisons were done by examining relative fit of the linear and quadratic models. For this, Akaike's Information Criterion (AIC) and Bayesian Information Criterion (BIC) were used. Lower values of BIC and AIC indicate better fit. Missing data were handled using Full Information Maximum Likelihood (FIML), which performs well for both Missing at Random (MAR) and Missing Completely at Random (MCAR) missing processes. This technique does not eliminate nor impute missing observations. Instead, it creates subsets of raw data with a common pattern of missing observations from which information is extracted to compute parameter estimates of the model (Enders, 2010; Kline, 2016). LGMs were computed in Mplus 8.7 (L. K. Muthén & Muthén, 1998-2017).

3. RESULTS

3.1. Psychometric properties of cognition scales in SHARE

3.1.1. 10-Word Recall Test

3.1.1.1. Recent recall

Findings from the series of confirmatory factor models of recent recall are presented in Table 11. Only when both primacy and recency effects were taken into account could the model fit be regarded as adequate. As a result, this model was chosen, since it best captures the factor structure of recent recall. Coefficient omega was used to estimate reliability, and the resulting estimate, $\omega = .98$, indicated excellent reliability.

Figure 6a shows the standardized factor loadings and correlations among the items that represent the primacy and recency effects. In general, factor loadings are statistically significant and low. Additionally, the first and second words as well as the ninth and tenth words present the largest correlations. Therefore, serial position effects seem to fade. In this line, the correlation between the first and third words

(r = .021, p = .139) was not statistically significant, and correlation between the eighth and tenth words (r = -.051, p < .001) was very small.

Table 11

Series of competitive models of recent recall

	No effects	Primacy effect	Recency effect	Primacy and recency effects
χ^2	1351.65	1180.88	1033.76	882.21
df	35	32	32	29
p	< .001	< .001	< .001	< .001
$\Delta\chi^2$	464.18	286.89	153.64	-
df	6	3	3	-
p	< .001	< .001	< .001	-
CFI	.854	.873	.889	.905
ΔCFI	.051	.032	.016	-
RMSEA	.032	.031	.029	.028
90% CI RMSEA	.031 - .034	.030 - .033	.028 - .031	.027 - .030
SRMR	.038	.036	.034	.031

As the presence of serial position effects was identified, correlations between recent recall and cognitive reserve, measured as the respondents' level of educational, were examined in the model with no effects and in the retained model with both primacy and recency effects. In the model with no serial position effects, a correlation of r = .611 (.597 - .624) was estimated between recent recall and education. In the model with serial position effects, education and recent recall were estimated to correlate r =.647 (.631 - .662). Given that there is no overlap of the confidence intervals of both estimates, the models are considered to have statistically different correlations. The strength of the correlations suggests that the association between recent recall and cognitive reserve is attenuated when primacy and recency effects are not modelled. A graphical representation of both correlations and their confidence intervals is displayed in Figure 7.

Figure 6

(a) Recent recall: standardized factor loadings, and primacy and recency effects. (b) Delayed recall: standardized factor loadings

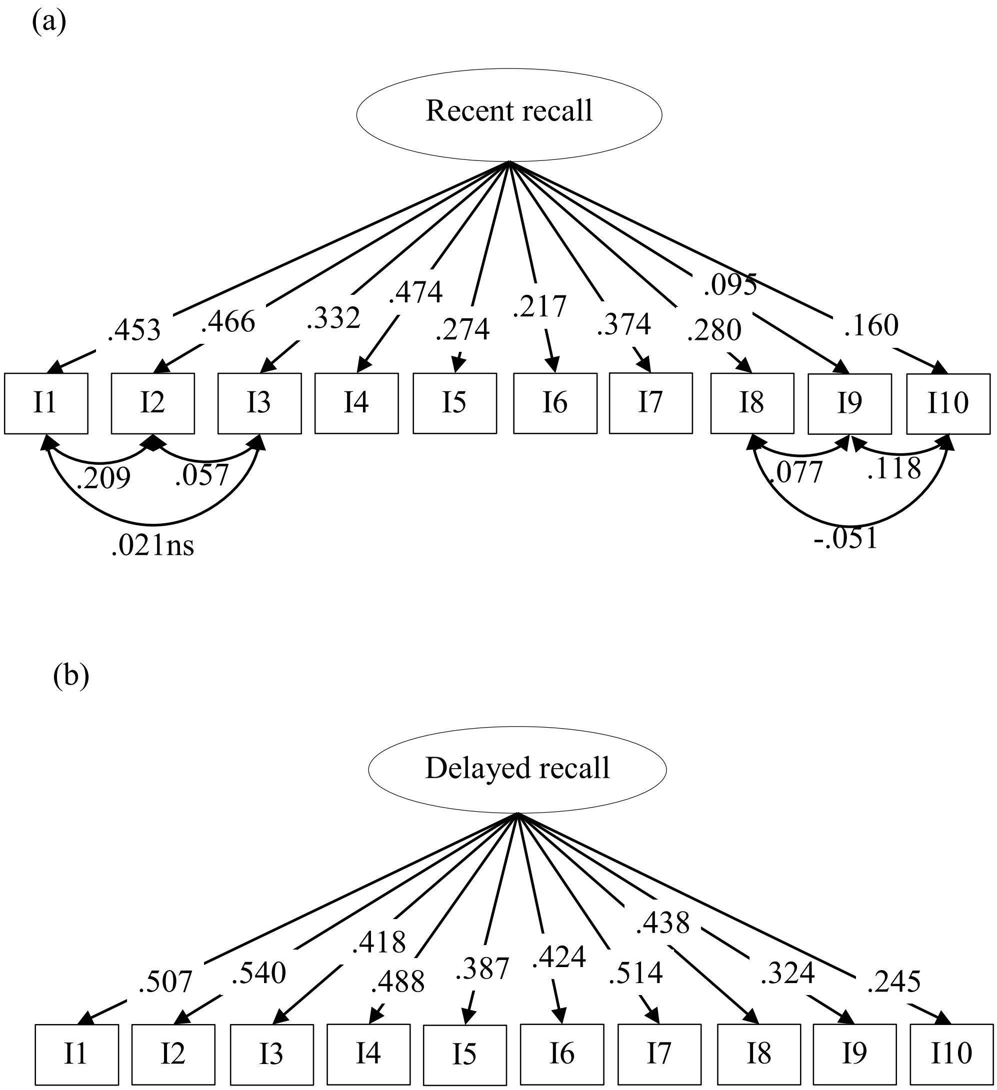
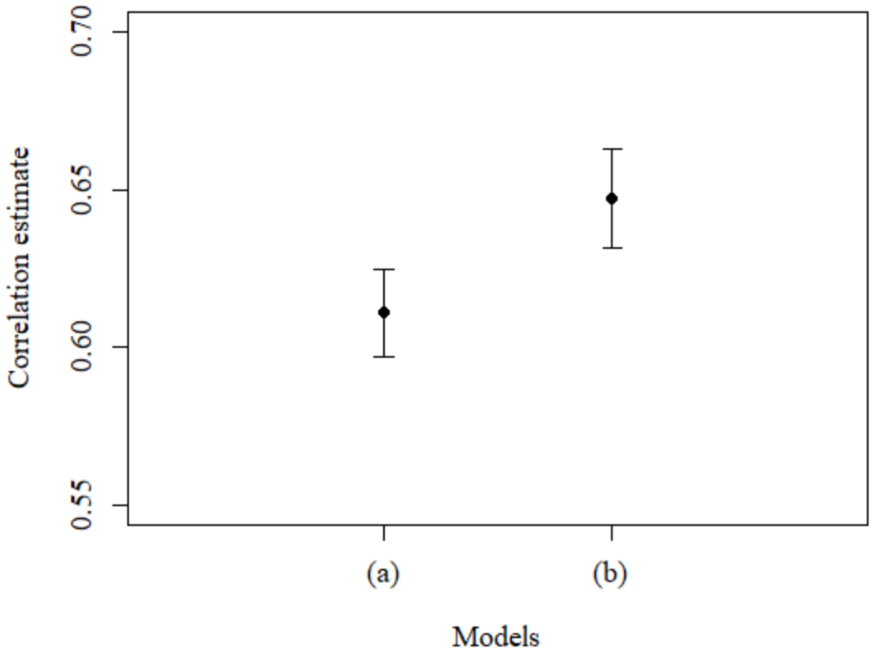


Figure 7

Correlations between education and recent recall when serial position effects are not (a) or are (b) acknowledged



3.1.1.2. Delayed recall

The same model sequence as in section 3.1.1.1 was tested for delayed recall. Table 12 shows the results, which differ from those found for recent recall. In this case, acknowledging serial position effects did not significantly improve model fit. As a result, the best fitting model was the one-factor model of delayed recall with no primacy or recency effects. Internal consistency was estimated to be $\omega = .99$ using coefficient omega, indicating excellent reliability. Figure 6b shows the standardized factor loadings of the retained model.

Table 12

Series of competitive models of delayed recall

	No effects	Primacy effect	Recency effect	Primacy and recency effects
χ^2	906.41	839.72	877.29	814.05
df	35	32	32	29
p	< .001	< .001	< .001	< .001
$\Delta\chi^2$	96.46	30.34	64.19	-
df	6	3	3	-
p	< .001	< .001	< .001	-
CFI	.957	.960	.959	.962
ΔCFI	.005	.002	.003	
RMSEA	.026	.026	.027	.027
90% CI RMSEA	.025 - .028	.025 - .028	.025 - .028	.026 - .029
SRMR	.031	.030	.030	.029

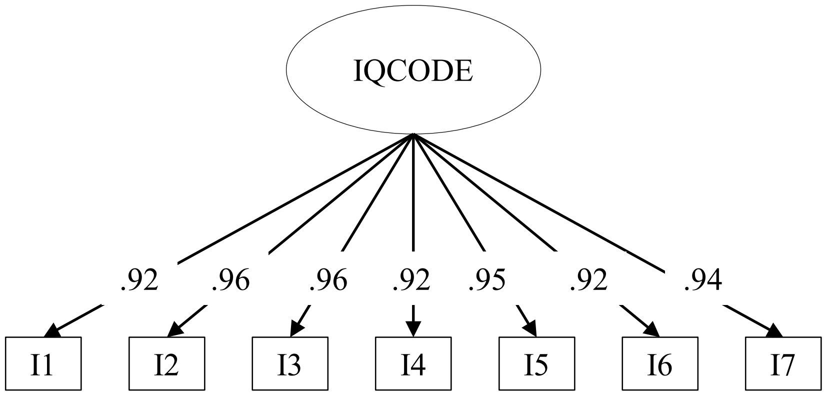
3.1.2. Informant Questionnaire on Cognitive Decline in the Elderly

3.1.2.1.Factor structure

A one-factor CFA model was established according to the theoretical structure of the scale. The model fitted the data adequately: $\chi2(14) = 218.92$, $p < .001$, CFI = .99, RMSEA = .118 [.104 - .132], SRMR = .028. The RMSEA fails to meet the criteria, but this is typical of models with few degrees of freedom (Kenny et al., 2015). Figure 8 shows the item loadings, which were all statistically significant and extremely high.

Figure 8

Standardized factor loadings for the on-factor model of the IQCODE



3.1.2.2.Internal consistency

The omega coefficient for the unidimensional model of informants' perceptions of cognitive decline was $\omega = .94$, indicating that the scale has excellent internal consistency.

3.1.2.3.Criterion-related validity

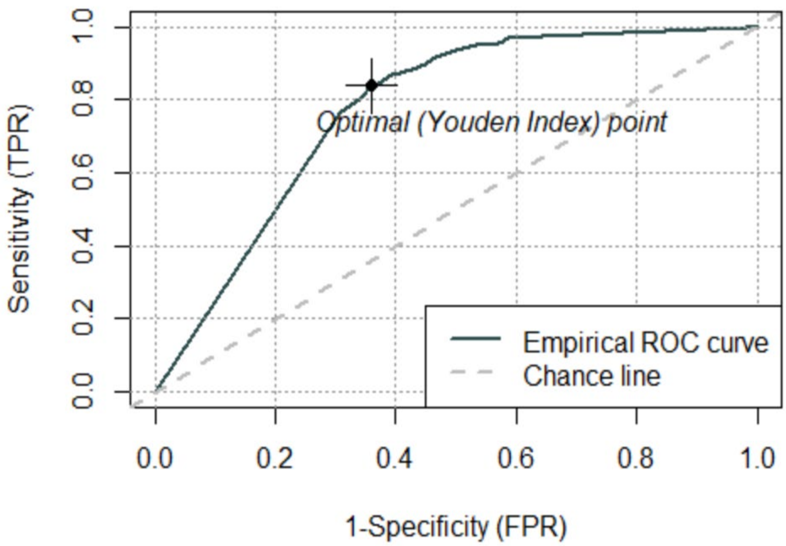
To investigate criterion-related validity, a t-test was used to compare informants' perceptions of cognitive loss between those who had been diagnosed with Alzheimer's disease or another form of dementia and those who had not. The t-test results were as follows: $t(1009.04) = 20.61$, $p < .001$, $d = 1.16$. The mean of informants of respondents with dementia's score was 2.89 ($SD = 0.23$), while the average score of informants of respondents who had not been diagnosed with dementia was 2.46 ($SD = 0.44$). Therefore, the results showed that there was a significantly higher score of informants' perception of cognitive impairment among those individuals whose respondent had a dementia diagnosis, with a large effect size.

3.1.2.4. Diagnostic validity

To assess diagnostic validity, a ROC curve was generated using the mean IQCODE score, and with the respondents' reported dementia diagnosis as the criterion. Figure 9 illustrates the curve. The area under the curve was 77.33%, indicating adequate discrimination (Hosmer et al., 2013). Youden's Index (Youden, 1950) was used to determine the best cut-off point. The optimal IQCODE cut-off score for this index was 2.80 points. This corresponded to a .838 sensitivity and a .641 specificity.

Figure 9

ROC curve for establishing the optimal IQCODE cut-off point



3.2. A holistic model of cognition

The proposed theoretical model in Figure 5 was estimated and tested. The overall fit was excellent: χ^2 (52) = 1969.01, $p < .001$, CFI = .987, RMSEA = .022 90% CI [.027 -.030], SRMR =.027. Table 13 reports the correlations between exogenous variables, and Table 14 displays standardized coefficients, standard errors, and associated p-values. Correlations among dependent variables are shown in Table 15.

Regarding temporal orientation, all predictors were statistically significant, except gender and loneliness. Age, physical inactivity and depression were negatively related to temporal orientation, while education, number of chronic disorders, social activity and intellectual activity were positively related. Considering the size of the effects, the most relevant factor was age (β = -.337), followed by depression (β = -.167) and intellectual activity (β = .148). The strength of the effects of education's (β = .083) and social activity's (β = .071) were similar for explaining temporal orientation's variance. Physical health factors contemplated in the model presented medium to small effects (β = -.088 for physical inactivity and β = .020 for number of chronic diseases).

Table 13

Correlation coefficients and standard errors among exogenous variables. All correlations are statistically significant (p < .001). Note: gender coded 0 = female, 1 = male

		(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**	**(8)**
(1) Age		1							
(2) Gender	Coefficient	.030	1						
	Standard error	.005							
(3) Years of education	Coefficient	-.209	.068	1					
	Standard error	.005	.005						
(4) Physical inactivity	Coefficient	.209	-.038	-.139	1				
	Standard error	.004	.005	.005					
(5) Number of chronic diseases	Coefficient	.275	-.046	-.126	.189	1			
	Standard error	.004	.005	.005	.004				
(6) Social activity	Coefficient	-.115	.018	.248	-.225	-.118	1		
	Standard error	.005	.005	.004	.006	.005			
(7) Intellectual activity	Coefficient	-.053	-.073	.267	-.248	-.042	.303	1	
	Standard error	.005	.005	.005	.005	.005	.004		
(8) Depression	Coefficient	.133	-.169	-.138	.263	.319	-.144	-.159	1
	Standard error	.004	.005	.005	.004	.004	.005	.005	
(9) Loneliness	Coefficient	.135	-.084	-.134	.228	.183	-.167	-.190	.444
	Standard error	.004	.005	.005	.004	.004	.006	.005	.003

Table 14

Standardised results of the tested model. Note: gender coded 0= female, 1= male; Coef. = Standardised coefficient; SE= Standard Error

		Coef.	SE	p-value
Temporal orientation	Age	-.337	.008	< .001
	Gender	-.017	.010	.085
	Years of education	.083	.010	< .001
	Physical inactivity	-.088	.008	< .001
	Number of chronic diseases	.020	.010	.044
	Social activity	.071	.010	< .001
	Intellectual activity	.148	.009	< .001
	Depression	-.167	.009	< .001
	Loneliness	-.016	.009	.077
Numeracy	Age	-.086	.005	< .001
	Gender	.049	.005	< .001
	Years of education	.128	.005	< .001
	Physical inactivity	-.018	.005	< .001
	Number of chronic diseases	-.007	.005	.149
	Social activity	.036	.005	< .001
	Intellectual activity	.127	.005	< .001
	Depression	-.104	.005	< .001
	Loneliness	-.017	.005	< .001
Verbal fluency	Age	-.208	.003	< .001
	Gender	.002	.004	.056
	Years of education	.168	.003	< .001
	Physical inactivity	-.091	.003	< .001
	Number of chronic diseases	< .001	.004	.999
	Social activity	.126	.004	< .001
	Intellectual activity	.234	.003	< .001
	Depression	-.050	.004	< .001
	Loneliness	-.062	.004	< .001
Memory	Age	-.319	.004	< .001
	Gender	-.105	.004	< .001
	Years of education	.185	.004	< .001
	Physical inactivity	-.053	.004	< .001
	Number of chronic diseases	-.032	.004	< .001
	Social activity	.127	.005	< .001
	Intellectual activity	.194	.005	< .001
	Depression	-.102	.005	< .001
	Loneliness	-.046	.005	< .001

Every predictor contemplated in the model had a statistically significant effect in memory, with age, being male, physical inactivity, number of chronic diseases, loneliness and depression, being negatively related to memory, and the rest being positively related. In reference to the relative impact of the predictors, age (β = -.319), intellectual activity (β = .148) and education (β = .185) had the largest significant effects, while smaller effects were found for chronic diseases (β = -.032), physical inactivity (β = -.053) and loneliness (β = -.046).

Table 15

Correlation coefficients and standard errors among dependent variables. All correlations are statistically significant (p < .001)

		(1)	(2)	(3)
(1) Temporal orientation		1		
(2) Numeracy	Coefficient	.241	1	
	Standard error	.010		
(3) Verbal fluency	Coefficient	.433	.149	1
	Standard error	.007	.004	
(4) Memory	Coefficient	.521	.240	.406
	Standard error	.007	.005	.003

All predictors, except for chronic diseases, demonstrated a statistically significant association to numeracy. Age, physical inactivity, loneliness and depression all had a negative impact, while being male, years of education and social and intellectual activity participation had a positive impact. Years of education (β = .128), intellectual activity (β = .127) and depression (β = -.104) were the main predictors of numeracy. The remaining predictors had negligible effects.

Finally, all predictors had statistically significant effects on verbal fluency except gender and chronic diseases. Age, physical inactivity, depression and loneliness were all associated with lower verbal fluency, whereas years of education and participation in social and intellectual activities were all associated with higher verbal fluency. Age ($\beta = -.208$), years of education ($\beta = .168$), intellectual activity ($\beta = .234$), and social activity ($\beta = .126$) had the largest estimated effects explaining the variance in verbal fluency.

Overall, the model adequately fitted the data and significantly predicted the various components of older adults' cognitive function, with verbal fluency and memory being the components that were better explained by the predictors considered in the model (29.2% of verbal fluency's variance and 37.4% of memory's variance), followed by temporal orientation (28.2% of explained variance) and numeracy (9.7% of explained variance).

3.3. Longitudinal study of cognition

3.3.1. Recent memory

3.3.1.1. Recent memory across time

First, means and standard deviations of recent recall across all study waves employed in the analysis were computed, and are displayed in Table 16. Next, both linear and quadratic trajectories of change in recent memory were tested. A total of 820 cases had missing data in all time points and were excluded from the analyses. Both models present adequate fit to the data. The linear model yields the following results: χ^2 (10) = 416.41, $p < .001$, CFI = .990, RMSEA = .027 [.025 – .029], SRMR = .016, AIC = 655298.07, BIC = 655387.36. However, adding a quadratic term slightly improves fit, both in terms of AIC and BIC: χ^2 (6) = 135.87, $p < .001$, CFI = .997, RMSEA = .020 [.017 – .023], SRMR = .013, AIC = 654991.23, BIC = 655116.24. The quadratic model was retained as the best-fitting model. A graphical representation of the model, with unstandardized estimates, is shown in Figure 10.

Figure 10

*Covariances from the quadratic latent growth model of recent memory. Note: * p < .05; ** p < .001*

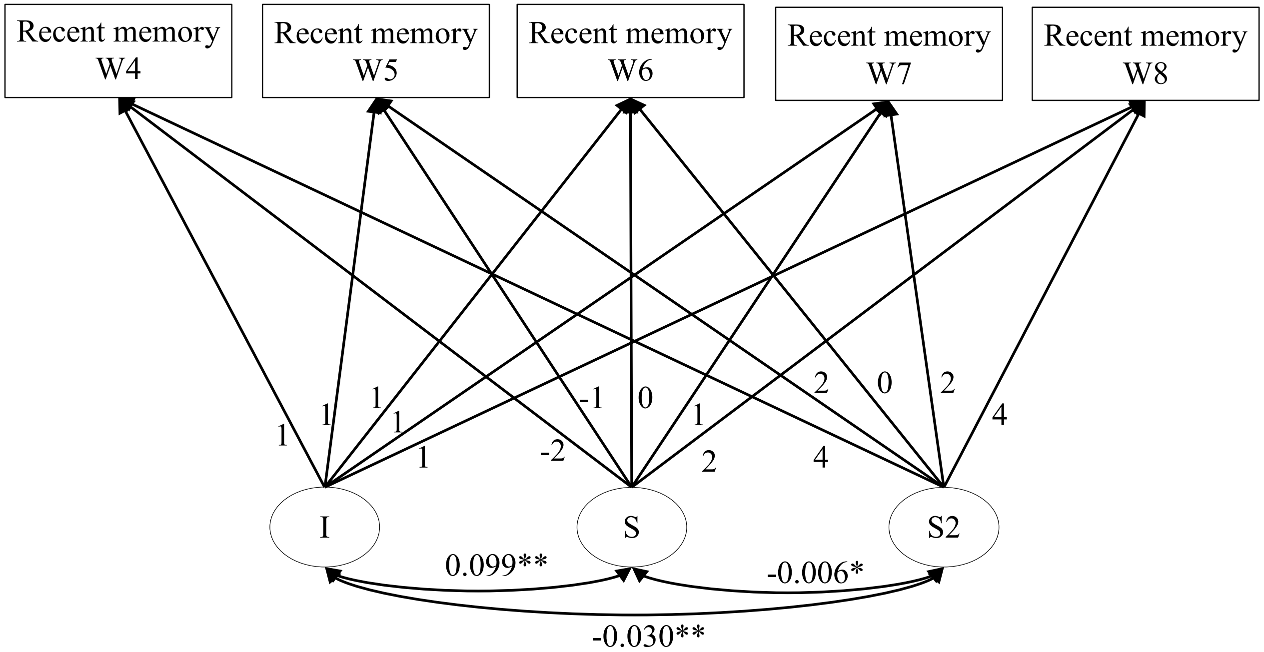


Table 16

Sample statistics of recent recall through all waves considered in the analysis

Recent recall	M ± SD	n (%) of missing data
Wave 4	5.14 ± 1.86	1512 (2.7)
Wave 5	5.31 ± 1.85	19643 (34.7)
Wave 6	5.26 ± 1.83	24199 (42.7)
Wave 7	5.14 ± 1.89	26430 (46.7)
Wave 8	5.27 ± 1.81	37564 (66.3)

M= Mean; SD= Standard Deviation

The retained model has an estimated mean intercept of 5.11 ($p < .05$) and the estimated variance of the intercept is 2.20 ($p < .05$). Model's average linear slope is estimated at -0.072 ($p < .05$) and its estimated variance is 0.057 ($p < .05$). Regarding the quadratic slope, the average estimate is -0.029 ($p < .05$) with an estimated variance of 0.011 ($p < .05$).

In general, the model displays a quadratic trajectory of decline in recent memory, with an initial linear decline followed by a steeper, quadratic, decline (inverted u-shape). That is, individuals' recent memory experiences decline, on average, becomes sharper over time. As previously shown in Figure 10, covariance estimates between the latent intercept, latent linear slope, and latent quadratic slope were all statistically significant. The intercept and the linear slope present a positive covariance of 0.099. As time scores were centred at mean time, this positive covariance indicates that respondents with higher levels of recent memory at wave 6 also present a steeper initial decline. The covariance estimate between the intercept and the quadratic slope is -0.030, which indicates that individuals with higher levels of recent memory at wave 6 present less quadratic decline. Finally, the covariance estimate between the linear and the quadratic slope is -0.006, which informs that respondents experiencing steeper linear decline present less acute quadratic decline, and vice-versa. Additionally, the correlation between the latent intercept and the latent linear slope is .278 ($p < .05$), the correlation between the latent intercept and the latent quadratic slope is -.189 ($p < .05$), and the correlation between the latent linear slope and the latent quadratic slope is -.250 ($p < .05$).

3.3.1.2. Explaining recent memory

Age, gender, educational attainment, physical inactivity, depressive symptomatology and social engagement, measured at wave 4, were introduced as covariates in the retained model from section 3.3.1.1 to explain the longitudinal trajectory for recent memory performance. Table 17 displays the sample statistics of the aforementioned covariates.

The model presents an adequate fit to the data: χ^2 (18) = 133.12, $p < .001$, CFI = .998, RMSEA = .011 [.009 – .013], SRMR = .008, AIC = 570349.02, BIC = 570631.74. The model is represented in Figure 11, and standardized effects of the covariates are available in Table 18. All covariates have a statistically significant effect on the latent intercept. For the linear slope, all covariates except physical inactivity and social engagement present statistically significant effects, while the only statistically significant effects on the quadratic latent slope are those of age and educational attainment. Figure 12 offers the estimated latent quadratic trajectory of recent memory for the whole sample (a) and for 50 random respondents (b).

Regarding the correlations among latent variables, they are statistically significant, being the latent intercept positively correlated ($r = .248$, $p < .001$) with the linear latent slope, and negatively correlated with the quadratic latent slope ($r = -.281$, $p < .001$). The linear and the quadratic latent slopes also present a negative statistically significant correlation ($r = -.239$, $p < .05$). That is, individuals with higher average recent memory present higher linear decline but lower quadratic decline. Overall, the model explains 51.4% of the variance of the latent intercept, 11.8% of the variance of the linear latent slope, and 0.8% of the variance of the quadratic latent slope.

Table 17

Sample statistics of the covariates included in the model to explain individuals' recent memory trajectories over time

	M ± SD or n (%)	n (%) of missing data
Age	65.93 ± 10.01	0 (0)
Gender (Male)	24893 (44.0)	0 (0)
Educational level		1252 (2.1)
ISCED Level 0	1675 (3.0)	
ISCED Level 1	10913 (19.3)	
ISCED Level 2	10724 (18.9)	
ISCED Level 3	18561 (32.8)	
ISCED Level 4	2583 (4.6)	
ISCED Level 5	10457 (18.5)	
ISCED Level 6	451 (0.8)	
Physical inactivity (Yes)	11156 (19.7)	684 (1.2)
Depression	2.60 ± 2.30	1848 (3.3)
Social engagement	2.22 ± 1.35	3308 (5.8)

M= Mean; SD= Standard Deviation

Figure 11

Representation of the quadratic latent growth model of recent memory with covariates. Note: Covariances among latent variables not shown for simplicity. I= Intercept; S= Linear slope; S2= Quadratic slope

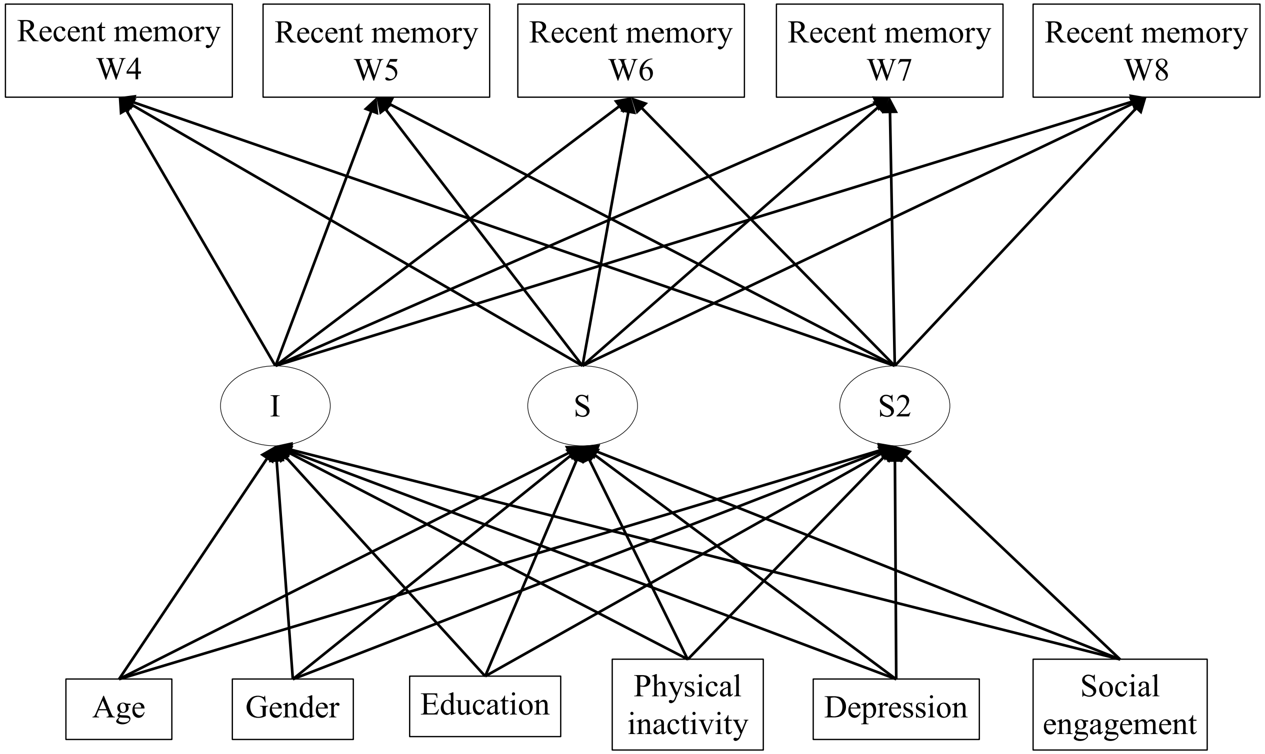


Table 18

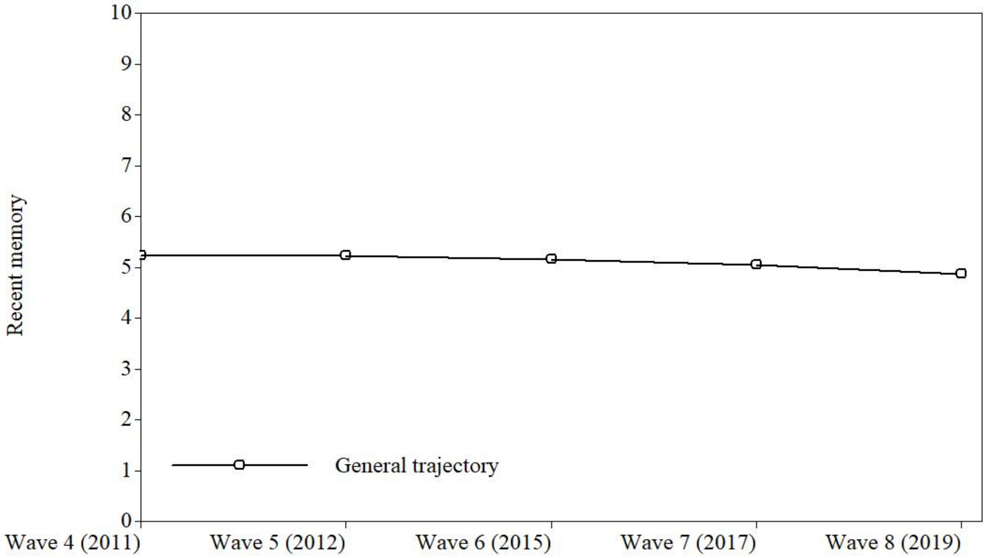
Standardized model results for the quadratic latent growth model of recent memory with covariates

	Coefficient β	Standard error	p-value
Intercept			
Age	-.444	.005	< .001
Gender (Male)	-.137	.005	< .001
Educational attainment	.374	.005	< .001
Physical inactivity	-.101	.006	< .001
Depression	-.130	.005	< .001
Social engagement	.047	.005	< .001
Linear slope			
Age	-.336	.015	< .001
Gender (Male)	-.042	.012	< .001
Educational attainment	.027	.012	< .05
Physical inactivity	.004	.013	.767
Depression	.059	.012	< .001
Social engagement	-.007	.011	.500
Quadratic slope			
Age	-.071	.023	< .05
Gender (Male)	-.015	.020	.469
Educational attainment	-.052	.021	< .05
Physical inactivity	-.011	.022	.616
Depression	-.025	.022	.245
Social engagement	.028	.020	.165

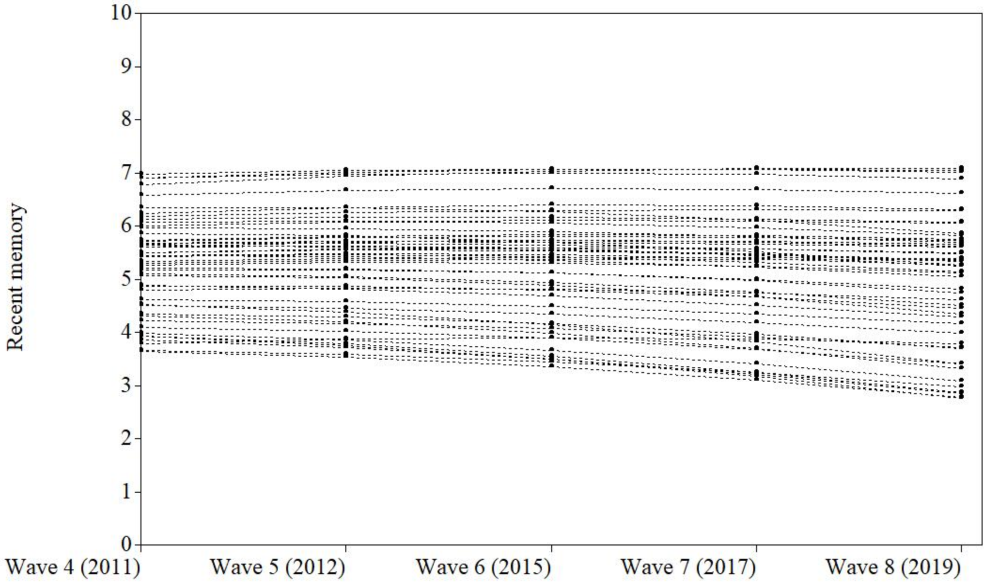
Figure 12

Estimated recent memory latent quadratic trajectory for the general sample (a) and for 50 random respondents (b), after controlling for the effects of covariates

(a)



(b)



3.3.2. Delayed memory

3.3.2.1. Delayed memory across time

First, means and standard deviations of delayed recall across all study waves employed in the analysis were computed, and are displayed in Table 19. Next, both linear and quadratic trajectories of change in delayed memory were tested. A total of 833 cases had missing data in all time points and were therefore excluded from the analyses. Both models present adequate fit to the data. The linear model yields the following results: χ^2 (10) = 738.86, $p < .001$, CFI = .985, RMSEA = .036 [.034 – .038], SRMR = .018, AIC = 711403.92, BIC = 711493.21. However, adding a quadratic term slightly improves fit, both in terms of AIC and BIC: χ^2 (6) = 268.18, $p < .001$, CFI = .994, RMSEA = .028 [.025 – .031], SRMR = .011, AIC = 710903.80, BIC = 711028.81. The quadratic model was retained as the best-fitting model. A graphical representation of the model, with unstandardized estimates, is shown in Figure 13.

Table 19

Sample statistics of delayed recall through all waves considered in the analysis. Note: M = Mean; SD = Standard Deviation

Delayed recall	M ± SD	n (%) of missing data
Wave 4	3.75 ± 2.19	1517 (2.7)
Wave 5	3.98 ± 2.25	19728 (34.8)
Wave 6	3.92 ± 2.24	24193 (42.7)
Wave 7	3.73 ± 2.22	26247 (46.4)
Wave 8	3.91 ± 2.21	37601 (66.4)

The retained model has an estimated mean intercept of 3.75 ($p < .05$) and the estimated variance of the intercept is 3.18 ($p < .05$). Model's linear slope mean is estimated at -0.082 ($p < .05$) and its estimated variance is 0.077 ($p < .05$). Regarding the quadratic slope, the mean estimate is -0.041 ($p < .05$) with an estimated variance of 0.014 ($p < .05$).

In general, the model displays a quadratic trajectory of decline in delayed memory. That is, individuals' delayed memory experiences, on average, decline that becomes sharper over time. As shown in Figure 13, covariance estimates between the latent intercept, latent linear slope, and latent quadratic slope were all statistically significant. The intercept and the linear slope present a positive covariance of 0.118. As time scores were centred at mean time, this positive covariance indicates that respondents with higher levels of delayed memory at wave 6 also present a steeper initial decline. The covariance estimate between the intercept and the quadratic slope is -0.064, which indicates that individuals with higher levels of delayed memory at wave 6 present less quadratic decline. Finally, the covariance estimate between the linear and the quadratic slope is -0.009, which informs that respondents experiencing steeper linear decline present less acute quadratic decline, and vice-versa. Additionally, the correlation between the latent intercept and the latent linear slope is .238 ($p < .05$), the correlation between the latent intercept and the latent quadratic slope is -.300 ($p < .05$), and the correlation between the latent linear slope and the latent quadratic slope is -.274 ($p < .05$).

3.3.2.2.Explaining delayed memory

Age, gender, educational attainment, physical inactivity, depressive symptomatology and social engagement, measured at wave 4, were introduced as covariates in the retained latent growth model of delayed memory to explain its latent intercept and slopes. The sample statistics of the covariates included in the model correspond to the ones displayed in Table 17.

The resulting model presents an adequate fit to the data: χ^2 (18) = 288.51, $p < .001$, CFI = .996, RMSEA = .017 [.015 – .019], SRMR = .007, AIC = 627516.39, BIC = 627799.10. The model is represented in Figure 14, and standardized effects of the covariates are available in Table 20. All covariates have a statistically significant effect on the latent intercept. For the linear slope, only age and depression present statistically significant effects, while the only statistically significant effects on the quadratic latent slope are those of age and educational attainment. Figure 15 offers the estimated latent quadratic trajectory of delayed memory for the whole sample (a) and for 50 random respondents (b).

The correlations among latent variables are all statistically significant. The latent intercept is positively correlated (r = .231, p < .001) with the linear latent slope, and negatively correlated with the quadratic latent slope (r = -.368, p < .001). The linear and the quadratic latent slopes also present a negative statistically significant correlation (r = -.288, p < .05). That is, individuals with higher average delayed memory present higher linear decline but lower quadratic decline. Overall, the model explains 46.3% of the variance of the latent intercept, 10.3% of the variance of the linear latent slope, and 0.9% of the variance of the quadratic latent slope.

Figure 13

*Covariances from the quadratic latent growth model of delayed memory. Note: * p < .05; ** p < .001; I= Intercept; S= Linear slope; S2= Quadratic slope*

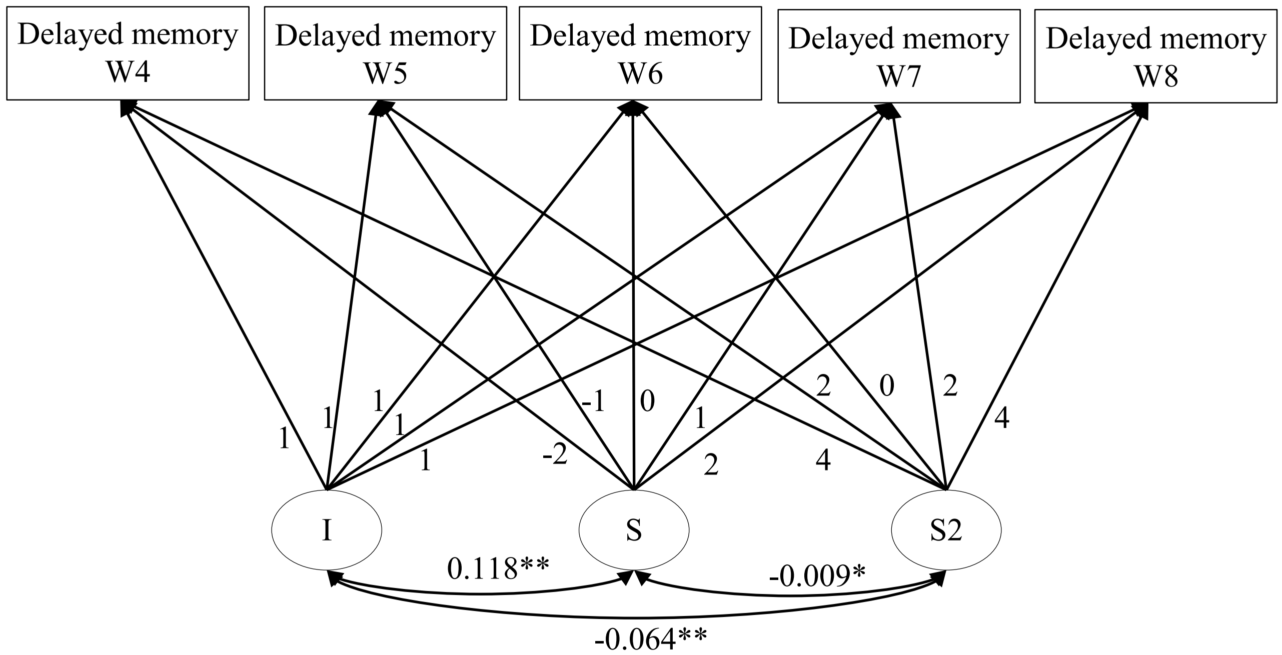


Table 20

Standardized model results for the quadratic latent growth model of delayed memory with covariates

	Coefficient β	Standard error	p-value
Intercept			
Age	-.423	.005	< .001
Gender (Male)	-.145	.005	< .001
Educational attainment	.355	.005	< .001
Physical inactivity	-.083	.005	< .001
Depression	-.121	.005	< .001
Social engagement	.056	.005	< .001
Linear slope			
Age	-.313	.015	< .05
Gender (Male)	-.021	.012	.084
Educational attainment	.008	.012	.515
Physical inactivity	-.011	.013	.423
Depression	.085	.013	< .001
Social engagement	.003	.012	.780
Quadratic slope			
Age	-.063	.024	< .05
Gender (Male)	.023	.021	.281
Educational attainment	-.061	.022	< .05
Physical inactivity	.037	.024	.114
Depression	-.025	.023	.279
Social engagement	-.026	.021	.212

Figure 14

Representation of the quadratic latent growth model of delayed memory with covariates. Note: Covariances among latent variables not shown for simplicity. I= Intercept; S= Linear slope; S2= Quadratic slope

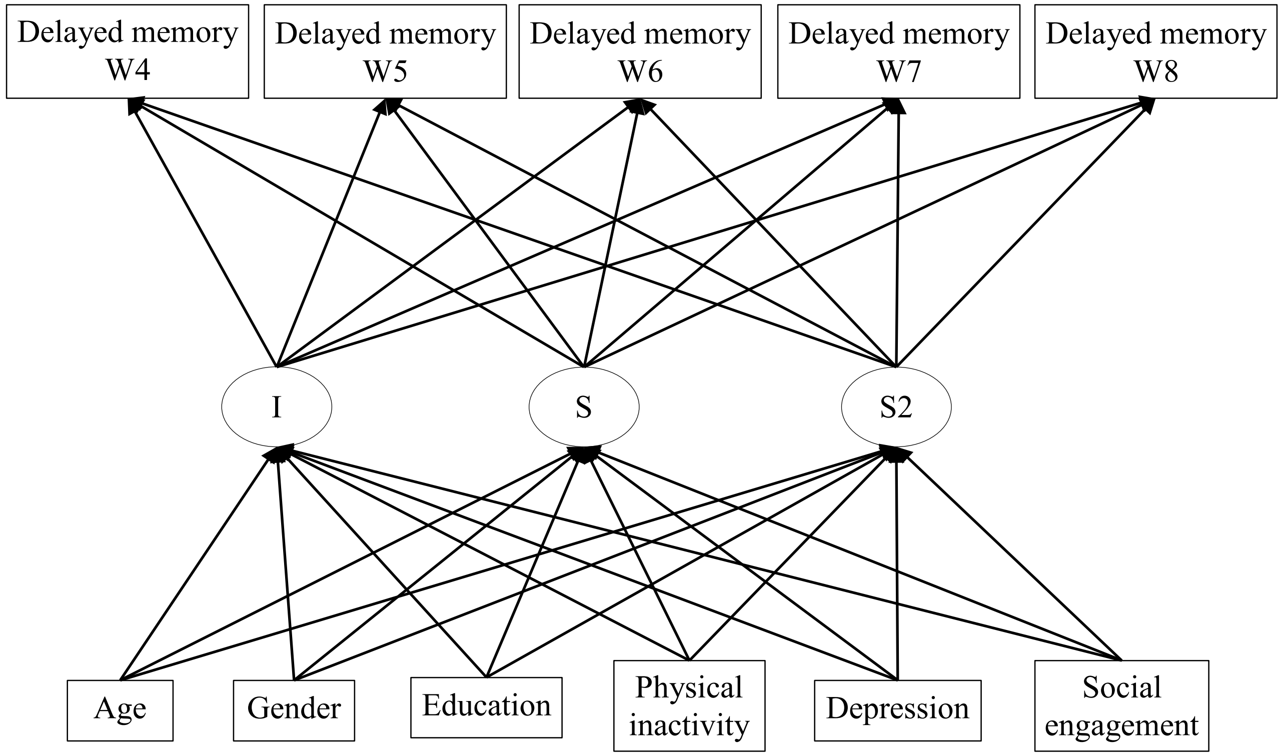
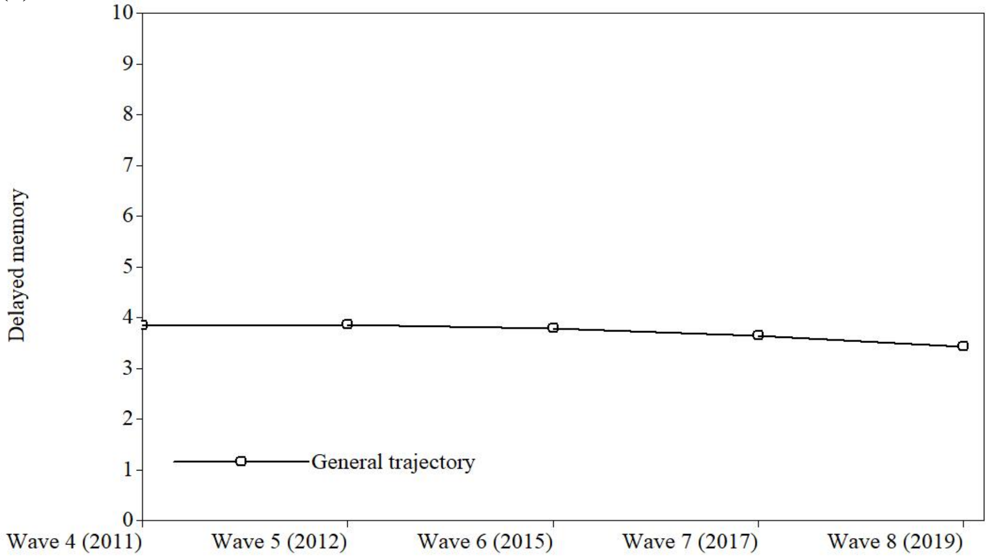


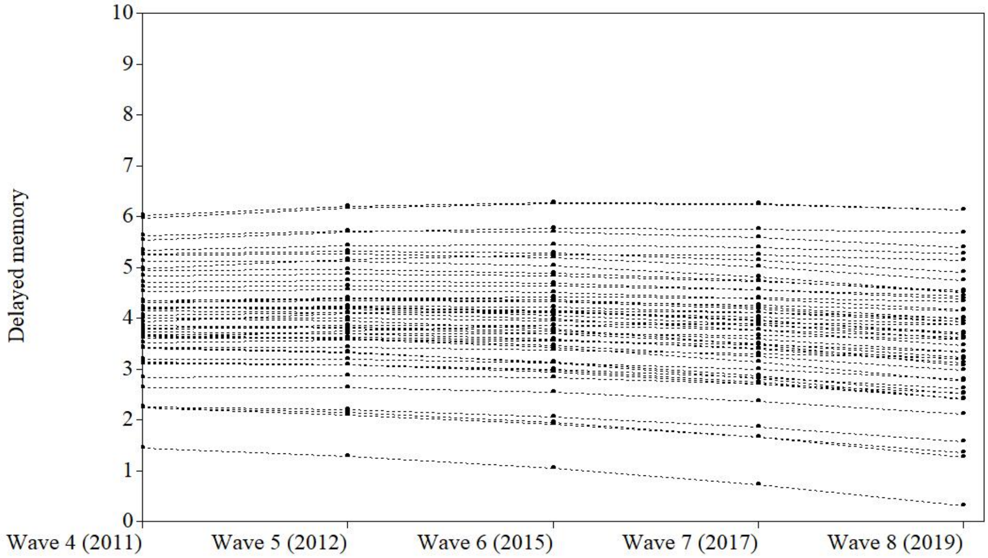
Figure 15

Estimated delayed memory latent quadratic trajectory for the general sample (a) and for 50 random respondents (b), after controlling for the effects of covariates

(a)



(b)



3.3.3. Semantic verbal fluency

3.3.3.1. Semantic verbal fluency across time

Means and standard deviations of semantic verbal fluency across all study waves employed in the analysis were computed, and are displayed in Table 21. Linear and quadratic latent growth trajectories of semantic verbal fluency were tested. From the baseline sample, 1056 cases were discarded due to complete missing data in all of the dependent variables. The linear LGM fitted the data adequately: χ^2 (10) = 169.86, $p < .001$, CFI = .983, RMSEA = .017 [.015 - .019], SRMR = .020, AIC = 1010840.17, BIC = 1010929.43. The quadratic LGM also fitted the data very well: χ^2 (6) = 15.92, $p = .014$, CFI = .999, RMSEA = .005 [.002 - .009], SRMR = .011, AIC = 1010543.41, BIC = 1010668.36. The quadratic model displayed a better fit to the data, with lower values of both AIC and BIC, as well as a very low value of the chi-square statistic. Therefore, we retained this model as best representing the data. A graphical representation of the model, with unstandardized estimates, is shown in Figure 16.

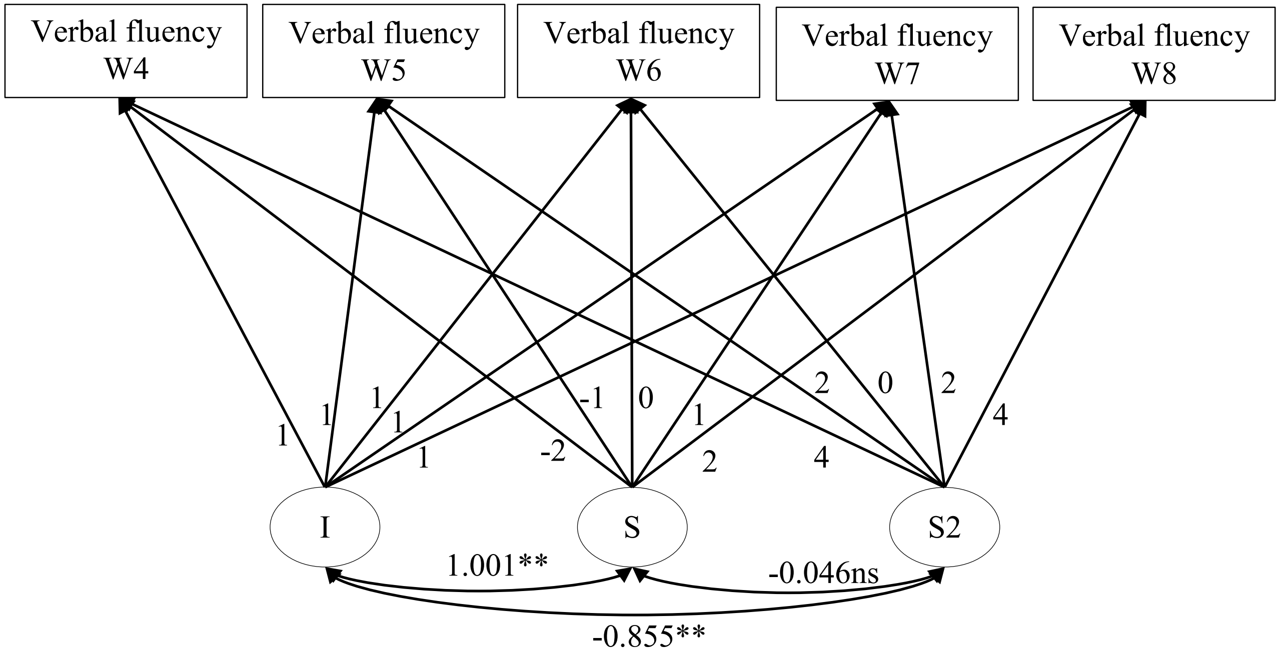
Table 21

Sample statistics of semantic verbal fluency through all waves considered in the analysis. Note: M = Mean; SD = Standard Deviation

Verbal fluency	M ± SD	n (%) of missing data
Wave 4	19.66 ± 7.72	1778 (3.1)
Wave 5	20.62 ± 7.73	19704 (34.8)
Wave 6	20.45 ± 7.81	24154 (42.7)
Wave 7	19.84 ± 8.28	45991 (81.2)
Wave 8	20.88 ± 7.71	37603 (66.4)

Figure 16

*Covariances from the quadratic latent growth model of semantic verbal fluency. Note: ** p < .001; ns= not significant (p > .05). I= Intercept; S= Linear slope; S2= Quadratic slope*



This model presented a mean intercept of 19.87 ($p < .001$), a mean linear slope of -0.066 ($p < .001$) and a mean quadratic slope of -0.087 ($p < .001$). The statistically significant and negative values of the slopes imply that semantic verbal fluency follows a quadratic latent trajectory of decline along time, which means that decline in semantic verbal fluency becomes more acute with time (inverted u-shape). The variances of the latent factors were 42.32 ($p < .001$) for the intercept, 0.917 ($p < .001$) for the linear slope term and 0.182 ($p < .001$) for the quadratic slope term, which indicate that there is between-subject variability in the average level of semantic verbal fluency as well as in the rate of decline.

Finally, as shown in Figure 16, there are statistically significant covariances between the intercept and both slopes. The covariance between the latent intercept and the latent linear slope is positive, with an estimated value of 1.001, meaning that individuals with higher intercepts also display steeper linear decline. The covariance between the latent intercept and the latent quadratic slope, in its part, is negative (estimated value of -0.855), implying that individuals with higher intercepts display less acute quadratic decline. The covariance between the latent linear and quadratic slopes is not statistically significant. Referring to correlations, the correlation between the latent intercept and the latent linear slope is .161 ($p < .05$), the correlation between the latent intercept and the latent quadratic slope is -.308 ($p < .05$), and the correlation between the latent linear slope and the latent quadratic slope is -.113 ($p > .05$).

3.3.3.2. Explaining semantic verbal fluency

Age, gender, educational attainment, physical inactivity, depressive symptomatology and social engagement, measured at wave 4, were introduced as covariates in the retained latent growth model of semantic verbal fluency to explain its latent intercept and slopes. The sample statistics of the covariates included in the model correspond to the ones displayed in Table 17.

The resulting model presents an excellent fit to the data: χ^2 (18) = 32.50, p = .019, CFI = 1.00, RMSEA= .004 [.002 – .006], SRMR = .005, AIC = 905942.04, BIC = 906224.73. The model is represented in Figure 17, and standardized effects of the covariates are available in Table 22. All covariates have a statistically significant effect on the latent intercept. For the linear slope, only age and physical inactivity present statistically significant effects, while the only statistically significant effects on the quadratic latent slope are those of educational attainment and physical inactivity. Figure 18 offers the estimated latent quadratic trajectory of semantic verbal fluency for the whole sample (a) and for 50 random respondents (b).

Regarding the correlations among the latent variables, the latent intercept is positively correlated (r = .137, p < .001) with the linear latent slope, and negatively correlated with the quadratic latent slope (r = -.347, p < .001). The linear and the quadratic latent slopes do not present a statistically significant correlation (r = -.038, p = .798). That is, individuals with higher average verbal fluency present higher linear decline but lower quadratic decline. Overall, the model explains 39.6% of the variance of the latent intercept, 11.6% of the variance of the linear latent slope, and 0.6% of the variance of the quadratic latent slope.

Figure 17

Representation of the quadratic latent growth model of semantic verbal fluency with covariates. Note: Covariances among latent variables not shown for simplicity. I= Intercept; S= Linear slope; S2= Quadratic slope

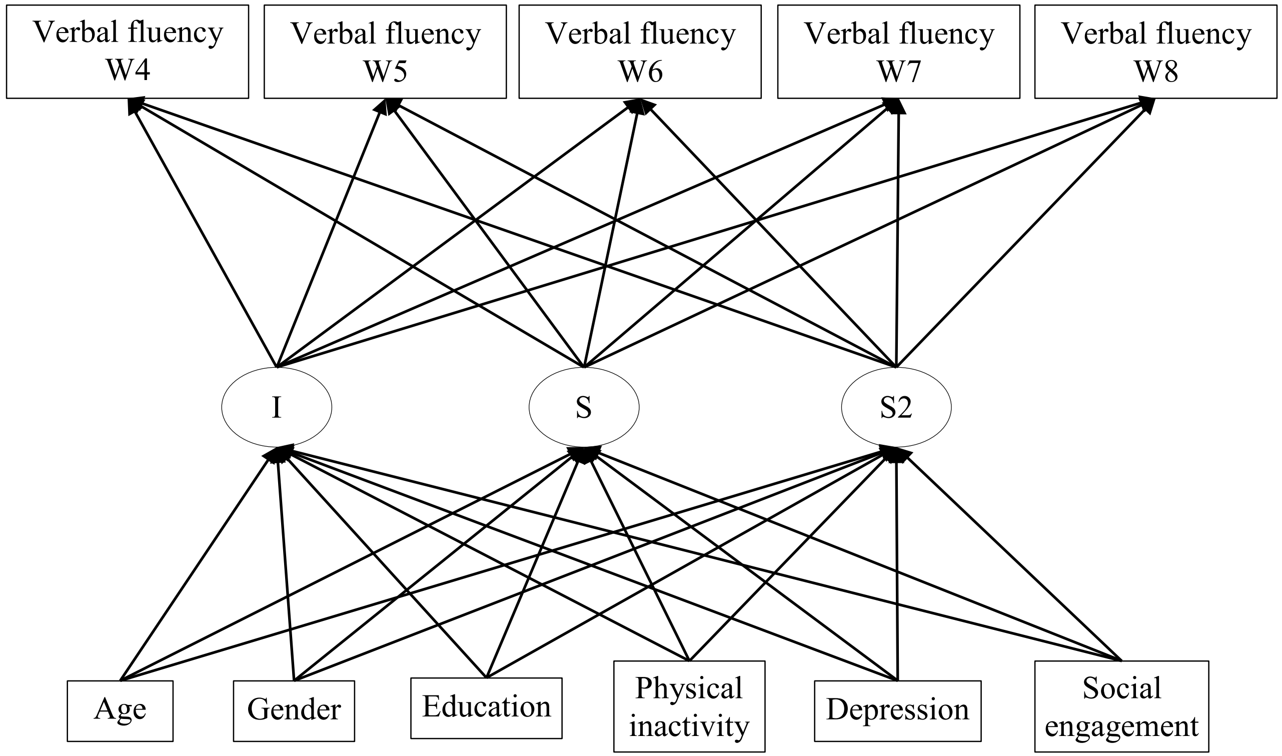


Table 22

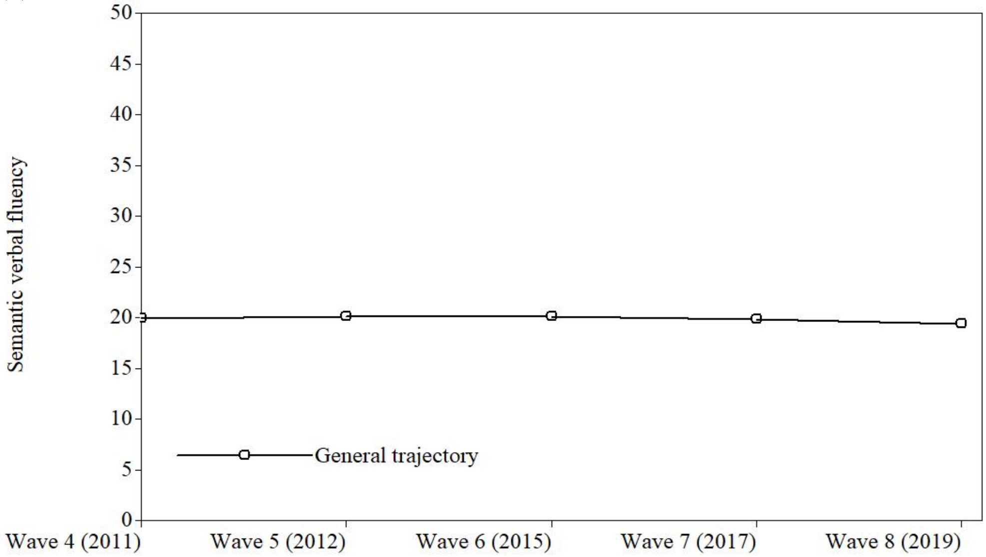
Standardized model results for the quadratic latent growth model of semantic verbal fluency with covariates

	Coefficient β	Standard error	p-value
Intercept			
Age	-.337	.005	< .001
Gender (Male)	-.038	.005	< .001
Educational attainment	.371	.005	< .001
Physical inactivity	-.109	.005	< .001
Depression	-.125	.005	< .001
Social engagement	.043	.005	< .001
Linear slope			
Age	-.351	.021	< .001
Gender (Male)	.014	.012	.245
Educational attainment	-.021	.011	.065
Physical inactivity	.043	.013	< .05
Depression	.018	.012	.142
Social engagement	.003	.011	.801
Quadratic slope			
Age	-.017	.020	.389
Gender (Male)	-.011	.019	.542
Educational attainment	-.049	.019	< .05
Physical inactivity	-.065	.021	< .05
Depression	.015	.019	.443
Social engagement	.003	.017	.853

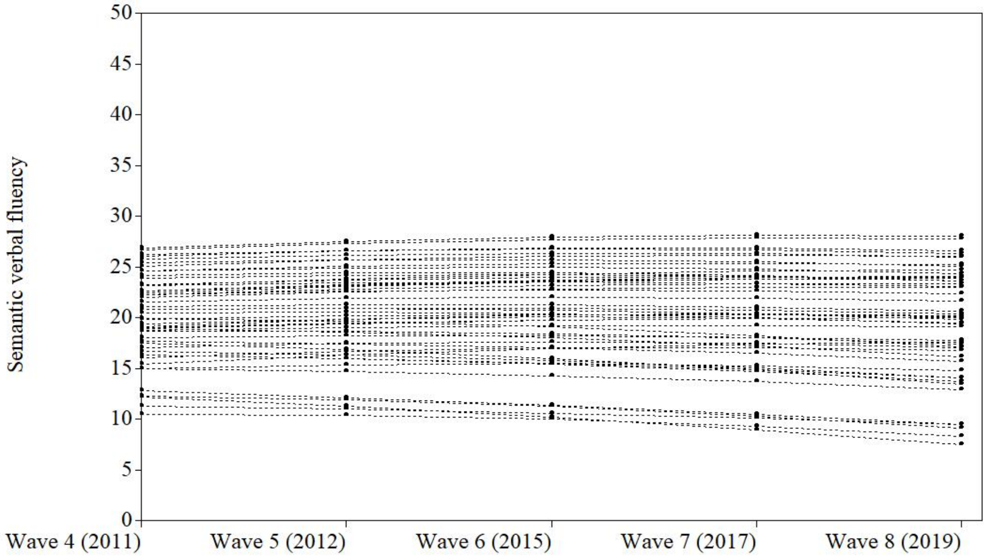
Figure 18

Estimated semantic verbal fluency latent quadratic trajectory for the general sample (a) and for 50 random respondents (b), after controlling for the effects of covariates

(a)



(b)



3.4. Cognition and successful ageing

Quality of life was used as a marker or indicator of successful ageing, following the Comprehensive PCP model by Kahana et al. (2014). The sample statistics of quality of life across study waves employed in the analyses are displayed in Table 23.

Table 23

Sample statistics of quality of life through all waves considered in the analysis. Note: M = Mean; SD = Standard Deviation

Quality of life	M ± SD	n (%) of missing data
Wave 4	37.03 ± 6.46	3479 (6.1)
Wave 5	37.78 ± 6.34	20763 (36.7)
Wave 6	37.28 ± 6.29	24866 (43.9)
Wave 7	37.20 ± 6.39	27190 (48.0)
Wave 8	38.09 ± 6.04	38301 (67.7)

3.4.1. Recent memory and successful ageing

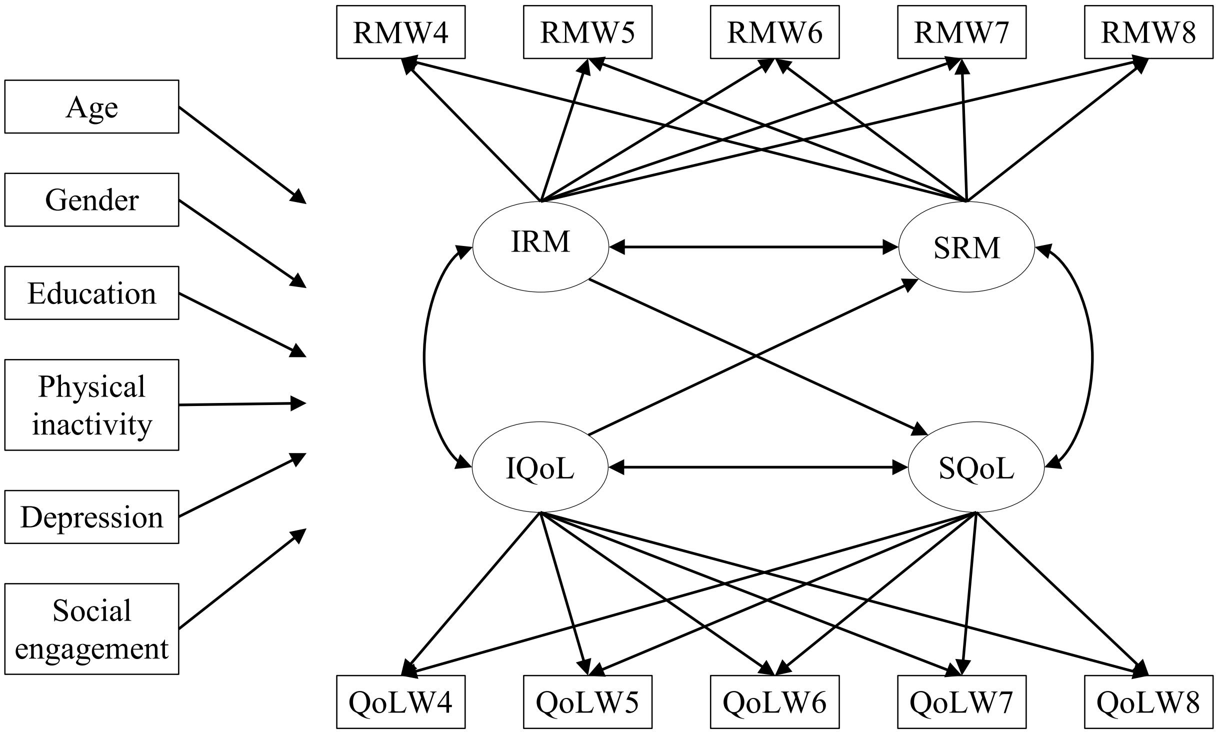
A Parallel Process Latent Growth Model (PP- LGM) with linear trajectories of recent memory and quality of life with covariates was tested. Quadratic growth terms were omitted in favour of parsimony. From the general sample, 5702 respondents were excluded in the analysis due to missing data. Therefore, the sample size employed in the analysis was 50914. The model presents an adequate fit to the data: χ^2 (77) = 1808.36, p < .001, CFI = .989, RMSEA = .021 [.020 – .022], SRMR= .020, AIC = 1489700.98, BIC = 1490125.19. The resulting model is depicted in Figure 19.

The mean of the intercept of recent memory is 5.26 (p < .05), with a variance of 1.82 (p < .05). Its average latent slope is -0.082 (p < .05) with a variance of 0.051 (p < .05). That is, recent memory follows a negative linear trend, with inter-individual variability both at the initial time and at the rate of change. Moreover, the covariance between recent memory's latent intercept and slope has an estimated value of 0.015 (p < .05). This indicates that individuals with higher initial levels of recent memory will display steeper decline over time.

Quality of life's average latent intercept is 37.18 (p < .05) with a variance of 28.65 (p < .05), and its latent slope has a mean estimate of -0.090 (p < .05) and an estimated variance of 0.922 (p < .05). Similar to recent memory, individuals' quality of life displays a negative trend over time, with inter-individual variability at both initial level and rate of change. However, in this case the covariance between the latent intercept and the latent slope has an estimated negative value of -1.09 (p < .05), which implies that individuals with higher initial levels of quality of life will experience less decline than their counterparts.

Figure 19

Representation of the PP-LGM of recent memory and quality of life with covariates. Note: IRM= Intercept of recent memory; SRM= Slope of recent memory; IQoL= Intercept of quality of life; SQoL= Slope of quality of life



Turning to the standardised effects of the latent intercepts on latent slopes, the effect of recent memory onto quality of life was statistically significant (β = .063, $p < .05$). This was not the case for the effect of quality of life's initial level onto recent memory's trend (β = -.008, $p = .679$). Therefore, the results suggest that initial recent memory explains quality of life over time but initial quality of life has no explicative capacity over recent memory's trend. A potential causal relationship can be inferred from these results, with higher levels of recent memory causing less decline in quality of life over time.

Finally, the intercept of recent memory and the intercept of quality of life have a statistically significant estimated correlation of .213 ($p < .05$), indicating that individuals with higher initial levels of recent memory also present higher initial levels of quality of life. In turn, recent memory's slope and quality of life's slope present an estimated correlation of .350 ($p <.05$), that suggests a positive association between the decline of recent memory and the decline of quality of life over time.

Regarding the effects of the covariates shown in Table 24, all present statistically significant effects on the latent intercepts of recent memory and quality of life in the expected direction. The effect of depression on quality of life's intercept is especially relevant for its size, compared to the rest of the covariates. Further, age, gender, educational attainment and depression present statistically significant effects on recent memory's slope. For the slope of quality of life, education does not have a statistically significant effect, but age, gender and depression do. Depression, for both latent slopes, has a positive effect, which can be interpreted as less decline for those individuals who present higher levels of depressive symptomatology at the beginning.

Table 24

Standardised effects of age, gender, educational attainment, physical inactivity, depressive symptomatology and social engagement in the latent intercepts and slopes of recent memory and quality of life. Note: β = Standardized structural coefficient; SE= Standard error; p= p-value

	Recent memory			Quality of life		
	β	SE	*p*	β	SE	*p*
Intercept						
Age	-.381	.005	< .001	-.043	.004	< .001
Gender (Male)	-.138	.005	< .001	-.044	.004	< .001
Educational attainment	.386	.005	< .001	.167	.004	< .001
Physical inactivity	-.116	.005	< .001	-.166	.005	< .001
Depression	-.169	.005	< .001	-.570	.004	< .001
Social engagement	.060	.005	< .001	.064	.004	< .001
Linear slope						
Age	-.339	.015	< .001	-.301	.013	< .001
Gender (Male)	-.041	.012	< .05	.048	.010	< .001
Educational attainment	.032	.012	< .05	.008	.012	.485
Physical inactivity	.007	.014	.590	.019	.011	.089
Depression	.065	.017	< .001	.323	.011	< .001
Social engagement	-.013	.011	.270	-.006	.009	.485

Although it may seem counterintuitive, as depression also presents negative effects on the initial levels of recent recall and quality of life, these positive effects can be understood as a floor effect. That is, individuals with high depressive symptomatology already display diminished initial levels of recent memory and quality of life, and may have less room for variation over time.

Overall, the model was able to explain 47.9% of the variance of initial quality of life and 18.2% of the variance of quality of life's slope. For recent memory, 49.2% of the variance of the intercept and 12% of the variance of the slope was explained by the model.

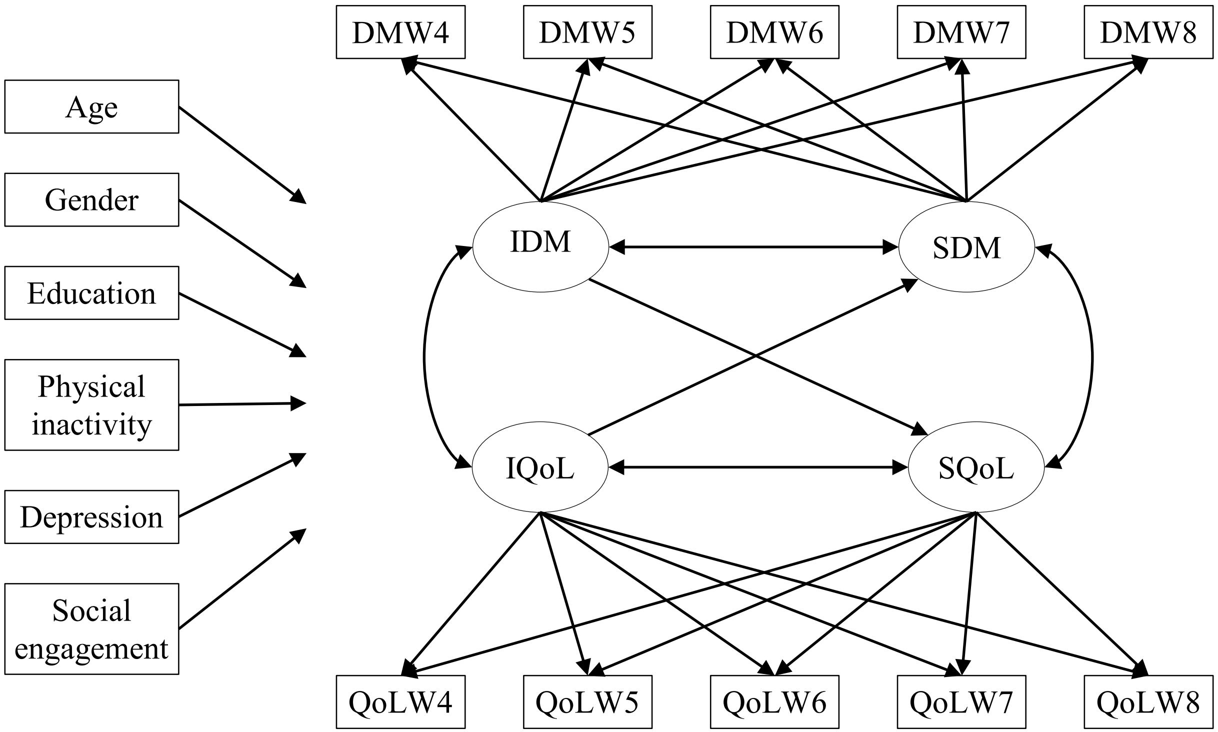
3.4.2. Delayed memory and successful ageing

Next, a PP- LGM with linear trajectories of delayed memory and quality of life with covariates was tested. Like section 3.4.1, 5703 respondents from the general sample were excluded from the analysis due to missing data. Therefore, the sample size employed in the analysis was 50913. The model presents an adequate fit to the data: χ^2 (77) = 2068.94, $p < .001$, CFI = .987, RMSEA = .023 [.022 – .023], SRMR= .020, AIC = 1547207.98, BIC = 1547632.19. The resulting model is depicted in Figure 20.

The mean of the intercept of delayed memory is 3.88 ($p < .05$), with a variance of 2.72 ($p < .05$). Its mean latent slope is -0.092 ($p < .05$) with a variance of 0.070 ($p < .05$). As in the previous section with recent memory, delayed memory follows a negative linear trend, with inter-individual variability both at the initial time and at the rate of change. Moreover, the covariance between delayed memory's latent intercept and slope has an estimated value of 0.010 ($p = .255$). This indicates that there is no association between individuals' higher initial levels of delayed memory and their trend over time.

Figure 20

Representation of the PP-LGM of delayed memory and quality of life with covariates. Note: IDM= Intercept of delayed memory; SDM= Slope of delayed memory; IQoL= Intercept of quality of life; SQoL= Slope of quality of life



Quality of life's average latent intercept is 37.16 ($p < .05$) with a variance of 28.65 ($p < .05$), and its latent slope has a mean estimate of -0.085 ($p < .05$) and an estimated variance of 0.913 ($p < .05$). The interpretation follows that of delayed memory, individuals' quality of life displays a negative trend over time, with inter-individual variability at both initial level and rate of change. Additionally, the covariance between the latent intercept and the latent slope has an estimated negative value of -1.12 ($p < .05$), which implies that individuals with higher initial levels of quality of life will experience less decline that their counterparts.

Turning to the standardised effects of the latent intercepts on latent slopes, the effect of delayed memory onto quality of life was statistically significant ($\beta = .053$, $p < .05$). This was not the case for the effect of quality of life's initial level onto delayed memory's trend ($\beta = -.021$, $p = .308$). Therefore, the results suggest that initial delayed memory explains quality of life over time but initial quality of life has no explicative capacity over delayed memory's trend. As with recent memory, a potential causal relationship can be inferred from these results, with higher levels of delayed memory causing less decline in quality of life over time.

Finally, the intercept of delayed memory and the intercept of quality of life have a statistically significant estimated correlation of .213 ($p < .05$), indicating that individuals with higher initial levels of delayed memory also present higher initial levels of quality of life. In turn, delayed memory's slope and quality of life's slope present an estimated correlation of .289 ($p <.05$), that suggests a positive association between the degree of delayed memory decline and the degree of quality of life decline over time.

Table 25

Standardised effects of age, gender, educational attainment, physical inactivity, depressive symptomatology and social engagement in the latent intercepts and slopes of delayed memory and quality of life. Note: β = Standardized structural coefficient; SE= Standard error; p= p-value

	Delayed memory			Quality of life		
	β	SE	*p*	β	SE	*P*
Intercept						
Age	-.371	.005	< .001	-.043	.004	< .001
Gender (Male)	-.148	.005	< .001	-.044	.004	< .001
Educational attainment	.373	.005	< .001	.167	.004	< .001
Physical inactivity	-.082	.005	< .001	-.166	.005	< .001
Depression	-.166	.005	< .001	-.570	.004	< .001
Social engagement	.054	.005	< .001	.064	.004	< .001
Linear slope						
Age	-.307	.014	< .001	-.300	.012	< .001
Gender (Male)	-.023	.012	.052	.048	.010	< .001
Educational attainment	.013	.012	.282	.010	.011	.343
Physical inactivity	-.018	.013	.168	.018	.011	.100
Depression	.083	.017	< .001	.325	.011	< .001
Social engagement	.007	.012	.528	-.006	.009	.475

The effects of the covariates are shown in Table 25. All have statistically significant effects on the latent intercepts of delayed memory and quality of life in the expected direction. The effect of depression on quality of life's intercept is especially relevant for its size, compared to the rest of the covariates. Further, age and depression present statistically significant effects on delayed memory's slope. For the slope of quality of life, age, gender and depression present statistically significant effects.

In this case, depressive symptomatology presents statistically significant negative effects on the intercepts of both delayed memory and quality of life. Again, the effect of depression on the intercept of quality of life stands out. Moreover, depression has positive statistically significant effects on both latent slopes, which can be interpreted as less decline for those individuals who present higher levels of depressive symptomatology at the beginning. The interpretation of the effects of depression on the latent intercepts and slopes is that of section 3.4.1.

Overall, the model was able to explain 47.9% of the variance of initial quality of life and 18.1% of the variance of quality of life's slope. For delayed memory, 44.8% of the variance of the intercept and 10.1% of the variance of the slope was explained by the model.

3.4.3. Verbal fluency and successful ageing

Finally, a PP- LGM with linear trajectories of verbal fluency and quality of life with covariates was tested. Due to missing data, 5717 respondents from the general sample were excluded from the analysis. The sample size considered in the analysis was 50899. The model presents an adequate fit to the data: χ^2 (77) = 1729.17, p < .001, CFI =

.985, RMSEA = .021 [.020 – .021], SRMR = .020, AIC = 1825634.89, BIC= 1826059.09. The resulting model is depicted in Figure 21.

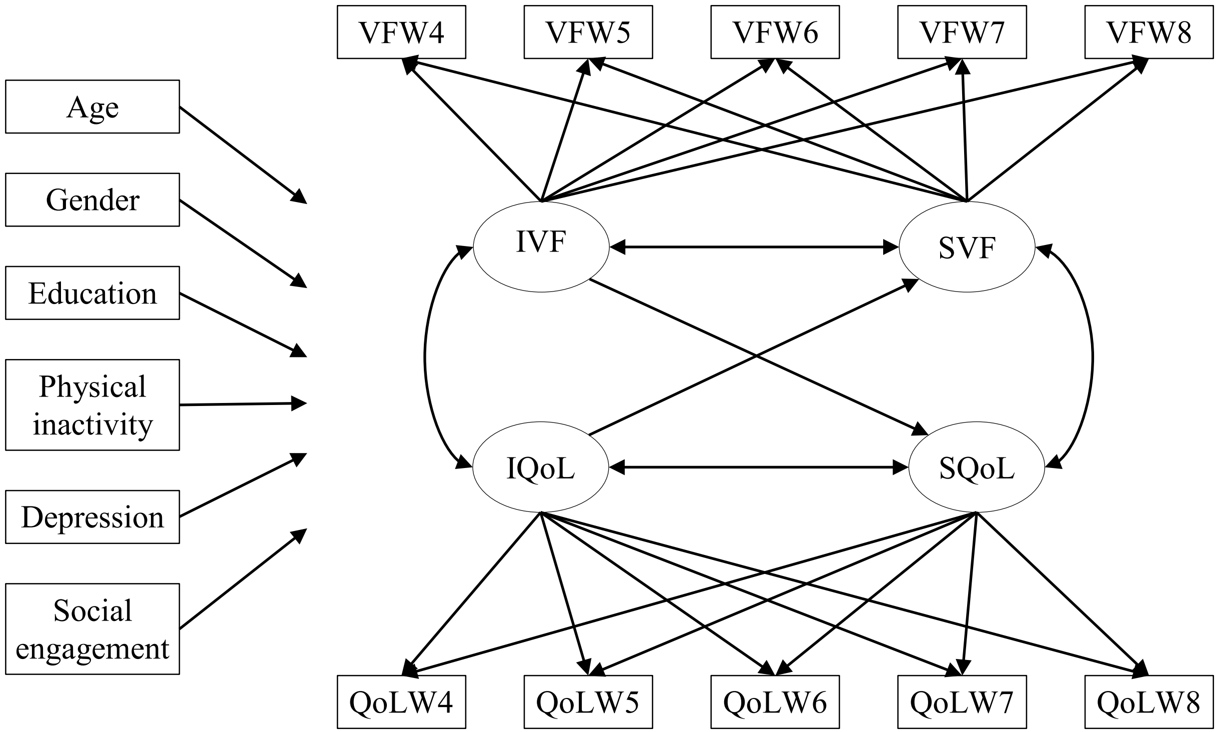
The mean of the intercept of verbal fluency is 20.00 ($p < .05$), with a variance of 37.80 ($p < .05$). Its average latent slope is -0.112 ($p < .05$) with a variance of 0.885 ($p < .05$). As in the previous section with recent and delayed memory, verbal fluency displays a negative linear trend, with inter-individual variability both at the initial time and at the rate of change. Moreover, the covariance between verbal fluency's latent intercept and slope has an estimated value of -0.240 ($p = .069$). This indicates that there is no association between individuals' higher initial levels of verbal fluency and their trend over time.

Quality of life's mean intercept is 37.16 ($p < .05$) with a variance of 28.64 ($p < .05$), and its slope is, on average, -0.081 ($p < .05$) with an estimated variance of 0.914 ($p < .05$). The interpretation follows that of verbal fluency, individuals' quality of life displays a negative trend over time, with inter-individual variability at both initial level and rate of change. Additionally, the covariance between the latent intercept and the latent slope has an estimated negative value of -1.12 ($p < .05$), which implies that individuals with higher initial levels of quality of life will experience less decline that their counterparts.

Turning to the standardised effects of the latent intercepts on latent slopes, the estimated effect of verbal fluency onto quality of life is $\beta = -.02$ ($p = .119$) and the estimated effect of quality of life's initial level onto verbal fluency's trend is $\beta = .014$ ($p = .475$). Therefore, the results suggest that initial levels of verbal fluency do not influence quality of life's trend over time and vice-versa.

Figure 21

Representation of the PP-LGM of verbal fluency and quality of life with covariates. Note: IVF= Intercept of verbal fluency; SVF= Slope of verbal fluency; IQoL= Intercept of quality of life; SQoL= Slope of quality of life



Finally, the intercept of verbal fluency and the intercept of quality of life have a statistically significant estimated correlation of .198 ($p < .05$), indicating that individuals with higher initial levels of verbal fluency also present higher initial levels of quality of life. In turn, verbal fluency's slope and quality of life's slope present an estimated correlation of .365 ($p < .05$), that suggests a positive association between the degree of verbal fluency decline and the degree of quality of life decline over time.

The effects of the covariates are shown in Table 26. All have statistically significant effects on the latent intercepts of verbal fluency and quality of life in the expected direction. The effect of depression on quality of life's intercept is especially relevant for its size, compared to the rest of the covariates. Further, age and physical inactivity present statistically significant effects on verbal fluency's slope. For the slope of quality of life, age, gender, educational attainment and depression present statistically significant effects.

Present results show a positive effect of being physically inactive in verbal fluency decline over time. This can be interpreted in a similar way to the positive effect of depressive symptomatology on the trend of quality of life. That is, individuals who are physically inactive at the beginning already experience diminished verbal fluency skills. Starting at a lower level, their verbal fluency skills do not decline as much as their physically active counterparts.

Overall, the model was able to explain 47.9% of the variance of initial quality of life and 17.9% of the variance of quality of life's slope. For verbal fluency, 37.2% of the variance of the intercept and 12.5% of the variance of the slope was explained by the model.

Table 26

Standardised effects of age, gender, educational attainment, physical inactivity, depressive symptomatology and social engagement in the latent intercepts and slopes of verbal fluency and quality of life. Note: β = Standardized structural coefficient; SE= Standard error; p= p-value

	Verbal fluency			Quality of life		
	β	SE	*p*	β	SE	*P*
Intercept						
Age	-.250	.005	< .001	-.043	.004	< .001
Gender (Male)	-.049	.005	< .001	-.044	.004	< .001
Educational attainment	.392	.005	< .001	.167	.004	< .001
Physical inactivity	-.146	.005	< .001	-.166	.005	< .001
Depression	-.137	.005	< .001	-.570	.004	< .001
Social engagement	.046	.005	< .001	.064	.004	< .001
Linear slope						
Age	-.365	.018	< .001	-.325	.011	< .001
Gender (Male)	-.023	.012	.147	.038	.009	< .001
Educational attainment	-.024	.012	.054	.039	.011	< .001
Physical inactivity	.060	.014	< .001	.010	.011	.347
Depression	.028	.017	.100	.313	.010	< .001
Social engagement	.001	.012	.960	-.003	.009	.744

4. DISCUSSION

This doctoral dissertation aims to establish a holistic framework accounting for the main bio-psycho-social factors involved in the maintenance of cognitive function in the old age. Moreover, it also attempts at examining the role of cognition for ageing successfully.

In this final section, the results will be interpreted and discussed in light of previous evidence. This will be done for each general objective separately, as they represent different frameworks that contribute to understanding of cognition in the older population and its role in successful ageing. Under each general objectives, the hypotheses will be discussed in light of present findings. An exception is the General Objective 5, GO5, to study cognitive functioning in older adults from a gender perspective. GO5 was cross-sectional to any other objective of this work, as a gender perspective is accomplished by considering gender-specific relationships and this has been done through all this work.

4.1.Psychometric properties of cognition-related instruments in SHARE

The first general objective, GO1, was to assess psychometric adequacy of measurement instruments tapping cognition employed in the Survey of Health, Aging and Retirement in Europe (SHARE). This was done for two measurement instruments, one tapping memory and another recently adapted instrument for which no evidence of psychometric adequacy was available.

Evidence of adequate psychometric properties of instruments tapping latent traits is a prerequisite for making inferences from the results obtained from such instruments (Crocker & Algina, 2008). Consequently, and although not an explicit objective of this doctoral dissertation, it was also essential to assess the psychometric properties of the other measures employed in the analysis of this doctoral dissertation, as well as measures more widely used in SHARE. This was done in studies that have been published simultaneously to the development of the present work, most of which were cited in the methodology section. The psychometric properties of the EURO-D scale (Prince et al., 1999) were examined in the study by Tomás et al. (2022). The psychometric properties of CASP-12 (Hyde et al., 2003) were assessed in the work by Oliver et al. (2021). Social and intellectual activity participation were assessed as differentiated activities in the work by Fernández et al. (2023). Last, the psychometric properties of the BFI-10 (Rammstedt & John, 2007), a measure of the five big factors of personality (extraversion, neuroticism, conscientiousness, agreeableness and openness to experience) were studied in the work by Fernández et al. (2022).

4.1.1. 10-Word Recall Test

Specific objective 1, SO1, was to examine factor structure, reliability and convergent validity of the 10-Word Recall Test (10WRT), paying special attention to serial position effects and their role in the relationship between recent/delayed recall and education. In this line, the following hypotheses, based on previous literature, were proposed:

1a. Recent recall will display a one-factor structure with recency, but not primacy, effects.
1b. Delayed recall will display a one-factor structure with primacy, but not recency, effects.
1c. The 10-WRT will present adequate reliability estimates, both for recent and delayed recall.
1d. The existence of serial position effects will distort the relationships between recent/delayed recall and education.

Regarding hypothesis 1a, findings suggest that recent recall is best represented by a one-factor model with both recency and primacy effects. Oral and visual information do not produce the same cognitive stimulus. According to Leeuw (2005), oral information demands more memory capacity, which can produce recency effects (*i.e.* tendency to recall the latter words of a list) in long lists. This is also argued by Osth and Farrell (2019) in the context of the Dual-Store Model (Atkinson & Shiffrin, 1968). Because the recall is immediate, it triggers retrieval from the Short-Term Store (STS) containing the most recent information (*i.e.* the latter words of the list).

The primacy effect in recent recall was rather unexpected. However, some authors (Ward & Tan, 2019) have shown that serial position effects vary according to the way information is presented and requested. In the study by Ward and Tan (2019), they observed that primacy effects (i.e. tendency to recall the first words of a list) appeared when subjects were instructed to recall every item of a list. This result is also consistent with Serial Position Curves (SPC) in which the items most often recalled are those at the beginning and at the end of the list (Murdock, 1962).

For hypothesis 1b, primacy effects were expected in delayed recall. According to Leicht (1968), the first items of a list remain longer in the STS, which makes them more likely to be stored in the Long-Term Store (LTS). This would give rise to the appearance of primacy effects in delayed recall trials. However, results showed that the data was best represented by a one-factor model of delayed recall with no serial position effects. One possibility is that this was due to the nature of the sample. A study by Griffin et al (2017) provided evidence that older adults showed different delayed retention than younger adults. In this line, Innocenti et al. (2013) also found absence of recency effects in individuals with alterations in the STS. Therefore, one possibility is that as individuals age and their LTS capacity diminishes, the primacy effect is also attenuated.

Hypothesis 1c argued that both recent and delayed memory would present adequate reliability estimates. Results provide evidence of this hypothesis, as estimates were adequate in both cases.

Finally, hypothesis 1d evaluated the effects of serial position effects on the relationships with other variables. In this case, cognitive reserve, operationalised as educational attainment, was employed for its documented relationship to memory (Harrison et al., 2015; Lavrencic et al., 2018; Ritchie et al., 2015; Roldán-Tapia et al., 2012; Stern, 2012).

Results provided evidence for this hypothesis. More concretely, when the correlation between educational level and recent memory was estimated with and without acknowledging serial position effects, the results yielded different estimates. Not acknowledging serial position effects attenuated the association between recent recall and cognitive reserve.

There is a lack of studies paying attention to the psychometric properties of measures affected by serial position effects, which can be considered a specific type of method effect. A counterexample is the study by Cernat et al. (2022), that examined measurement quality across three survey designs, in one the information was presented aurally and in the other two the information was presented visually. These authors reported higher probabilities of recency effects in the oral mode, although the relationship was weak. Moreover, they tested measurement invariance of 21 item batteries across the three survey designs and concluded that, in general, measurement of latent variables was comparable. However, these researchers did not examine the relationships between measures affected by serial position effects and their criteria.

Although present results also show a slight diminution of the correlation coefficient estimate, this ought to be further explored in other scales with a different number of items/words. It could be possible that shorter or longer word lists magnify the effects and this has an impact on the distortion of the correlation coefficient.

4.1.2. Informant Questionnaire on Cognitive Decline in the Elderly

Specific objective 2, SO2, was to assess factor structure, reliability, criterion-related validity and diagnostic validity of SHARE's adaptation of the Informant Questionnaire on Cognitive Decline in the Elderly (IQCODE). In this line, the following hypotheses, based on previous literature, were proposed:

2a. The IQCODE will display a one-factor structure of cognitive decline.
2b. The IQCODE will present adequate reliability estimates.
2c. Informants' perceptions of respondents' cognitive decline, as measured by the IQCODE, will be higher for respondents with a self-reported diagnosis of dementia.
2d. There will be a cut-off point for the IQCODE that represents an adequate balance between sensitivity and specificity.

To test hypothesis 2a, a one-factor CFA of informant's perception of a respondent's cognitive decline was estimated. The results yielded an elevated value of the RMSEA. However, high values of the RMSEA index in the context of simple models with few variables and a reduced number of degrees of freedom have been previously documented (Kenny et al., 2015). Authors argue that CFI and SRMR may be better suited to assess goodness-of-fit in this context (Shi et al., 2020). These two fit indexes indicated that the model presented an excellent fit to the data. More evidence of this came from the large, statistically significant, factor loadings of all items of the SHARE-IQCODE scale. Consequently, a one-factor structure of informant's perception of cognitive decline was regarded as adequate to represent the factor structure of SHARE-IQCODE. Just as its 16-item version (Reichenheim et al., 2015; Truong et al., 2021), this new adaptation also displays a unidimensional structure.

Hypothesis 2b argues that the scale's reliability would be adequate in terms of internal consistency. Evidence for this was found in the results, as reliability estimated showed an excellent internal consistency of the scale. This was also evidenced by the similarity and large magnitude of the factor loadings, indicating that individuals provided congruent answers across items. Previous studies on the psychometric propertied of the 16-item version (Foroughan et al., 2019; Othman et al., 2015; Truong et al., 2021) had also found very high estimates, between .90 and .95, in line with the results presented here.

Hypotheses 2c and 2d made reference to other evidences of validity in addition to factor validity. Hypothesis 2c stated that informants' perceptions of respondents' cognitive decline would be higher for respondents with a self-reported diagnosis of dementia, therefore implying criterion-validity of SHARE-IQCODE scores. Results provided evidence for this, as the scale's scores significantly differed between those with a report of dementia and those without it.

Specifically, informants of individuals diagnosed with dementia provided significant higher scores of cognitive decline than informants whose relative was not diagnosed with dementia.

In its part, hypothesis 2d made reference to diagnostic validity, as it stated that a cut-off point could be found that represented an adequate balance between sensitivity and specificity. For this, a ROC curve was tested, using dementia's diagnosis as the criterion. Results showed that the SHARE-IQCODE displayed acceptable discrimination of cognitively-impaired individuals (Hosmer et al., 2013). That is, respondents' judgement of individuals' cognitive worsening was in line with individuals' diagnosis. This result concurs with previous evidence of diagnostic validity of the 16-item version that found similar values of area under the curve of around 80% (Jorm, 2004; dos Santos Sanchez & Lourenço, 2013).

Once the degree of discrimination was assessed, the resulting cut-off score was examined. The results yielded a value of 2.80 as the cut-off point of the scale that maximized specificity and sensitivity. This score, then, can be used to discern between cognitively impaired and non-affected individuals in SHARE that did not answer the cognitive tests. Nonetheless, as discrimination was not excellent, the scale's use is only advised as a first approximation to the detection of dementia within the two-stage process suggested by Burton et al. (2021b).

Overall, SHARE's adaptation of the IQCODE seems to work just as fine as the former 16-item version by Jorm (1994). Originally developed for clinical practice, the IQCODE has also become a research tool with its inclusion in large-scale surveys such as HCAP (Langa et al., 2020) or SHARE.

Together with its limited use as a screening tool, there are some remarks that ought to be done about the SHARE-IQCODE and the results derived from this work. The first one is related to the criterion variable employed in classification. Although this has been previously acknowledged, it should be kept in mind that the variable employed to establish the cut-off point was not an official medical record but a self-reported diagnostic status. One possible source of error would come from individuals not reporting their diagnostic status truthfully because of self-stigma (Gajardo et al., 2021; Nguyen & Li, 2020). Another consideration is in reference of the nature of the sample employed. The SHARE-IQCODE was only administered to informants of individuals who were not able to answer cognitive tests, and therefore this may bias the results due to an over-coverage of cognitive impairment.

Be that as it may, this work constitutes a novel contribution to the IQCODE literature, as it provides evidence on the psychometric properties of a new adaptation of the scale. This work is also especially relevant in the context of SHARE research, as it gives SHARE researchers evidence about the adequacy of this scale as an approximation to cognitive impairment when direct data are not available.

4.2. A holistic model of cognition

The second general objective, GO2, was to establish a comprehensive model that predicts cognitive functioning from a bio-psycho-social perspective. A predictive model of older adults' cognitive function was established to fulfil this general objective.

Two different specific objectives (SO) were proposed. SO3 was to test the differential relationships between predictors of cognition and four cognitive dimensions (temporal orientation, memory, numeracy and verbal fluency). Consequently, temporal orientation, memory, numeracy and verbal fluency were modelled as four different outcomes of cognition, and relationships from predictors onto each dimension were analysed separately. Based on previous literature, it was hypothesised that the predictors would display differential effects on the cognitive dimensions considered (hypothesis 3).

SO4 was to test the relative impact of years of education, chronic disorders, physical inactivity, psychological factors (loneliness and depression), and social and intellectual activity participation on the cognitive dimensions, controlling for age. From this specific objective, two hypotheses were drawn:

4a. Years of education, social activity participation and intellectual activity participation will present positive statistically significant effects on the different cognitive dimensions considered.

4b. Chronic disorders, physical inactivity, loneliness and depression will present negative statistically significant effects on the different cognitive dimensions considered.

The resulting model presents two main contributions to the study of cognition. First, the integration of bio-psycho-social factors contributes at generating a global, holistic, picture of agents involved in optimal cognitive status among older adults. Additionally, the partition of cognition into differentiated domains allows the study of effect heterogeneity of each predictor onto the distinct cognitive components considered, in line with that argued by previous research (Bourassa et al., 2017; Litwin & Stoeckel, 2016).

Indeed, regarding hypothesis 3, evidence for predictors' differential effects was found. For example, physical health, measured by individuals' number of chronic disorders, had no predictive capacity over temporal orientation, numeracy and verbal fluency. Only a small negative effect of chronic disorders onto memory was found. Physical inactivity displayed very small predictive effects in all domains, being the most noticeable those onto temporal orientation and verbal fluency.

Regarding psychological variables, loneliness had a small effect in general, being statistically non-significant in the case of temporal orientation and that were bigger in the case of verbal fluency and memory. Depression, in turn, had bigger negative effects in all cognitive dimensions, being the one of verbal fluency notably smaller and the one of temporal orientation higher. The differential effects of depression could be interpreted in light of the vascular depression hypothesis (Alexopoulos et al., 1997), by which neurovascular deterioration is responsible for depressive symptomatology in the old age, and this usually affects prefrontal and frontal regions of the brain (Taylor et al., 2013) which have been also seen to play a role in executive functions (Otero & Barker, 2014; Stuss, 2011).

Participation in social and intellectual activities had a significant impact every cognitive domain considered, but their effects were biggest for memory and verbal fluency. When it comes to numeracy and verbal fluency, intellectual activity had the greatest predictive effect. Previous studies (Van Aken et al., 2016) have associated executive function to fluid intelligence, which involves adapting and being flexible in cognitively demanding contexts (Cattell, 1963). According to the cognitive enrichment hypothesis (Scarmeas & Stern, 2003), participation in intellectual activities could serve as training for such fluid abilities. In the same line, diminished effects of social activity participation onto temporal orientation and numeracy could be explained by the situations in which social activities take place. It is possible that these activities create cognitive-demanding contexts in line with cognitive enrichment hypothesis, but cognitive function in these situations relies on other cognitive domains such as verbal fluency and memory, and not on temporal orientation and numeracy.

Turning to hypotheses 4a and 4b, education, social activity participation and intellectual activity participation were expected to exert positive effects onto the cognitive dimensions, while chronic disorders, loneliness and depression were expected to present negative effects. In general, evidence was found that supported both hypotheses, although effects were not statistically significant in some cases, as it was just reported.

The effects of the bio-psycho-social factors considered in the model were generally consistent with the literature. Nonetheless, chronic diseases and physical inactivity showed somewhat surprising results, as their effects were diminished in comparison to the ones previously reported (for example: Buchman et al., 2012; Gorelick et al., 2011; Lim et al., 2016; Lourenco et al., 2018). It is possible that when bio-psycho-social effects onto cognition are simultaneously examined, the relative impact of these predictors is diminished in comparison to that of other predictors like participation in social and intellectual activities or depression.

Similarly, previous research had established a positive association between social activity participation and cognitive performance (Choi, 2020; Fu et al., 2018; Glei et al., 2005; Hwang et al., 2018; Krueger et al., 2009; Litwin & Stoeckel, 2015; Miceli et al. 2019; Seeman et al., 2011). In this line, present results showed a moderate effect of social activity participation onto memory and verbal fluency. However, the effects were much smaller for temporal orientation and numeracy. Therefore, findings of this work, in general, showed diminished effects of social participation. It should be noted that previous studies failed to differentiate among cognitive domains and used either a measure of global cognition (Choi, 2020; Fu et al., 2018; Hwang et al., 2018; Krueger et al., 2009; Miceli et al., 2019) or a measure of memory (Litwin & Stoeckel, 2016). The only study that considered more than one cognitive domain was that by Seeman et al. (2011), which employed measures of executive function and measures of memory. In this study, the same diminished effect of social activity onto executive function, in comparison to that of memory, was also found. Although the different instruments employed across studies do not allow for the comparison of specific effects, this work found evidence in line with that of Seeman et al. (2011).

In the case of intellectual activity participation, all effects were statistically significant and relevant, in relation to the rest of predictors. This result replicates that of Hultsch et al. (1999) and reinforces the idea of intellectual training interventions targeted at maintaining cognitive abilities in the old age. Nonetheless, as previously noted in Hultsch et al. (1999), it could be that only individuals with good levels of cognition are interested in participating in intellectual activities. Other studies analysing the effects of intellectual activity participation are available from Krueger et al. (2009). These authors included intellectual activities as a covariate and did not inform about its specific effects onto cognition. They, however, stated that the effects of social activities diminished when considering intellectual activities, which goes in line with present findings.

For the psychological variables, loneliness and depression, effects were as expected according to previous research (Boss et al., 2015; Cacioppo & Hawkley, 2009; T. Y. Chen & Chang, 2016; Downer et al., 2017; L. Han et al., 2016; Howrey et al., 2015; McDermott & Ebmeier, 2009; Min, 2018; Yu et al., 2015). Namely, both variables displayed statistically significant and negative effects to every component of cognition, the only exception being the effect of loneliness onto temporal orientation. Furthermore, in line with other authors (Kong et al., 2018), there was a positive, statistically significant, and high correlation between both variables. Another interesting finding was the diminished effects of loneliness in comparison to those of depression. It seems that the effects of loneliness may appear magnified when depression is not acknowledged (Kong et al., 2018).

The aforementioned general objective 5, GO5, to study cognitive functioning in older adults from a gender perspective, cross-sectional to the rest of general objectives, contained a specific objective, SO10, which consisted in testing the relative impact of gender on temporal orientation, memory, numeracy and verbal fluency. Based on previous literature, the derived hypothesis from SO10 was that females would present statistically higher levels of global memory and verbal fluency than males (hypothesis 10).

Results from this work provide evidence partially supporting the hypothesis in that females presented statistically higher levels of memory. This finding is in line with previous results (Ding et al., 2019; Lin et al., 2017; McFall et al., 2019; Z. Wu et al., 2021). However, no statistically significant differences between males and females were found in verbal fluency. This latter incongruence could be due to the measures of cognitive function employed in other studies reporting better executive ability among females (Lin et al., 2017; Z. Wu et al., 2021).

In sum, this model presents a holistic approach to the study of cognition, as it offers a bio-psycho-perspective on the study of different cognitive domains. As suggested by previous research (Bourassa et al., 2017; Litwin & Stoeckel, 2016), heterogeneity in the magnitude of predictors onto different cognitive components was found. Moreover, the probabilistic sampling strategy employed in SHARE maximizes the likelihood that results will be generalizable to the population of individuals aged 50 years or older from European countries and Israel. Nonetheless, there are some limitations to this work that ought to be acknowledged.

First, data employed in the analyses comes from a large-scale survey covering different topics of older adults' life, which employs a Computer-Assisted Personal Interview (CAPI) during which individuals are surveyed in all these topics in a short period of time. Therefore, the measurement instruments need to be brief, and therefore provide coarse measures of the topics under study. As an example in the context of this work, social and intellectual activity participation was registered in terms of occurrence during the previous year and not as a function of individuals' satisfaction with their involvement in these activities. Moreover, model complexity did not allow for longitudinal analysis of the relationships and therefore causal attributions cannot be inferred from the results. Although the directionality of the effects was theoretically established, it is possible that reverse causality occurs and therefore additional longitudinal analyses need to be done to advance on the study of the determinants of cognition.

4.3. Explaining latent trajectories of cognitive dimensions

The third general objective (GO3) of this work was to establish the possible explicative effects of the most relevant factors documented in the literature on cognitive functioning. This general objective entailed two specific objectives (SO) and several hypotheses were derived from each of these.

The first specific objective, SO5, was to establish the shape of the latent trajectories of memory, differentiating between recent and delayed recall, and verbal fluency, and accordingly three hypotheses were derived based on previous findings:

5a. Recent recall will display either a linear or a quadratic latent trajectory of decline.

5b. Delayed recall will display either a linear or a quadratic latent trajectory of decline.

5c. Verbal fluency will display either a linear or a quadratic latent trajectory of decline.

The second specific objective, SO6, was to test the explicative power of educational attainment, physical inactivity, depression and social engagement on memory and verbal fluency, controlling for age. Based on previous literature, the expected results were written in the form of two additional hypotheses:

6a. Educational attainment and social engagement will have positive and statistically significant effects in the latent trajectories of recent memory, delayed memory and verbal fluency.
6b. Physical inactivity and depression will have negative and statistically significant effects in the latent trajectories of recent memory, delayed memory and verbal fluency.

In general, results showed recent memory, delayed memory and verbal fluency to display quadratic latent trajectories of decline, which imply a first stage of decline that is followed by a second stage of steeper decline. Therefore, evidence was found for hypotheses 5a, 5b and 5c.

Previous research had most frequently reported either linear or quadratic trends of cognitive decline (Bertola et al., 2019; Ding et al., 2019; Liampas et al., 2022; Terrera et al., 2010; Yam et al., 2014; W. Zhang et al., 2022) in studies with different temporal lengths and employing diverse cognitive measures, either global or domain-specific. In the case of verbal fluency, no previous research had focused on the shape of this latent trajectory specifically. In fact, the general tendency is to employ a measure of global cognition (for example: Cheng et al., 2016; Downer et al., 2017; Howrey et al., 2015; Min, 2018; Terrera et al., 2010; Yu et al., 2015). Nonetheless, this tendency may fail to detect subtler changes that occur at specific domains of cognition (Steinerman et al., 2010). Additionally, as stated by Murman (2015), early worsened performance occurs in cognitive tasks that require handling and transforming information, as is the case of working memory -recent and delayed- and verbal fluency, and not in cognitive tasks based on cumulative knowledge. Mixing cognitive tasks to compute a global score of cognition, or directly employing a cognitive measure that assesses general cognitive ability, could hide this subtler, non-pathological, deterioration, that is considered as normative cognitive ageing (Harada et al., 2013) and that later progresses to pathological deterioration affecting individuals' functional abilities (Bermejo-Pareja et al., 2021; Murman, 2015).

Moreover, as seen in the findings from this work, model deterioration of the linear Latent Growth Model (LGM) against the quadratic LGM was very subtle. Although the quadratic model better fitted the data, the linear model also fitted the data adequately and was more parsimonious. Therefore, other studies might have guided their decisions by parsimony instead of model fit and hence linear trajectories had been reported. It should be noted, however, that studies with longer study periods ought not ignore the quadratic latent slope, as it may become more relevant in longer trajectories.

The second specific objective involved testing the effects of physical, psychological and social covariates, together with gender and cognitive reserve (measured as the level of education) onto the latent terms of the LGMs of recent memory, delayed memory and verbal fluency, controlling for respondents' age. Hypotheses 6a and 6b were stated about the directionality of these effects. Findings derived from this work only partially support these hypotheses.

Higher age, more depression, being male, and physical inactivity all predicted a lower average level of recent memory, as denoted by the negative statistically significant effects of these covariates onto the latent intercept, whereas more social engagement and higher educational attainment had a positive effect. Age and educational attainment presented the largest effects, followed by being male and depression. For physical inactivity and social engagement, effects were statistically significant but smaller in magnitude, especially in the case of the latter.

In terms of the linear slope of recent memory, effects of covariates were similar to those of the latent intercept except that physical inactivity and social engagement did not significantly contributed to explaining recent memory's linear slope. Moreover, effect size was in general diminished, and the effect of depression turned positive. That is, higher initial levels of depression had a small protective effect onto the linear slope of recent memory.

Lastly, the quadratic slope of recent memory was only explained by age and educational attainment. Age had a negative statistically significant effect, by which older individuals would present a higher level of quadratic decline. In the case of educational attainment, this covariate also explained quadratic worsening of recent memory over time. This latter effect of education also deemed counterintuitive, as cognitive reserve theory (Stern, 2002) had repeatedly established a positive effect of education onto older adults' cognition (Espeland et al., 2018; Weber et al., 2014), especially evident in the cognitive domain of memory (Bertola et al., 2019; Ding et al., 2019; Lourenco et al., 2018). This was indeed the case for the latent intercept and latent linear slope.

All in all, all effects of covariates onto recent memory's latent intercept and latent slopes, linear and quadratic, were in the expected direction according to previous literature examining memory trajectories over time (Ding et al., 2019; Liampas et al., 2022; McFall et al., 2019; Z. Wu et al., 2021). The only exceptions were the aforementioned positive effect of depression onto the latent linear slope and the negative effect of education onto the latent quadratic slope.

Previous research employing a person-centred approach analysed the effect of initial levels of depression onto the probability of belonging to a latent class of a certain cognitive trajectory. These studies did found a consistent higher likelihood of depressed individuals to belong to less favourable cognitive trajectory classes (Chang et al. 2016; Downer et al., 2017; Howrey et al., 2015; Min, 2018; Yu et al., 2015). However, given the analytical approach used, this higher likelihood could be only reflecting the differences among the latent intercepts of the reported trajectories. In this work, a small but positive effect of depression was found onto the latent linear slope, implying that individuals with higher initial depressive symptomatology display less linear decline than their non-depressed counterparts.

This counterintuitive result was already seen and commented in section 3.4. As already proposed, a plausible explanation of this positive effect accompanied by the negative effect of depression onto the latent intercept is that individuals who present high depressive symptomatology at the beginning also present diminished recent memory and may not have as much room for variation over time as less depressed individuals. Therefore, this would not be a beneficial effect of depression onto the latent trajectory of recent memory but the manifestation of a floor effect.

Regarding the positive effect of education onto the latent quadratic slope of recent memory, a plausible interpretation comes from the neural compensation reserve hypothesis (Barulli & Stern, 2013) and previous similar results were reported in Williams et al., (2021). This hypothesis proposes that compensatory neural networks come into play when deterioration starts affecting primary networks. In the aforementioned study by Williams et al. (2021), no protective effect of education was found for individuals classified in the rapid decline memory trajectory class. These authors suggested that education could play a role in protecting against initial memory decline but, as decline become more severe and that primary network deteriorated, education would not be able to compensate for cognitive loss as alternative compensatory neural networks started to be used. According to this, educational attainment would protect against initial deterioration but, as deterioration progresses and this network is no longer active, more rapid decline would occur as the consequence of education no longer being an efficient protector, as pointed by the results from this work.

Turning to delayed memory, being older, having higher initial depressive symptomatology, being male and not being physically active explained lower levels of the latent intercept, while higher level of educational attainment and being more socially engaged was predictive of higher scores of delayed memory's latent intercept. These results were similar to those of recent memory in that age and education displayed the biggest effects, followed by the effects of gender and depression. Again, physical inactivity and social engagement displayed the smallest effects onto the latent intercept of delayed memory.

Regarding the latent slopes of delayed memory, older age explained higher delayed memory decline in both terms, although the effect was considerably larger for the linear term. Depressive symptomatology additionally explained lower levels of the latent linear slope, while the only additional covariate that exerted a negative effect onto the latent quadratic slope was educational attainment.

The unexpected effect of depression could also be the manifestation of a floor effect, in line with the interpretation of the previously positive effect of depression onto recent memory's latent linear slope. In the same fashion, the negative effect of education onto the latent quadratic slope of delayed memory resembles that of recent memory and could be interpreted as the consequence of the primary network abolishment.

Again, the effects of the covariates onto the latent terms of the delayed recall trajectory are in line with those found in previous research examining memory trajectories over time (Ding et al., 2019; Liampas et al., 2022; McFall et al., 2019; Z. Wu et al., 2021). Be that as it may, this work contributes to pre-existing literature by differentiating between recent and delayed recall. Either previous studies employed a measure of delayed recall alone (Ding et al., 2019; Z. Wu et al., 2021) or a composite measure of global memory (Liampas et al., 2022; McFall et al., 2019). Only the study by McCarrey et al. (2016) established the effects of age and gender onto recent and delayed memory separately and found differential effects of these variables onto both measures of memory. This work expands McCarrey et al.'s (2016) results by including additional covariates whose effects onto cognition has been repeatedly established.

Finally, regarding semantic verbal fluency, it was hypothesised that older age, male gender, physical inactivity, and depressive symptomatology would have a negative impact on semantic verbal fluency, implying that decline would become more severe, whereas having higher levels of education and social engagement would have the opposite effect. Given the lack of studies analysing trajectories of verbal fluency specifically, it was expected that this trajectory would behave similarly to documented trajectories of general cognition, memory and other executive functions (Cheng et al., 2016; Ding et al., 2019; Downer et al., 2017; Howrey et al., 2015; Liampas et al., 2022; McFall et al., 2019; Min, 2018; Terrera et al., 2009; Z. Wu et al., 2021; Yu et al., 2015).

Findings from this work only partially supported this hypothesis. While all covariates presented statistically significant effects onto the latent intercept of verbal fluency, only age and physical inactivity significantly explained the latent linear slope of verbal fluency. In turn, the latent quadratic slope of verbal fluency was explained by physical inactivity and education.

In general, the effects of covariates onto the latent intercept were as expected based on previous research (for example: Cheng et al., 2016; Howrey et al., 2015; McFall et al., 2019). In any case, while age displayed a negative and large effect onto the latent linear intercept, the estimated effect of physical inactivity was smaller but positive. This positive effect indicates that physical inactivity at the beginning explains trajectories with less linear decline over time. This result ought to be complemented by the negative effect of physical inactivity onto the latent quadratic slope. That is, physical inactivity at initial time explains trajectories with less degree of linear decline but acute quadratic decline. This result is especially interesting when comparing it against the effects of the covariates onto recent and delayed memory, for which no effects of physical inactivity was found onto any of the latent slopes. Therefore, it seems that predictors display differential effects onto different cognitive domains, a result that was also seen at the correlational level in section 4.2.

Regarding the negative effect of education onto the latent quadratic slope of semantic verbal fluency, and following that stated by neural compensation hypothesis (Barulli & Stern, 2013), cognitive reserve seems to serve a protective role against cognitive decline up to a point in which the network is deactivated, and accelerated latter deterioration takes place.

Furthermore, this work employed a variable-centred analytical approach to the study of cognitive trajectories. It should be noted that most previous research examining the effects of covariates did so from a person-centred perspective and focused in either memory (Ding et al., 2019; Liampas et al., 2022; McFall et al., 2019; Z. Wu et al., 2021) or global cognition (Cheng et al., 2016; Cohen et al., 2022; Downer et al., 2017; Howrey et al., 2015; Min, 2018; Terrera et al., 2010; Tu et al., 2020; Z. Wu et al., 2021; Yu et al., 2015). Consequently, the diminished effects of covariates found in this work may be due to the fact that more fine-grained dimensions of cognition were considered. Similarly, the analytical approach employed could also be responsible for the disparity of results, as previously reported effects in person-centred studies could have only been a reflection of differences among intercepts and not among slopes. In this way, this works provides a more realistic picture of the role these covariates play in explaining cognitive ability over time by using an alternative analytical approach.

This work presents both strengths and limitations. On the one hand, the use of a probabilistic sampling strategy from the population of adults aged 50 years old or older in several European countries provides evidence of cognitive decline before the old age. That is, adults already start experiencing decline in different cognitive domains, which has direct implications for intervention development. Namely, interventions focused on cognitive training are usually targeted at older individuals. Evidence from this work, however, highlights the need to foster cognition already in adulthood to prevent later cognitive decline. Moreover, the effect of covariates on latent slopes gives clues for developing these interventions. For example, physical inactivity should be addressed to prevent verbal fluency deterioration, while depression seems to play a key role in the deterioration of recent and delayed memory.

Another important result, with respect to the study of cognition from a gender perspective stated in GO5, and more specifically noted in specific objective 11, SO11, "to study the explicative role of gender in latent trajectories of recent and delayed memory, and verbal fluency" is that males display lower levels of the latent intercepts of the three considered cognitive domains and that male gender explained worsened decline at the latent linear slope level in the case of recent memory. These results partially support hypotheses 11a and 11b, derived from SO11:

11a. Females will present statistically lower levels of recent memory and verbal fluency decline than males over time.

11b. Females will present statistically higher levels of delayed memory decline over time.

Moreover, these results are in line with findings reported in previous studies studying the effect of gender onto the latent trajectories of memory (Ding et al., 2019; Lin et al., 2017; Lundervold et al., 2014; McFall et al., 2019; Z. Wu et al., 2021) and executive function (Lin et al., 2017; Z. Wu et al., 2021). In its part, previous results by Liampas et al. (2022) reported a greater likelihood of females to belong to the less favourable latent class of delayed memory. However, present results indicated females to display higher average levels of delayed memory's latent intercept in comparison to males.

All in all, gender differences in latent trajectories of recent memory, delayed memory and verbal fluency suggest that policy-makers should consider designing gender-specific interventions in these cognitive domains, as men's and women's cognition does not seem to age equivalently.

On the other hand, the main limitation of this work is that already commented in section 4.2, namely the types of measures employed in the SHARE study. As a large-scale panel study, time and resource constraints limit the type of indicators used. In addition to this known comeback, longitudinal analysis of the data comes with high proportions of missing data due to panel attrition. Although missing data was handled, results could still be biased because participants displaying worse health conditions are more likely to stop participating in the study.

4.4. The role of cognitive function for successful ageing

The fourth general objective (GO4) of this work was to examine the relationship between cognitive function and successful ageing outcomes. Quality of life was chosen as an indicator of successful ageing, in line with the Comprehensive Preventive and Corrective Proactivity (PCP) model proposed by Kahana et al. (2014). This general objective entailed three specific objectives (SO), which are stated next:

SO7. To study the longitudinal latent associations between recent recall and quality of life, controlling for covariates.

SO8. To study the longitudinal latent associations between delayed recall and quality of life, controlling for covariates.

SO9. To study the longitudinal latent associations between verbal fluency and quality of life, controlling for covariates.

Within each specific objective, it was hypothesised that changes in recent recall (hypothesis 7), delayed recall (hypothesis 8) and verbal fluency (hypothesis 9) would explain changes in quality of life. The findings supported hypotheses 7 and 8, but not hypothesis 9.

Regarding hypothesis 7, a statistically significant and positive effect of the latent intercept of recent memory onto the latent slope of quality of life was found, indicating that higher initial levels of recent memory explain less decline of quality of life over time. The initial level of quality of life did not present, however, a statistically significant effect on the rate of change of recent memory.

Results supporting hypothesis 8 came from the statistically significant and positive effect of delayed memory's latent intercept onto the latent slope of quality of life. Again, the initial level of quality of life did not exert an effect onto delayed memory change over time, but higher initial levels of delayed memory explained less quality of life decline over time. Causal relationships can be potentially inferred from these findings, as the relationship of recent memory and delayed memory with quality of life was unidirectional. This result is in line with the theoretical Comprehensive PCP model (Kahana et al., 2014) of successful ageing, that states that age-related stressors, such as cognitive impairment, affect successful ageing, conceptualised as quality of life outcomes.

In turn, no evidence was found for hypothesis 9, as verbal fluency did not affect quality of life. In this case, initial levels of verbal fluency were associated with initial levels of quality of life and a higher degree of decline in verbal fluency was associated with higher quality of life decline over time. Therefore, the relationship between verbal fluency and quality of life was dynamic, and no clear directionality of the effects can be inferred.

Next, the effects of the covariates introduced in the Parallel Process Latent Growth Models (PP-LGM) will be discussed in relation to quality of life in the context of the Comprehensive PCP model. The effects of covariates onto the cognitive dimensions were in line with those previously examined and discussed in section 4.3.

The Comprehensive PCP model further contemplates contextual factors such as demographics, temporality and the space in which the individual develops. In this work, age and gender were introduced as covariates in the PP-LGM to acknowledge the contextual factors that affect the individual's ageing process. In the case of age, results displayed a statistically significant effect of this covariate onto the initial quality of life, denoted by the latent intercept, and onto the rate of change of quality of life, denoted by the slope. According to these results, older individuals present lower initial levels of quality of life and their decline is more severe over time than that of younger individuals. Previous studies examining latent quality of life trajectories had also reported negative effects of age on both terms (Roberts & Adams, 2018; Ward et al., 2019; Zaninotto et al., 2009).

Moreover, gender displayed statistically significant effects onto the latent intercept and slope of quality of life, with women displaying higher initial levels of quality of life and steeper decline. Within GO5, "to study cognitive functioning in older adults from a gender perspective", specific objective 12, SO12, was to determine the effect of gender in the latent trajectory of quality of life. More specifically, it was hypothesised that females would present statistically higher levels of decline in quality of life than males (hypothesis 12). Findings from this work provide evidence supporting this hypothesis, which was based on the results by Cao et al. (2020) suggesting that women's gains in healthy life expectancy were not proportional to men's. Additionally, no hypothesis was proposed about gender differences in the initial level of quality of life, but results showed a statistically significant difference, with women displaying higher initial levels of quality of life than men.

Nonetheless, the male advantage on quality of life over time could also be a manifestation of a floor effect. As men's initial quality of life is diminished, a possible explanation is that their quality of life cannot decline much over time and therefore, in comparison to women, their quality of life deteriorates less severely. Previous studies have also reported this female advantage in initial levels of quality of life (Roberts & Adams, 2018; Ward et al., 2019; Zaninotto et al., 2009), but none of them found evidence of gender having an effect on the latent slope of quality of life.

Educational attainment and social engagement could be considered as individual's resources to face the ageing process successfully, according to the Comprehensive PCP model (Kahana et al., 2014). Both of these covariates had statistically significant and positive effects on the latent intercept of quality of life but did not display statistically significant effects on quality of life's latent slope. That is, individuals' level of education and social engagement was associated with higher initial levels of quality of life, but these variables did not have any effect in explaining quality of life over time. Although social engagement has been regarded as an important determinant of successful ageing (Rowe & Kahn, 1997), previous results reported by Roberts and Adams (2018) showed social engagement to affect only initial levels of quality of life and not its change over time, in line with present results.

In the case of educational attainment, findings from this work provided evidence about the role of education in the maintenance of recent memory, and the role of recent memory in the maintenance of quality of life. It is possible that, although this covariate did not explain quality of life's trajectory over time, educational attainment to be an important determinant of factors affecting quality of life trajectories, such as recent memory. In fact, previous studies analysing quality of life trajectories reported non-significant effects of education onto both the slope and the intercept (Roberts & Adams, 2018; Ward et al., 2019), except for the study by Zaninotto et al. (2009) that reported a positive effect of educational attainment onto the initial level of quality of life but not on its latent slope.

Within the Comprehensive PCP model, proactive behavioural adaptations constitute preventive and corrective actions aimed at reducing or buffering the negative impact of stressors onto successful ageing (Kahana et al., 2014). These adaptations, therefore, act as moderators of the relationship of stressors and successful ageing. Among adaptations, health promotion refers to engagement in healthy lifestyles that reduce or postpone the onset of disease. Physical activity could be considered a form of health promotion, as evidence points towards its beneficial effect in the old age (Weyh et al., 2020). In this work, we considered physical inactivity as a covariate explaining latent quality of life trajectories, and not as a moderator of the relationship between stressors and successful ageing. Previous findings had reported a direct effect of physical health onto quality of life (Ward et al., 2019). Results from this work show a negative and statistically significant effect of physical inactivity on baseline levels of quality of life but not in change over time, similar to that documented in Ward et al. (2019).

Finally, the Comprehensive PCP model argues that cumulative stressors negatively impact successful ageing. Depression can be understood as a cumulative stressor that presents negative associated outcomes for the lives of older individuals (T. Hu et al., 2022; Zenebe et al., 2021). Depressive symptomatology was introduced in the model as a covariate and statistically significant effects onto both the latent intercept and the latent slope of quality of life were found. Namely, depression had a negative and large effect onto the latent intercept and a positive and also large effect onto the latent slope. Throughout section 3.4, it was already mentioned that the positive effect of depression onto the latent slope of recent memory, delayed memory, verbal fluency and, most notably, quality of life, could simply be the manifestation of a floor effect, indicating that individuals displaying high depressive symptomatology already display lower initial levels of both recent memory and quality of life and have less room for decline over time.

All in all, this work found evidence supporting the effects of memory, both recent and delayed, on successful ageing, operationalised following the Comprehensive PCP model (Kahana et al., 2014) as quality of life. Data employed from this work came from waves 4 to 8 of the Survey of Health, Ageing and Retirement in Europe (SHARE). Some of the previously examined research used data form the English Longitudinal Study of Ageing (ELSA; Zaninotto et al., 2009) and The Irish Longitudinal Study of Ageing (TILDA; Ward et al., 2019). These constitute the three main panel studies targeted at older adults in Europe. Previous studies, however, only focused on quality of life trajectories and did not test parallel latent trajectories of other important phenomena for successful ageing, such as cognitive ability.

Moreover, most previous studies examining the relationship of cognition and quality of life had employed measures of health-related quality of life (for example: Ezzati et al., 2019; C. L. Li et al., 2020; H. W. Li et al., 2021; Xue et al., 2022). Health-related quality of life is a frequently used term within geriatric research. This term is defined as the individual's evaluation of their health and is usually operationalised in terms of perceived health (Karimi & Brazier, 2016). Moreover, within Economics the term quality of life has been used in relation to happiness or evaluative well-being. However, measures employed to capture these constructs are usually operationalisations of life satisfaction, as seen in previous studies (for example: Frijters & Beatton, 2012; Graham & Pozuelo, 2017; Gwozdz & Souso-Poza, 2010; Kieny et al., 2022). The lack of a common definition of quality of life has posed additional difficulties in the study of this marker of successful ageing.

The main shortfall in this work concerns the selection of covariates as well as the lack of fine-grained information that is characteristic of the large-scale panel surveys such as SHARE. On the one hand, the complexity of data modelling employing Mixture Modelling methods complicated the inclusion of an elevated number of covariates. Apart from demographics and education, which are time-invariant covariates whose effects are well-documented, physical inactivity, depressive symptomatology and social engagement were selected as indicators of the individuals' bio-psycho-social status. Although these covariates are clearly time-variant, they were introduced onto the models as time-invariant. This was done because introducing the covariates as time-variant would have yielded an estimation of the latent trajectories of cognitive dimensions and quality of life corrected by the effect of the covariates. However, the aim of this work was to estimate the effect these covariates have on future performance in cognitive domains and successful ageing.

On the other hand, a good compromise between quality of life predictors and cognitive predictors had to be determined. In this sense, previous studies examining quality of life trajectories employed measures of functional limitations instead of physical inactivity, which was introduced here for its strong association to cognitive ability.

5. CONCLUSIONS

The main aim of this doctoral dissertation was to establish a holistic framework for the study of cognition in the old age and its implications for older adults' successful ageing.

Throughout all this work, the theoretical framework offered by the Preventive and Corrective Proactivity (PCP) model (Kahana et al., 2014) has been used. This model was considered because it views successful ageing both as an outcome and as a process. That is, the model does not only consider successful ageing as the achievement of good quality of life in the old age, but also as the efficient use of proactive behavioural adaptations, given the available internal and external resources, to cope with age-related and cumulative stressors. Moreover, the Comprehensive PCP model argues that successful ageing is to be interpreted in the context in which the person is ageing, considering spatial and temporal contexts as well as any additional stressor linked to individuals' demographics, as age, gender or marital status.

Overall, findings from this work provide support to previous evidence about the importance of key factors for the maintenance of cognitive ability, differentiating among recent memory, delayed memory and verbal fluency. Additionally, results also provide evidence for the

Comprehensive PCP model and the effect of cognition, as an age-related stressor, onto older adults' successful ageing outcomes.

Next, the main conclusions from this work are highlighted:

- Cognitive scales employed in SHARE can be considered to display adequate psychometric properties. Nonetheless, recent memory, measured by the 10-Word Recall Test, presents primacy and recency effects that could be causing underestimation of the relationships between recent memory and other variables.
- Social and intellectual participation in activities are significantly associated with different components of cognition. Further longitudinal studies are needed, however, to elucidate the directionality of these effects.
- Cognitive ability ought to be studied at the domain level. Predictors of cognition display heterogeneity of the magnitude, and even of the occurrence, of the effects onto different cognitive domains.
- Cognitive decline is not exclusive of the old age. Adults already start experiencing decline in different cognitive domains. Interventions could be developed to foster cognition in adulthood, as to prevent later cognitive decline.
- Memory impairment can be considered an age-related stressor affecting the quality of life of older individuals.
- The study of cognition and its associated outcomes differs across men and women. Hence, research and intervention should incorporate a gender perspective.

6. REFERENCES

Alencar, M. A., Domingues-Dias, J. M., Costa-Figueiredo, L., & Corrêa-Dias, R. (2013). Frailty and cognitive impairment among community-dwelling elderly. *Arquivos de Neuro-Psiquiatria, 71*(6), 362–367. https://doi.org/10.1590/0004-282X20130039

Alexopoulos, G. S., Meyers, B. S., Young, R. C., Campbell, S., Silbersweig, D., & Charlson, M. (1997). "Vascular depression" hypothesis. *Archives of General Psychiatry, 54*, 915–922. https://doi.org/10.1001/archpsyc.1997.01830220033006

American Psychiatric Association (2022). *Diagnostic and Statistical Manual of Mental Disorders, Fifth Edition, Text Revision*. American Psychiatric Association.

Ardila, A., Ostrosky-Solís, F., & Bernal, B. (2006). Cognitive testing toward the future: The example of Semantic Verbal Fluency (ANIMALS). *International Journal of Psychology, 41*(5), 324-332. https://doi.org/10.1080/00207590500345542

Atkinson, R., & Shiffrin, R. (1968). Human memory: a proposed system and its control processes. *Psychology of Learning and*

Motivation, 2, 89–195. https://doi.org/10.1016/s0079-7421(08)60422-3.

Auyeung, T. W., Lee, J. S. W., Kwok, T., & Woo, J. (2011). Physical frailty predicts future cognitive decline - A four-year prospective study in 2737 cognitively normal older adults. *Journal of Nutrition, Health and Aging, 15*(8), 690–694. https://doi.org/10.1007/s12603-011-0110-9

Ávila-Funes, J. A., Pina-Escudero, S. D., Aguilar-Navarro, S., Gutierrez-Robledo, L. M., Ruiz-Arregui, L., & Amieva, H. (2011). Cognitive impairment and low physical activity are the components of frailty more strongly associated with disability. *Journal of Nutrition, Health and Aging, 15*(8), 683–689. https://doi.org/10.1007/s12603-011-0111-8

Baker, L. D., Frank, L. L., Foster-Schubert, K., Green, P. S., Wilkinson, C. W., McTiernan, A., Plymate, S. R., Fishel, M. A., Watson, G. S., Cholerton, B. A., Duncan, G. E., Mehta, P. D., & Craft, S. (2010). Effects of aerobic exercise on mild cognitive impairment: A controlled trial. *Archives of Neurology, 67*(1), 71–79. https://doi.org/10.1001/archneurol.2009.307

Baltes, P. B., & Baltes, M. M. (1990). Psychological perspectives on successful aging: the model of selective optimization with compensation. In B. Baltes & M. M. Baltes (Eds.), *Successful Aging: Perspectives from the Behavioral Sciences* (pp. 1-34). Cambridge University Press.

Barnes, L. L., Mendes de Leon, C. F., Wilson, R. S., Bienias, J. L., & Evans, D. A. (2004). Social resources and cognitive decline in a population of older African Americans and whites. *Neurology, 63*, 2322–2326. https://doi.org/10.1212/01.wnl.0000147473.04043.b3

Bárrios, H., Narciso, S., Guerreiro, M., Maroco, J., Logsdon, R., & De Mendonça, A. (2013). Quality of life in patients with mild cognitive impairment. *Aging and Mental Health, 17*(3), 287–292. https://doi.org/10.1080/13607863.2012.747083

Barulli, D., & Stern, Y. (2013). Efficiency, capacity, compensation, maintenance, plasticity: Emerging concepts in cognitive reserve. *Trends in Cognitive Sciences, 17*(10), 502–509. https://doi.org/10.1016/j.tics.2013.08.012

Bauer, D. J., & Curran, P. J. (2003). Distributional Assumptions of Growth Mixture Models: Implications for Overextraction of Latent Trajectory Classes. *Psychological Methods, 8*(3), 338–363. https://doi.org/10.1037/1082-989X.8.3.338

Baumgart, M., Snyder, H. M., Carrillo, M. C., Fazio, S., Kim, H., & Johns, H. (2015). Summary of the evidence on modifiable risk factors for cognitive decline and dementia: A population-based perspective. *Alzheimer's and Dementia, 11*(6), 718–726. https://doi.org/10.1016/j.jalz.2015.05.016

Béland, F., Zunzunegui, M. V., Alvarado, B., Otero, A., & del Ser, T. (2005). Trajectories of cognitive decline and social relations. The *Journals of Gerontology: Series B, 60*, 320–330. https://doi.org/10.1093/geronb/60.6.p320

Bergmann, M., & Börsch-Supan, A., (2021). *SHARE Wave 8 Methodology: Collecting Cross-National Survey Data in Times* *of COVID-19.* Munich Center for the Economics of Aging (MEA).

Bergmann, M., Scherpenzeel, A., & Börsch-Supan, A. (2019). *SHARE Wave 7 Methodology: Panel Innovations and Life Histories*. Munich Center for the Economics of Aging (MEA).

Berkman, L. F., Glass, T., Brissette, I., & Seeman, T. E. (2000). From social integration to health: Durkheim in the new millennium. *Social Science and Medicine, 51*(6), 843–857. https://doi.org/10.1016/S0277-9536(00)00065-4

Bermejo-Pareja, F., Contador, I., del Ser, T., Olazarán, J., Llamas-Velasco, S., Vega, S., & Benito-León, J. (2021). Predementia constructs: Mild cognitive impairment or mild neurocognitive disorder? A narrative review. *International Journal of Geriatric Psychiatry, 36*(5), 743–755. https://doi.org/10.1002/gps.5474

Bertola, L., Wei-Ming Watson, C., Avila, J. F., Zahodne, L. B., Angevaare, M., Schupf, N., & Manly, J. J. (2019). Predictors of Episodic Memory Performance Across Educational Strata: Multiple-Group Comparisons. *Journal of the International Neuropsychological Society, 25*(9), 901–909. https://doi.org/10.1017/S1355617719000717

Bethmann, A., Bergmann, M., & Scherpenzeel, A. (2019). *SHARE Sampling Guide – Wave 8*. SHARE Working Paper Series 33-2019.

Beydoun, M. A., Beydoun, H. A., Gamaldo, A. A., Teel, A., Zonderman, A. B., & Wang, Y. (2014). Epidemiologic studies of modifiable factors associated with cognition and dementia: systematic review and meta-analysis. *BMC Public Health, 14*, 643. http://dx.doi.org/10.1186/1471-2458-14-643

Biswas, M., Rahaman, S., Biswas, T. K., Haque, Z., & Ibrahim, B. (2021). Association of Sex, Age, and Comorbidities with Mortality in COVID-19 Patients: A Systematic Review and Meta-Analysis. *Intervirology, 64*(1), 36–47. https://doi.org/10.1159/000512592

Blondell, S. J., Hammersley-Mather, R., & Veerman, J. L. (2014). Does physical activity prevent cognitive decline and dementia?: A systematic review and meta-analysis of longitudinal studies. *BMC Public Health, 14*(1), 1–12. https://doi.org/10.1186/1471-2458-14-510

Börsch-Supan, A. (2022a). S*urvey of Health, Ageing and Retirement in Europe (SHARE) Wave 2*. Release version: 8.0.0. SHARE-ERIC. Data set. https://doi.org/10.6103/SHARE.w2.800

Börsch-Supan, A. (2022b). *Survey of Health, Ageing and Retirement in Europe (SHARE) Wave 8.* Release version: 8.0.0. SHARE-ERIC. Data set. https://doi.org/10.6103/SHARE.w8.800

Börsch-Supan, A. (2022c). *Survey of Health, Ageing and Retirement in Europe (SHARE) Wave 4*. Release version: 8.0.0. SHARE-ERIC. Data set. https://doi.org/10.6103/SHARE.w4.800

Börsch-Supan, A. (2022d). *Survey of Health, Ageing and Retirement in Europe (SHARE) Wave 5.* Release version: 8.0.0. SHARE-ERIC. Data set. https://doi.org/10.6103/SHARE.w5.800

Börsch-Supan, A. (2022e). *Survey of Health, Ageing and Retirement in Europe (SHARE) Wave 6*. Release version: 8.0.0. SHARE-ERIC. Data set. https://doi.org/10.6103/SHARE.w6.800

Börsch-Supan, A. (2022f). *Survey of Health, Ageing and Retirement in Europe (SHARE) Wave 7.* Release version: 8.0.0. SHARE-ERIC. Data set. https://doi.org/10.6103/SHARE.w7.800

Börsch-Supan, A., Brandt, M., Hunkler, C., Kneip, T., Korbmacher, J., Malter, F., Schaan, B., Stuck, S., & Zuber, S. (2013). Data resource profile: The survey of health, ageing and retirement in europe (SHARE). *International Journal of Epidemiology, 42*(4), 992–1001. https://doi.org/10.1093/ije/dyt088

Boss, L., Kang, D. H., & Branson, S. (2015). Loneliness and cognitive function in the older adult: A systematic review. *International Psychogeriatrics, 27*(4), 541–553. https://doi.org/10.1017/S1041610214002749

Bourassa, K. J., Memel, M., Woolverton, C., & Sbarra, D. A. (2017). Social participation predicts cognitive functioning in aging adults over time: comparisons with physical health, depression, and physical activity. *Aging and Mental Health, 21*(2), 133–146. https://doi.org/10.1080/13607863.2015.1081152

Boyle, P. A., Buchman, A. S., Wilson, R. S., Leurgans, S. E., & Bennett, D. A. (2010). Physical frailty is associated with incident mild cognitive impairment in community-based older persons. *Journal of the American Geriatrics Society, 58*(2), 248–255. https://doi.org/10.1111/j.1532-5415.2009.02671.x

Brandt, J., Spencer, M., & Folstein, M. (1988). The telephone interview for cognitive status. *Neuropsychiatry, Neuropsychology and Behavioral Neurology, 1*(2), 111–117.

Brigola, A. G., Rossetti, E. S., dos Santos, B. R., Neri, A. L., Zazzetta, M. S., Inouye, K., & Pavarini, S. C. I. (2015). Relação entre cognição e fragilidade em idosos: Uma revisão sistemática. *Dementia e Neuropsychologia, 9*(2), 110–119. https://doi.org/10.1590/1980-57642015DN92000005

Buchman, A. S.; Boyle, P. A.; Yu, L.; Shah, R. C.; Wilson, R. S.; Bennett, D. A. (2012). Total daily physical activity and the risk of ad and cognitive decline in older adults. *Neurology, 79*(10), 1071. https://doi.org/10.1212/WNL.0b013e31826bd5cf

Burton, J. K., Fearon, P., Noel-Storr, A. H., McShane, R., Stott, D. J., & Quinn, T. J. (2021a). Informant Questionnaire on Cognitive Decline in the Elderly (IQCODE) for the detection of dementia within a general practice (primary care) setting. *Cochrane Database of Systematic Reviews, 2021*(7). https://doi.org/10.1002/14651858.CD010771.pub3

Burton, J. K., Fearon, P., Noel-Storr, A. H., McShane, R., Stott, D. J., & Quinn, T. J. (2021b). Informant Questionnaire on Cognitive Decline in the Elderly (IQCODE) for the detection of dementia within a secondary care setting. *Cochrane Database of Systematic Reviews, 2021*(7). https://doi.org/10.1002/14651858.CD010772.pub3

Cacioppo, J. T., & Hawkley, L. C. (2009). Perceived social isolation and cognition. *Trends in Cognitive Sciences, 13*(10), 447–454. https://doi.org/10.1016/j.tics.2009.06.005

Cadar, D., Robitaille, A., Clouston, S., Hofer, S. M., Piccinin, A. M., & Muniz-Terrera, G. (2017). An International Evaluation of Cognitive Reserve and Memory Changes in Early Old Age in 10 European Countries. *Neuroepidemiology, 48*(1–2), 9–20. https://doi.org/10.1159/000452276

Cantarero-Prieto, D., Leon, P. L., Blazquez-Fernandez, C., Juan, P. S., & Cobo, C. S. (2020). The economic cost of dementia: A systematic review. *Dementia, 19*(8), 2637–2657. https://doi.org/10.1177/1471301219837776

Cao, X., Hou, Y., Zhang, X., Xu, C., Jia, P., Sun, X., Sun, L., Gao, Y., Yang, H., Cui, Z., Wang, Y., & Wang, Y. (2020). A Comparative, Correlate Analysis and Projection of Global and Regional Life Expectancy, Healthy Life Expectancy, and their GAP: 1995-2025. *Journal of Global Health, 10*(2). https://doi.org/10.7189/jogh.10.020407

Carpentieri, J. D., Elliott, J., Brett, C. E., & Deary, I. J. (2017). Adapting to aging: Older people talk about their use of selection, optimization, and compensation to maximize well-being in the context of physical decline. *Journals of Gerontology - Series B Psychological Sciences and Social Sciences, 72*(2), 351–361. https://doi.org/10.1093/geronb/gbw132

Cattell, R. B. (1963). Theory of fluid and crystallized intelligence: A critical experiment. *Journal of Educational Psychology, 54*(1), 1–22. https://doi.org/10.1037/h0046743

Cernat, A., Sakshaug, J., Christmann, P., & Gummer, T. (2022). The impact of survey mode design and questionnaire length on measurement quality. *Sociological Methods and Research*. https://doi.org/10.1177/00491241221140139

Chaker, L., Falla, A., van der Lee, S. J., Muka, T., Imo, D., Jaspers, L., Colpani, V., Mendis, S., Chowdhury, R., Bramer, W. M., Pazoki, R., & Franco, O. H. (2015). The global impact of non-communicable diseases on macro-economic productivity: a systematic review. *European Journal of Epidemiology, 30*(5), 357–395. https://doi.org/10.1007/s10654-015-0026-5

Chen, R., Hu, Z., Wei, L., Qin, X., McCracken, C., & Copeland, J. R. (2008). Severity of depression and risk for subsequent dementia: Cohort studies in China and the UK. *British Journal of Psychiatry, 193*(5), 373–377. https://doi.org/10.1192/bjp.bp.107.044974

Chen, T. Y., & Chang, H. Y. (2016). Developmental Patterns of Cognitive Function and Associated Factors among the Elderly in Taiwan. *Scientific Reports, 6*, 1–10. https://doi.org/10.1038/srep33486

Cheng, S. T. (2014). Defining successful aging: The need to distinguish pathways from outcomes. *International Psychogeriatrics, 26*(4), 527–531. https://doi.org/10.1017/S1041610213001713

Cheung, G. W., & Rensvold, R. B. (2009). Structural Equation Modeling : A Evaluating Goodness-of- Fit Indexes for Testing Measurement Invariance. *Structural Equation Modeling: A Multidisciplinary Journal, 9*(2), 233–255. https://doi.org/10.1207/S15328007SEM0902_5

Choi, M. (2020). Association between social participation and cognitive function among community-dwelling older adults living alone: Analysis of a nationally representative survey. International *Journal of Nursing Practice, 26,* e12841. https://doi.org/10.1111/ijn.12841

Chung, H. Y., Kim, D. H., Lee, E. K., Chung, K. W., Chung, S., Lee, B., Seo, A. Y., Chung, J. H., Jung, Y. S., Im, E., Lee, J., Kim, N. D., Choi, Y. J., Im, D. S., & Yu, B. P. (2019). Redefining chronic inflammation in aging and age-related diseases: Proposal of the senoinflammation concept. *Aging and Disease, 10*(2), 367–382. https://doi.org/10.14336/AD.2018.0324

Chung, H. Y., Kim, H. J., Kim, J. W., & Yu, B. P. (2001). The inflammation hypothesis of aging: Molecular modulation by calorie restriction. *Annals of the New York Academy of Sciences, 928*(3), 327–335. https://doi.org/10.1111/j.1749-6632.2001.tb05662.x

Collins, L. M., & Lanza, S. T. (2009). *Latent class and latent transition analysis*. John Wiley & Sons Inc.

Cragg, L., & Gilmore, C. (2014). Skills underlying mathematics: The role of executive function in the development of mathematics proficiency. *Trends in Neuroscience and Education, 3*, 63-68. https://doi.org/10.1016/j.tine.2013.12.001

Crane, P. K., Walker, R., Hubbard, R. A., Li, G., Nathan, D. M., Zheng, H., Haneuse, S., Craft, S., Montine, T. J., Kahn, S. E., McCormick, W., McCurry, S. M., Bowen, J. D., & Larson, E. B. (2013). Glucose levels and risk of dementia. *Forschende Komplementarmedizin, 20*(5), 386–387. https://doi.org/10.1056/nejmoa1215740

Crocker, L., & Algina, J. (2008). *Introduction to classical and modern test theory*. Cengage Learning.

Dai, C. T., Chang, Y. K., Huang, C. J., & Hung, T. M. (2013). Exercise mode and executive function in older adults: An ERP study of task-switching. *Brain and Cognition, 83*(2), 153–162. https://doi.org/10.1016/j.bandc.2013.07.007

De Souto Barreto, P., Delrieu, J., Andrieu, S., Vellas, B., & Rolland, Y. (2016). Physical Activity and Cognitive Function in Middle-Aged and Older Adults: An Analysis of 104,909 People From 20 Countries. *Mayo Clinic Proceedings, 91*(11), 1515–1524. https://doi.org/10.1016/j.mayocp.2016.06.032

Delis, D. C., Kramer, J. H., Kaplan, E., & Ober, B. A. (1987) *California Verbal Learning Test manual.* The Psychological Corporation.

Delis, D. C., Kramer, J. H., Kaplan, E., & Ober, B. A. (2000). *The California verbal learning test – second edition*. The Psychological Corporation.

Deng, L., & Chan, W. (2017). Testing the Difference Between Reliability Coefficients Alpha and Omega. *Educational and Psychological Measurement, 77*(2), 185–203. https://doi.org/10.1177/0013164416658325

Dewey, M.E. & Prince M.J.: Cognitive Function. In: Börsch-Supan, A., A. Brugiavini, H. Jürges, J. Mackenbach, J. Siegrist and G. Weber. (2005). *Health, ageing and retirement in Europe – First results from the Survey of Health, Ageing and Retirement in Europe* (118-125). Mannheim Research Institute for the Economics of Aging (MEA).

Dhana, K., Franco, O. H., Ritz, E. M., Ford, C. N., Desai, P., Krueger, K. R., Holland, T. M., Dhana, A., Liu, X., Aggarwal, N. T., Evans, D. A., & Rajan, K. B. (2022). Healthy lifestyle and life expectancy with and without Alzheimer's dementia: Population based cohort study. *The BMJ.* https://doi.org/10.1136/bmj-2021-068390

Ding, X., Charnigo, R. J., Schmitt, F. A., Kryscio, R. J., & Abner, E. L. (2019). Evaluating trajectories of episodic memory in normal cognition and mild cognitive impairment: Results from ADNI. *PLoS ONE, 14*(2), 1–16. https://doi.org/10.1371/journal.pone.0212435

Doblhammer, G., Fritze, T., Reinke, C., & Fink, A. (2022). Can dementia become the most prevalent disease at the time of death in Germany? Projections up to the year 2060 for the five most important diseases at the time of death. *Journal of Population*

Ageing, 15(2), 523–540. https://doi.org/10.1007/s12062-022-09365-7

dos Santos Sanchez, M. A., & Lourenço, R. A. (2013). Screening for dementia: Brazilian version of the Informant Questionnaire on Cognitive Decline on the Elderly and its psychometric properties. Geriatrics and Gerontology International, 13(3), 687–693. https://doi.org/10.1111/j.1447-0594.2012.00966.x

Downer, B., Chen, N. W., Raji, M., & Markides, K. S. (2017). A longitudinal study of cognitive trajectories in Mexican Americans age 75 and older. *International Journal of Geriatric Psychiatry, 32*(10), 1122–1130. https://doi.org/10.1002/gps.4575

Ebbinghaus, H. (1913). *Memory: A contribution to experimental psychology*. (H. A. Ruger & C. E. Bussenius, Trans.). Teachers College Press. https://doi.org/10.1037/10011-000

El-Hayek, Y. H., Wiley, R. E., Khoury, C. P., Daya, R. P., Ballard, C., Evans, A. R., Karran, M., Molinuevo, J. L., Norton, M., & Atri, A. (2019). Tip of the Iceberg: Assessing the Global Socioeconomic Costs of Alzheimer's Disease and Related Dementias and Strategic Implications for Stakeholders. *Journal of Alzheimer's Disease, 70*(2), 321–339. https://doi.org/10.3233/JAD-190426

Enders, C. K. (2010). *Applied missing data analysis.* Guilford Press.

Espeland, M. A., Chen, J. C., Weitlauf, J., Hayden, K. M., Rapp, S. R., Resnick, S. M., Garcia, L., Cannell, B., Baker, L. D., Sachs, B. C., Tindle, H. A., Wallace, R., & Casanova, R. (2018). Trajectories of Relative Performance with 2 Measures of Global

Cognitive Function. *Journal of the American Geriatrics Society, 66*(8), 1575–1580. https://doi.org/10.1111/jgs.15431

Eurostat (2022) Eurostat database. https://ec.europa.eu/eurostat/data/database

Ezzati, A., Zammit, A. R., Katz, M. J., Derby, C. A., Zimmerman, M. E., & Lipton, R. B. (2019). Health-related Quality of Life, Cognitive Performance, and Incident Dementia in a Community-based Elderly Cohort. A*lzheimer Disease and Associated Disorders, 33*(3), 240–245. https://doi.org/10.1097/WAD.0000000000000324

Facal, D., Maseda, A., Pereiro, A. X., Gandoy-Crego, M., Lorenzo-López, L., Yanguas, J., & Millán-Calenti, J. C. (2019). Cognitive frailty: A conceptual systematic review and an operational proposal for future research. *Maturitas, 121*, 48–56. https://doi.org/10.1016/j.maturitas.2018.12.006

Fernández, I., García-Mollá, A., Oliver, A., Sansó, N., & Tomás, J. M. (2023). The role of social and intellectual activity participation in older adults' cognitive function. *Archives of Gerontology and Geriatrics, 107*. https://doi.org/10.1016/j.archger.2022.104891

Fernández, I., Torres, Z., Martínez-Gregorio, S., Oliver, A., & Tomás, J. M. (2022). Method Effects associated to item valence: Evidence from the 10-item Big-Five Inventory in older adults. *Research on Aging*. https://doi.org/10.1177/01640275221132196

Ferrucci, L., & Fabbri, E. (2018). Inflammageing: chronic inflammation in ageing, cardiovascular disease, and frailty. *Nature Reviews*

Cardiology, 15(9), 505–522. https://doi.org/10.1038/s41569-018-0064-2

Finney, S. J., & DiStefano, C. (2006). Non-normal and categorical data in structural equation modeling. In G. R. Hancock & R. O. Mueller (Eds.), *Structural equation modeling: A second course* (269-314). Greenwich, CT: Information Age.

Floden, D., Busch, R. M., Cooper, S. E., Kubu, C. S., & Machado, A. G. (2015). Global cognitive scores do not predict outcome after subthalamic nucleus deep brain stimulation. *Movement Disorders, 30*(9), 1279–1283. https://doi.org/10.1002/mds.26292

Folstein, M. F., Folstein, S. E., McHugh, P. R. (1975). "Minimental state": a practical method for grading the cognitive state of patients for the clinician. *Journal of Psychiatric Research*, *12*(3), 189–98. https://doi.org/10.1016/0022-3956(75)90026-6

Foroughan, M., Jafari, Z., Ghaemmagham Farahani, I., & Rashedi, V. (2019). Validity and Reliability of the Informant Questionnaire on Cognitive Decline in the Elderly (IQCODE): Preliminary Findings among the Older Population of Iran. *GeroPsych: The Journal of Gerontopsychology and Geriatric Psychiatry, 32*(3), 145–151. https://doi.org/10.1024/1662-9647/a000209

Franceschi, C., Bonafè, M., Valensin, S., Olivieri, F., de Luca, M., Ottaviani, E., & de Benedictis, G. (2000). Inflamm-aging. An evolutionary perspective on Immunosenescence. *Annals of the New York Academy of Sciences, 908*(1), 244–254. https://doi.org/0.1111/j.1749-6632.2000.tb06651.x

Fratiglioni, L., Paillard-Borg, S., & Winblad, B. (2004). An active and socially integrated lifestyle in late life might protect against dementia. *Lancet Neurology, 3*(6), 343–353. https://doi.org/10.1016/S1474-4422(04)00767-7

Frederiksen, K. S., Verdelho, A., Madureira, S., Bäzner, H., O'Brien, J. T., Fazekas, F., Scheltens, P., Schmidt, R., Wallin, A., Wahlund, L. O., Erkinjunttii, T., Poggesi, A., Pantoni, L., Inzitari, D., & Waldemar, G. (2015). Physical activity in the elderly is associated with improved executive function and processing speed: The LADIS Study. *International Journal of Geriatric Psychiatry, 30*(7), 744–750. https://doi.org/10.1002/gps.4220

Freund, A. M., & Baltes, P. B. (1998). Selection, optimization, and compensation as strategies of life management. *Psychology and Aging*, *13*(4), 531-543. https://doi.org/10.1037/0882-7974.13.4.531

Freund, A. M., & Baltes, P. B. (2002). Life-management strategies of selection, optimization and compensation: Measurement by self-report and construct validity. *Journal of Personality and Social Psychology, 82*(4), 642–662. https://doi.org/10.1037/0022-3514.82.4.642

Fried, L. P., Tangen, C. M., Walston, J., Newman, A. B., Hirsch, C., Gottdiener, J., Seeman, T., Tracy, R., Kop, W. J., Burke, G., & McBurnie, M. A. (2001). Frailty in older adults: Evidence for a phenotype. *Journals of Gerontology - Series A Biological Sciences and Medical Sciences, 56*(3), 146–157. https://doi.org/10.1093/gerona/56.3.m146

Frijters, P., & Beatton, T. (2012). The mystery of the U-shaped relationship between happiness and age. *Journal of Economic Behavior and Organization, 82*(2–3), 525–542. https://doi.org/10.1016/j.jebo.2012.03.008

Fu, C., Li, Z., & Mao, Z. (2018). Association between social activities and cognitive function among the elderly in China: A cross-sectional study. *International Journal of Environmental Research and Public Health, 15*, 231. https://doi.org/10.3390/ijerph15020231

Gajardo, J., Alvarado, R., Slachevsky, A., & Gitlin, L. N. (2021). Self-stigma in people living with dementia in Chile: A qualitative exploratory study. *Aging and Mental Health*. https://doi.org/10.1080/13607863.2021.1998351

Glei, D., Landau, D., Goldman, N., Chuang, Y., Rodríguez, G., & Weinstein, M. (2005). Participating in social activities helps preserve cognitive function: an analysis of a longitudinal, population-based study of the elderly. *International Journal of Epidemiology, 34*(4), 864-871. https://doi.org/10.1093/ije/dyi049

Godin, J., Armstrong, J. J., Rockwood, K., & Andrew, M. K. (2017). Dynamics of frailty and cognition after age 50: Why it matters that cognitive decline is mostly seen in old age. *Journal of Alzheimer's Disease, 58*(1), 231–242. https://doi.org/10.3233/JAD-161280

Godin, J., Armstrong, J. J., Wallace, L., Rockwood, K., & Andrew, M. K. (2019). The impact of frailty and cognitive impairment on quality of life: Employment and social context matter. *International Psychogeriatrics, 31*(6), 789–797. https://doi.org/10.1017/S1041610218001710

Golden, J., Conroy, R. M., Bruce, I., Denihan, A., Greene, E., Kirby, M., & Lawlor, B. A. (2009). Loneliness, social support networks, mood and wellbeing in community-dwelling elderly. International *Journal of Geriatric Psychiatry, 24*(7), 694–700. https://doi.org/10.1002/gps.2181

Gorelick, P. B., Scuteri, A., Black, S. E., Decarli, C., Greenberg, S. M., Iadecola, C., Launer, L. J., Laurent, S., Lopez, O. L., Nyenhuis, D., Petersen, R. C., Schneider, J. A., Tzourio, C., Arnett, D. K., Bennett, D. A., Chui, H. C., Higashida, R. T., Lindquist, R., Nilsson, P. M., … Seshadri, S. (2011). Vascular contributions to cognitive impairment and dementia: A statement for healthcare professionals from the American Heart Association/American Stroke Association. *Stroke, 42*(9), 2672–2713. https://doi.org/10.1161/STR.0b013e3182299496

Graham, C., & Ruiz Pozuelo, J. (2017). Happiness, stress, and age: how the U curve varies across people and places. *Journal of Population Economics, 30*(1), 225–264. https://doi.org/10.1007/s00148-016-0611-2

Gray, S. L., Anderson, M. L., Hubbard, R. A., Lacroix, A., Crane, P. K., McCormick, W., Bowen, J. D., McCurry, S. M., & Larson, E. B. (2013). Frailty and incident dementia. *Journals of Gerontology - Series A Biological Sciences and Medical Sciences, 68*(9), 1083–1090. https://doi.org/10.1093/gerona/glt013

Green, R. C., Cupples, L. A., Kurz, A., Auerbach, S., Go, R., Sadovnick, D., Duara, R., Kukull, W. A., Chui, H., Edeki, T., Griffith, P. A., Friedland, R. P., Bachman, D., & Farrer, L. (2003). Depression as a risk factor for Alzheimer disease: the MIRAGE Study. *Archives of Neurology, 60*, 753–759. https://doi.org/10.1001/archneur.60.5.753

Griffin, J. W., John, S. E., Adams, J. W., Bussell, C. A., Saurman, J. L., & Gavett, B. E. (2017). The effects of age on the learning and forgetting of primacy, middle, and recency components of a multi-trial word list. *Journal of Clinical and Experimental Neuropsychology, 39*(9), 900–912. https://doi.org/10.1080/13803395.2017.1278746

Gwozdz, W., & Sousa-Poza, A. (2010). Ageing, health and life satisfaction of the oldest old: An analysis for Germany. *Social Indicators Research, 97*(3), 397–417. https://doi.org/10.1007/s11205-009-9508-8

Haber, M. G., Cohen, J. L., Lucas, T., & Baltes, B. B. (2007). The relationship between self-reported received and perceived social support: A meta-analytic review. *American Journal of Community Psychology, 39*(1–2), 133–144. https://doi.org/10.1007/s10464-007-9100-9

Han, E. S., Lee, Y., & Kim, J. (2014). Association of cognitive impairment with frailty in community-dwelling older adults. *International Psychogeriatrics, 26*(1), 155–163. https://doi.org/10.1017/S1041610213001841

Han, L., Gill, T. M., Jones, B. L., & Allore, H. G. (2016). Cognitive Aging Trajectories and Burdens of Disability, Hospitalization and Nursing Home Admission among Community-living Older Persons. *Journals of Gerontology - Series A Biological Sciences and Medical Sciences, 71*(6), 766–771. https://doi.org/10.1093/gerona/glv159

Harada, C. N., Natelson Love, M. C., & Triebel, K. L. (2013). Normal cognitive aging. *Clinics in Geriatric Medicine, 29*(4), 737–752. https://doi.org/10.1016/j.cger.2013.07.002

Harrison, K. L., Ritchie, C. S., Hunt, L. J., Patel, K., Boscardin, W. J., Yaffe, K., & Smith, A. K. (2022). Life expectancy for community-dwelling persons with dementia and severe disability. *Journal of the American Geriatrics Society*, *70*(6), 1807–1815. https://doi.org/10.1111/jgs.17767

Harrison, S. L., Sajjad, A., Bramer, W. M., Ikram, M. A., Tiemeier, H., & Stephan, B. C. M. (2015). Exploring strategies to operationalise cognitive reserve: A systematic review of reviews. *Journal of Clinical and Experimental Neuropsychology, 37*(3), 253–264. https://doi.org/10.1080/13803395.2014.1002759

Harvey, P. D. (2019). Domains of cognition and their assessment. *Dialogues in Clinical Neuroscience, 21*(3), 227–237. https://doi.org/10.31887/DCNS.2019.21.3/pharvey

Havighurst, R. (1961). Successful Aging. *The Gerontologist, 1*(1), 8-13. https://doi.org/10.1093/geront/1.1.8

Hayden, K. M., Reed, B. R., Manly, J. J., Tommet, D., Pietrzak, R. H., Chelune, G. J., Yang, F. M., Revell, A. J., Bennett, D. A., &

Jones, R. N. (2011). Cognitive decline in the elderly: An analysis of population heterogeneity. *Age and Ageing, 40*(6), 684–689. https://doi.org/10.1093/ageing/afr101

Henley, N. M. (1969). A psychological study of the semantics of animal terms. *Journal of Verbal Learning and Verbal Behavior, 8*(2), 176–184. https://doi.org/10.1016/S0022-5371(69)80058-7

Hertzog, C., Kramer, A., Wilson, R., & Lindenberger, U. (2008). Enrichment effects on adult cognitive development. *Psychological Science in the Public Interest, 9*, 1-65. https://doi.org/10.1111/j.1539-6053.2009.01034.x

Hessel, P., Kinge, J. M., Skirbekk, V., & Staudinger, U. M. (2018). Trends and determinants of the Flynn effect in cognitive functioning among older individuals in 10 European countries. *Journal of Epidemiology and Community Health, 72*(5), 383–389. https://doi.org/10.1136/jech-2017-209979

Hoe, J., Hancock, G., Livingston, G., Woods, B., Challis, D., & Orrell, M. (2009). Changes in the quality of life of people with dementia living in care homes. *Alzheimer Disease and Associated Disorders, 23*(3), 285–290. https://doi.org/10.1097/WAD.0b013e318194fc1e

Hosmer, D. W., Lemeshow, S., & Sturdivant, R. X. (2013). *Applied Logistic Regression*, *3rd ed*. Wiley. https://doi.org/10.1002/9781118548387

Howard, M. C., & Hoffman, M. E. (2018). Variable-Centered, Person-Centered, and Person-Specific Approaches: Where Theory Meets the Method. *Organizational Research Methods, 21*(4), 846–876. https://doi.org/10.1177/1094428117744021

Howrey, B., Raji, M., Masel, M., & Peek, M. (2015). Stability in Cognitive Function Over 18 Years: Prevalence and Predictors among Older Mexican Americans. *Current Alzheimer Research, 12*(7), 614-621. https://doi.org/10.2174/1567205012666150701102947

Hu, L. T., & Bentler, P. M. (1999). Cutoff criteria for fit indexes in covariance structure analysis: Conventional criteria versus new alternatives. *Structural Equation Modeling, 6*(1), 1–55. https://doi.org/10.1080/10705519909540118

Hu, T., Zhao, X., Wu, M., Li, Z., Luo, L., Yang, C., & Yang, F. (2022). Prevalence of depression in older adults: A systematic review and meta-analysis. *Psychiatry Research, 311*, 114511. https://doi.org/10.1016/j.psychres.2022.114511

Huang, Y. Z., & Kuan, C. C. (2022). Vaccination to reduce severe COVID-19 and mortality in COVID-19 patients: a systematic review and meta-analysis. *European Review for Medical and Pharmacological Sciences, 26*(5), 1770–1776. https://doi.org/10.26355/eurrev_202203_28248

Hughes, M. E., Waite, L. J., Hawkley, L. C., & Cacioppo, J. T. (2004). A short scale for measuring loneliness in large surveys: Results from two population-based studies. *Research on Aging, 26*(6), 655–672. https://doi.org/10.1177/0164027504268574

Hugo, J., & Ganguli, M. (2014). Dementia and Cognitive Impairment. Epidemiology, Diagnosis, and Treatment. *Clinics in Geriatric*

Medicine, 30(3), 421–442. https://doi.org/10.1016/j.cger.2014.04.001

Hultsch, D. F., Hertzog, C., Small, B. J., & Dixon, R. A. (1999). Use it or lose it: Engaged lifestyle as a buffer of cognitive decline in aging? *Psychology and Aging, 14*, 245–263.

Hurd, M. D., Martorell, P., Delavande, A., Mullen, K. J., & Langa, K. M. (2013). Monetary Costs of Dementia in the United States. *New England Journal of Medicine, 368*(14), 1326–1334. https://doi.org/10.1056/nejmsa1204629

Hwang, J., Park, S., & Kim, S. (2018). Effects of participation in social activities on cognitive function among middle-aged and older adults in Korea. *International Journal of Environmental Research and Public Health, 15*, 2315. https://doi.org/10.3390/ijerph15102315

Hyde, M., Wiggins, R. D., Higgs, P., & Blane, D. B. (2003). A measure of quality of life in early old age: The theory, development and properties of a needs satisfaction model (CASP-19). *Aging and Mental Health, 7*(3), 186–194. https://doi.org/10.1080/1360786031000101157

Innocenti, I., Cappa, S. F., Feurra, M., Giovannelli, F., Santarnecchi, E., Bianco, G., Cincotta, M., & Rossi, S. (2013). TMS interference with primacy and recency mechanisms reveals bimodal episodic encoding in the human brain. *Journal of Cognitive Neuroscience, 25*(1), 109–116. https://doi.org/10.1162/jocn_a_00304

Ismail, Z., Gatchel, J., Bateman, D. R., Barcelos-Ferreira, R., Chantillon, M., Jaeger, J., Donovan, N. J., & Mortby, M. E. (2018). Affective and emotional dysregulation as pre-dementia risk markers: Exploring the mild behavioral impairment symptoms of depression, anxiety, irritability, and euphoria. *International Psychogeriatrics, 30*(2), 185–196. https://doi.org/10.1017/S1041610217001880

James, B. D., Wilson, R. S., Barnes, L. L., & Bennett, D. A. (2011). Late-life social activity and cognitive decline in old age. *Journal of the International Neuropsychological Society, 17*, 998–1005. https://doi.org/10.1017/s1355617711000531

Janssen, F., Bardoutsos, A., El Gewily, S., & de Beer, J. (2021). Future life expectancy in Europe taking into account the impact of smoking, obesity and alcohol. *ELife, 10*, 1–28. https://doi.org/10.7554/eLife.66590

Jaspers, L., Colpani, V., Chaker, L., van der Lee, S. J., Muka, T., Imo, D., Mendis, S., Chowdhury, R., Bramer, W. M., Falla, A., Pazoki, R., & Franco, O. H. (2015). The global impact of non-communicable diseases on households and impoverishment: a systematic review. *European Journal of Epidemiology, 30*(3), 163–188. https://doi.org/10.1007/s10654-014-9983-3

Johnson, J. K., Gross, A. L., Pa, J., McLaren, D. G., Park, L. Q., & Manly, J. J. (2012). Longitudinal change in neuropsychological performance using latent growth models: A study of mild cognitive impairment. *Brain Imaging and Behavior, 6*(4), 540–550. https://doi.org/10.1007/s11682-012-9161-8

Johnson, J. K., Lui, L. Y., & Yaffe, K. (2007). Executive function, more than global cognition, predicts functional decline and mortality in elderly women. *Journals of Gerontology - Series A Biological Sciences and Medical Sciences, 62*(10), 1134–1141. https://doi.org/10.1093/gerona/62.10.1134

Jorm, A. F. (1994). A Short Form of the Informant Questionnaire on Cognitive Decline in the Elderly (Iqcode): Development and Cross-Validation. *Psychological Medicine, 24*(1), 145–153. https://doi.org/10.1017/S003329170002691X

Jorm, A. F. (2004). The Informant Questionnaire on Cognitive Decline in the Elderly (IQCODE): A review. *International Psychogeriatrics, 16*(3), 275–293. https://doi.org/10.1017/S1041610204000390

Jorm, A. F., & Korten, A. E. (1988). Assessment of cognitive decline in the elderly by informant interview. *British Journal of Psychiatry, 152*, 209–213. https://doi.org/10.1192/bjp.152.2.209

Jurado, M. B., & Rosselli, M. (2007). The elusive nature of executive functions: A review of our current understanding. *Neuropsychology Review, 17*, 213–233.

Kahana, E., & Kahana, B. (1996). Conceptual and empirical advances in understanding aging well through proactive adaptation. En V. L. Bengtson (Ed.), Adulthood and aging: Research on continuities and discontinuities (pp. 18-40). New York, NY, US: Springer Publishing Co.

Kahana, E., Kahana, B., & Lee, J. E. (2014). Proactive Approaches to Successful Aging: One Clear Path through the Forest. *Gerontology, 60*(5), 466–474. https://doi.org/10.1159/000360222

Kahana, E., Kahana, B., & Zhang, J. (2005). Motivational antecedents of preventive proactivity in late life: Linking future orientation and exercise. *Motivation and Emotion, 29*(4), 443–464. https://doi.org/10.1007/s11031-006-9012-2

Kahana, E., Kelley-Moore, J., & Kahana, B. (2012). Proactive aging: A longitudinal study of stress, resources, agency, and well-being in late life. *Aging and Mental Health, 16*(4), 438–451. https://doi.org/10.1080/13607863.2011.644519

Kahana, E., Lawrence, R. H., Kahana, B., Kercher, K., Wisniewski, A., Stoller, E., Tobin, J., & Stange, K. (2002). Long-term impact of preventive proactivity on quality of life of the old-old. *Psychosomatic Medicine, 64*(3), 382–394. https://doi.org/10.1097/00006842-200205000-00003

Karimi, M., & Brazier, J. (2016). Health, Health-Related Quality of Life, and Quality of Life: What is the Difference? *PharmacoEconomics, 34*(7), 645–649. https://doi.org/10.1007/s40273-016-0389-9

Katz, S., & Calasanti, T. (2015). Critical perspectives on successful aging: Does it “appeal more than it illuminates”? *The Gerontologist, 55*(1), 26–33. https://doi.org/10.1093/geront/gnu027

Kelaiditi, E., Cesari, M., Canevelli, M., Abellan Van Kan, G., Ousset, P. J., Gillette-Guyonnet, S., Ritz, P., Duveau, F., Soto, M. E., Provencher, V., Nourhashemi, F., Salva, A. Robert, P., Adrieu, S., Rolland, Y., Touchon, J., Fitten, J. L., & Vellas, B. (2013). Cognitive frailty: Rational and definition from an (I.A.N.A./

I.A.G.G.) international consensus group. *The Journal of Nutrition, Health & Aging, 17*(9), 726-734. https://doi.org/10.1007/s12603-013-0367-2

Kelly, M. E., Duff, H., Kelly, S., McHugh Power, J. E., Brennan, S., Lawlor, B. A., & Loughrey, D. G. (2017). The impact of social activities, social networks, social support and social relationships on the cognitive functioning of healthy older adults: a systematic review. *Systematic Reviews, 6*, 259. https://doi.org/10.1186/s13643-017-0632-2

Kenny, D. A., Kaniskan, B., & McCoach, D. B. (2015). The Performance of RMSEA in Models With Small Degrees of Freedom. *Sociological Methods and Research, 44*(3), 486–507. https://doi.org/10.1177/0049124114543236

Kieny, C., Flores, G., Ingenhaag, M., & Maurer, J. (2022). Healthy, Wealthy, Wise, and Happy? Assessing Age Differences in Evaluative and Emotional Well-Being Among Mature Adults from Five Low- and Middle-Income Countries. *Social Indicators Research*, *160*, 1019–1050. https://doi.org/10.1007/s11205-020-02515-4

Kimura, D., Takeda, T., Ohura, T., & Imai, A. (2017). Evaluation of facilitative factors for preventing cognitive decline: A 3-year cohort study of community intervention. *Psychogeriatrics, 17*, 9–16. https://doi.org/10.1111/psyg.12182

Kline, R. B. (2016). *Principles and practice of structural equation modeling (4th ed.)*. Guildford Press.

Kong, D., Davitt, J., & Dong, X. (2018). Loneliness, Depressive Symptoms, and Cognitive Functioning Among U.S. Chinese Older Adults. *Gerontology and Geriatric Medicine, 4*, 233372141877820. https://doi.org/10.1177/2333721418778201

Krueger, K., Wilson, R., Kamenetsky, J., Barnes, L., Bienias, J., & Bennett, D. (2009). Social engagement and cognitive function in old age. *Experimental Aging Research, 35*, 45-60. https://doi.org/10.1080/03610730802545028

Ku, P. W., Stevinson, C., & Chen, L. J. (2012). Prospective associations between leisure-time physical activity and cognitive performance among older adults across an 11-year period. *Journal of Epidemiology, 22*(3), 230–237. https://doi.org/10.2188/jea.JE20110084

Kulmala, J., Nykänen, I., Mänty, M., & Hartikainen, S. (2013). Association between frailty and dementia: A population-based study. *Gerontology, 60*(1), 16–21. https://doi.org/10.1159/000353859

Lam, L. C. W., Chau, R. C. M., Wong, B. M. L., Fung, A. W. T., Lui, V. W. C., Tam, C. C. W., Leung, G. T. Y., Kwok, T. C. Y., Chiu, H. F. K., Ng, S., & Chan, W. M. (2011). Interim follow-up of a randomized controlled trial comparing Chinese style mind body (Tai Chi) and stretching exercises on cognitive function in subjects at risk of progressive cognitive decline. International *Journal of Geriatric Psychiatry, 26*(7), 733–740. https://doi.org/10.1002/gps.2602

Langa, K. M., Ryan, L. H., McCammon, R. J., Jones, R. N., Manly, J. J., Levine, D. A., Sonnega, A., Farron, M., & Weir, D. R. (2020). The Health and Retirement Study Harmonized Cognitive Assessment Protocol Project: Study Design and Methods. *Neuroepidemiology, 54*(1), 64–74. https://doi.org/10.1159/000503004

Laursen, B., & Hoff, E. (2006). Person-Centered and Variable-Centered Approaches to Longitudinal Data. *Merrill-Palmer Quarterly, 52* (3), 377–389. https://doi.org/10.1353/mpq.2006.0029

Lautenschlager, N. T., Cox, K. L., Flicker, L., Foster, J. K., Van Bockxmeer, F. M., Xiao, J., Greenop, K. R., & Almeida, O. P. (2008). Effect of physical activity on cognitive function in older adults at risk for Alzheimer disease: A randomized trial. *JAMA*, *300*(9), 1027–1037. https://doi.org/10.1001/jama.300.9.1027

Lavrencic, L. M., Churches, O. F., & Keage, H. A. D. (2018). Cognitive reserve is not associated with improved performance in all cognitive domains. *Applied Neuropsychology: Adult, 25*(5), 473–485. https://doi.org/10.1080/23279095.2017.1329146

Lawson, R. A., Yarnall, A. J., Duncan, G. W., Breen, D. P., Khoo, T. K., Williams-Gray, C. H., Barker, R. A., Collerton, D., Taylor, J. P., & Burn, D. J. (2016). Cognitive decline and quality of life in incident Parkinson's disease: The role of attention. *Parkinsonism and Related Disorders, 27*, 47–53. https://doi.org/10.1016/j.parkreldis.2016.04.009

Lawson, R. A., Yarnall, A. J., Duncan, G. W., Khoo, T. K., Breen, D. P., Barker, R. A., Collerton, D., Taylor, J. P., & Burn, D. J. (2014).

Severity of mild cognitive impairment in early Parkinson's disease contributes to poorer quality of life. *Parkinsonism and Related Disorders, 20*(10), 1071–1075. https://doi.org/10.1016/j.parkreldis.2014.07.004

Lee, Y., & Jean Yeung, W. J. (2019). Gender matters: Productive social engagement and the subsequent cognitive changes among older adults. *Social Science and Medicine, 229*, 87–95. https://doi.org/10.1016/j.socscimed.2018.08.024

Leeuw, E. D. (2005). To Mix or Not to Mix Data Collection Modes in Surveys. Journal of Official Statistics, 21(2), 233–255.

Leicht, K. L. (1968). Differential rehearsal and primacy effects. *Journal of Verbal Learning and Verbal Behavior, 7*(6), 1115–1117. https://doi.org/:10.1016/s0022-5371(68)80079-9

Li, C. L., Chang, H. Y., & Stanaway, F. F. (2020). Combined effects of frailty status and cognitive impairment on health-related quality of life among community dwelling older adults. *Archives of Gerontology and Geriatrics, 87*, 103999. https://doi.org/10.1016/j.archger.2019.103999

Li, H. W., Lee, W. J., Lin, M. H., Peng, L. N., Loh, C. H., Chen, L. K., & Lu, C. C. (2021). Quality of life among community-dwelling middle-aged and older adults: Function matters more than multimorbidity. *Archives of Gerontology and Geriatrics, 95*(115), 104423. https://doi.org/10.1016/j.archger.2021.104423

Li, H., Li, C., Wang, A., Qi, Y., Feng, W., Hou, C., Tao, L., Liu, X., Li, X., Wang, W., Zheng, D., & Guo, X. (2020). Associations between social and intellectual activities with cognitive trajectories in Chinese middle-aged and older adults: A nationally representative cohort study. *Alzheimer's Research & Therapy, 12*(1). https://doi.org/10.1186/s13195-020-00691-6

Li, Y., Pan, A., Wang, D. D., Liu, X., Dhana, K., Franco, O. H., Kaptoge, S., Di Angelantonio, E., Stampfer, M., Willett, W. C., & Hu, F. B. (2018). Impact of healthy lifestyle factors on life expectancies in the US population. *Circulation, 138*(4), 345–355. https://doi.org/10.1161/CIRCULATIONAHA.117.032047

Liampas, I., Folia, V., Ntanasi, E., Yannakoulia, M., Sakka, P., Hadjigeorgiou, G., Scarmeas, N., Dardiotis, E., & Kosmidis, M. H. (2022). Longitudinal episodic memory trajectories in older adults with normal cognition. *The Clinical Neuropsychologist*. https://doi.org/10.1080/13854046.2022.2059011

Liao, J., & Scholes, S. (2017). Association of Social Support and Cognitive Aging Modified by Sex and Relationship Type: A Prospective Investigation in the English Longitudinal Study of Ageing. *American Journal of Epidemiology, 186*(7), 787–795. https://doi.org/10.1093/aje/kwx142

Lim, S. L., Gao, Q., Nyunt, M. S. Z., Gong, L., Lunaria, J. B., Lim, M. L., Ling, A., Lam, C. S. P., Richards, A. M., Ling, L. H., & Ng, T. P. (2016). Vascular Health Indices and Cognitive Domain Function: Singapore Longitudinal Ageing Studies. *Journal of Alzheimer's Disease, 50*(1), 27–40. https://doi.org/10.3233/JAD-150516

Lin, F. V., Wang, X., Wu, R., Rebok, G. W., & Chapman, B. P. (2017). Identification of Successful Cognitive Aging in the Alzheimer's

Disease Neuroimaging Initiative Study. *Journal of Alzheimer's Disease, 59*(1), 101–111. https://doi.org/10.3233/JAD-161278

Litwin, H., & Stoeckel, K. J. (2016). Social network, activity participation, and cognition. *Research on Aging, 38*, 76-97. https://doi.org/10.1177/0164027515581422

Liu, W., & McKibbin, W. (2022). Global macroeconomic impacts of demographic change. *World Economy, 45*(3), 914–942. https://doi.org/10.1111/twec.13166

Lourenco, J., Serrano, A., Santos-Silva, A., Gomes, M., Afonso, C., Freitas, P., Paul, C., & Costa, E. (2018). Cardiovascular risk factors are correlated with low cognitive function among older adults across Europe based on the SHARE database. *Aging and Disease, 9*(1), 90–101. https://doi.org/10.14336/AD.2017.0128

Lu, H., Ni, X., Fung, A. W. T., & Lam, L. C. W. (2018). Mapping the Proxies of Memory and Learning Function in Senior Adults with High-performing, Normal Aging and Neurocognitive Disorders. *Journal of Alzheimer's Disease, 64*, 815–826. https://doi.org/10.3233/jad-180225

Lundervold, A. J., Wollschläger, D., & Wehling, E. (2014). Age and sex related changes in episodic memory function in middle aged and older adults. *Scandinavian Journal of Psychology, 55*(3), 225–232. https://doi.org/10.1111/sjop.12114

Macuco, C. R. M., Batistoni, S. S. T., Lopes, A., Cachioni, M., Da Silva Falco, D. V., Neri, A. L., & Yassuda, M. S. (2012). Mini-Mental State Examination performance in frail, pre-frail, and non-frail community dwelling older adults in Ermelino Matarazzo, So

Paulo, Brazil. *International Psychogeriatrics, 24*(11), 1725–1731. https://doi.org/10.1017/S1041610212000907

Maki, Y., Yamaguchi, T., Yamagami, T., Murai, T., Hachisuka, K., Miyamae, F., Ito, K., Awata, S., Ura, C., Takahashi, R., & Yamaguchi, H. (2014). The impact of subjective memory complaints on quality of life in community-dwelling older adults. *Psychogeriatrics, 14*(3), 175–181. https://doi.org/10.1111/psyg.12056

Marsh, H. W., Hau, K. T., & Wen, Z. (2004). In search of golden rules: Comment on hypothesis-testing approaches to setting cutoff values for fit indexes and dangers in overgeneralizing Hu and Bentler's findings. *Structural Equation Modeling, 11*(3), 320–341. https://doi.org/10.1207/s15328007sem1103_2

Martinson, M., & Berridge, C. (2015). Successful aging and its discontents: A systematic review of the social gerontology literature. *The Gerontologist, 55*(1), 58–69. https://doi.org/10.1093/geront/gnu037

Mason, A., & Lee, R. (2022). Six ways population change will affect the global economy. *Population and Development Review, 48*(1), 51–73. https://doi.org/10.1111/padr.12469

McCracken, K., Phillips, D.R., (2017) Demographic and epidemiological transition. In: Richardson D, Castree N, Goodchild MF et al (eds) *The International Encyclopedia of Geography*. Wiley.

McDermott, L. M., & Ebmeier, K. P. (2009). A meta-analysis of depression severity and cognitive function. *Journal of Affective*

Disorders, 119(1–3), 1–8. https://doi.org/10.1016/j.jad.2009.04.022

McDonald, R. P. (1999). *Test theory: A unified treatment.* Lawrence Erlbaum Associates Publishers.

McFall, G. P., McDermott, K. L., & Dixon, R. A. (2019). Modifiable Risk Factors Discriminate Memory Trajectories in Non-Demented Aging: Precision Factors and Targets for Promoting Healthier Brain Aging and Preventing Dementia. *Journal of Alzheimer's Disease, 70*(s1), S101–S118. https://doi.org/10.3233/JAD-180571

Mehrbrodt, T., Gruber, S., & Wagner, M. (2021). *Scales and Multi-Item Indicators*. Munich Center for the Economics of Aging (MEA).

Miceli, S., Maniscalco, L., & Matranga, D. (2019). Social networks and social activities promote cognitive functioning in both concurrent and prospective time: evidence from the SHARE survey. *European Journal of Ageing, 16*(2), 145–154. https://doi.org/10.1007/s10433-018-0486-z

Middleton, L. E., Manini, T. M., Simonsick, E. M., Harris, T. B., Barnes, D. E., Tylavsky, F., Brach, J. S., Everhart, J. E., & Yaffe, K. (2011). Activity energy expenditure and incident cognitive impairment in older adults. *Archives of Internal Medicine, 171*(14), 1251–1257. https://doi.org/10.1001/archinternmed.2011.277

Migeot, J., Calivar, M., Granchetti, H., Ibáñez, A., & Fittipaldi, S. (2022). Socioeconomic status impacts cognitive and socioemotional processes in healthy ageing. *Scientific Reports, 12*(1), 1–11. https://doi.org/10.1038/s41598-022-09580-4

Miller, K. J., Siddarth, P., Gaines, J. M., Parrish, J. M., Ercoli, L. M., Marx, K., Ronch, J., Pilgram, B., Burke, K., Barczak, N., Babcock, B., & Small, G. W. (2012). The memory fitness program: Cognitive effects of a healthy aging intervention. *American Journal of Geriatric Psychiatry, 20*(6), 514–523. https://doi.org/10.1097/JGP.0b013e318227f821

Millis, S. R. (1995). Factor structure of the California Verbal Learning Test in moderate and severe closed-head injury. *Perceptual and Motor Skills*, *80*(1), 219–224. https://doi.org/10.2466/pms.1995.80.1.219

Min, J. W. (2018). A longitudinal study of cognitive trajectories and its factors for koreans aged 60 and over: A latent growth mixture model. *International Journal of Geriatric Psychiatry, 33*(5), 755–762. https://doi.org/10.1002/gps.4855

Moghimi, D., Scheibe, S., & Freund, A. M. (2019). The model of selection, optimization, compensation. In B. Baltes, C. Rudolph & H. Zacher (Eds.), *Work Across the Lifespan*. Elsevier Inc. https://doi.org/10.1016/B978-0-12-812756-8.00004-9

Moreira, V. G., & Lourenço, R. A. (2013). Prevalence and factors associated with frailty in an older population from the city of Rio de Janeiro, Brazil: The FIBRA-RJ Study. *Clinics, 68*(7), 979–985. https://doi.org/10.6061/clinics/2013(07)15

Moreno-Agostino, D., Wu, Y. T., Daskalopoulou, C., Hasan, M. T., Huisman, M., & Prina, M. (2021). Global trends in the prevalence and incidence of depression:a systematic review and meta-analysis. *Journal of Affective Disorders, 281*, 235–243. https://doi.org/10.1016/j.jad.2020.12.035

Morris, J. C., Mohs, R., Rogers, H., Fillenbaum, G., & Heyman, A. (1988). CERAD clinical and neuropsychological assessment of Alzheimer's disease. *Psychopharmacological Bulletin, 24*, 641-651

Muka, T., Imo, D., Jaspers, L., Colpani, V., Chaker, L., van der Lee, S. J., Mendis, S., Chowdhury, R., Bramer, W. M., Falla, A., Pazoki, R., & Franco, O. H. (2015). The global impact of non-communicable diseases on healthcare spending and national income: a systematic review. *European Journal of Epidemiology, 30*(4), 251–277. https://doi.org/10.1007/s10654-014-9984-2

Murata, C., Saito, T., Saito, M., & Kondo, K. (2019). The association between social support and incident dementia: A 10-year follow-up study in Japan. *International Journal of Environmental Research and Public Health, 16*(2). https://doi.org/10.3390/ijerph16020239

Murdock, B. B. (1962). The serial position effect of free recall. *Journal of Experimental Psychology, 64*(5), 482–488. https://doi.org/10.1037/h0045106

Murman, D. L. (2015). The Impact of Age on Cognition. *Seminars in Hearing, 36*(3), 111–121. https://doi.org/10.1055/s-0035-1555115

Muthén, B. O. (2003). Latent Variable Analysis: Growth Mixture Modeling and Related Techniques for Longitudinal Data. In D.

Kaplan (Ed.), *The SAGE Handbook of Quantitative Methodology for the Social Sciences* (pp. 345–368). SAGE Publications, Inc.

Muthén, L. K.; Muthén, B. O. (1998-2017). Mplus User's Guide, 8th ed. Muthén & Muthén.

Nagamatsu, L., Chan, A., Davis, J. C., Beattie, B. L., Graf, P., Voss, M. W., Sharma, D., & Liu-Ambrose, T. (2013). P1–370: The effects of exercise on memory performance in older adults with probable mild cognitive impairment: A 6-month randomized controlled trial. *Alzheimer's & Dementia*, 9. https://doi.org/10.1016/j.jalz.2013.05.597

Nagin, D. S. (1999). Analyzing developmental trajectories: A semiparametric, group-based approach. *Psychological Methods, 4*(2), 139–157. https://doi.org/10.1037/1082-989X.4.2.139

Nagin, D. S., & Tremblay, R. E. (2001). Analyzing developmental trajectories of distinct but related behaviors: A group-based method. *Psychological Methods, 6*(1), 18–33. https://doi.org/10.1037//1082-989X.6.1.18

Natelson-Love, M. C., Ruff , G., & Geldmacher, D. S. (2015). Social cognition in older adults: A review of neuropsychology, neurobiology, and functional connectivity. *Medical & Clinical Reviews, 1*, 6. https://doi.org/10.21767/2471-299x.1000006

Nguyen, T., & Li, X. (2020). Understanding public-stigma and self-stigma in the context of dementia: A systematic review of the global literature. *Dementia, 19*(2), 148–181. https://doi.org/10.1177/1471301218800122

Noll, H. H. (2021) The good life under attack: Reflections on the future of the quality of life concept. In A. C. Michalos (Ed.): *The Pope of happiness: A Festschrift for Ruut Veenhoven* (pp. 195-201). Springer Nature.

Norman, K.; Haß, U.; Pirlich, M. (2021). Malnutrition in Older Adults—Recent Advances and Remaining Challenges. *Nutrients, 13*, 2764. https://doi.org/10.1016/S1363-0814(98)80016-6

Oksuzyan, A., Brønnum-Hansen, H., & Jeune, B. (2010). Gender gap in health expectancy. *European Journal of Ageing, 7*(4), 213–218. https://doi.org/10.1007/s10433-010-0170-4

Oliver, A., Sentandreu-Mañó, T., Tomás, J. M., Fernández, I., & Sancho, P. (2021). Quality of life in European older adults of SHARE wave 7: Comparing the old and the oldest-old. *Journal of Clinical Medicine, 10*(13). https://doi.org/10.3390/jcm10132850

Openen, A., & Coscia, V. *Annual Activity Report 2021/22.* Munich Center for the Economics of Aging (MEA).

Osth, A. F., & Farrell, S. (2019). Using response time distributions and race models to characterize primacy and recency effects in free recall initiation. *Psychological Review, 126*(4), 578–609. https://doi.org/10.1037/rev0000149

Otero, T. M., & Barker, L. A. (2014). The frontal loves and executive functioning. In S. Goldstein & J. A. Naglieri (Eds.), *Handbook of executive functioning* (pp. 29-44). Springer. https://doi.org/10.1007/978-1-4614-8106-5_3

Othman, Z., Wong, S. T., Drahman, I., & Wee, K. W. (2015). Validation of the Malay version of short informant questionnaire on cognitive decline in the elderly (MS-IQCODE). *International Medical Journal, 22*(4), 260–262.

Ownby, R. L., Crocco, E., Acevedo, A., John, V., & Loewenstein, D. (2006). Depression and Risk for Alzheimer Disease. *Archives of General Psychiatry, 63*(5), 530. https://doi.org/10.1001/archpsyc.63.5.530

Pan, X. F., Li, Y., Franco, O. H., Yuan, J. M., Pan, A., & Koh, W. P. (2020). Impact of combined lifestyle factors on all-cause and cause-specific mortality and life expectancy in Chinese: The Singapore Chinese Health Study. *Journals of Gerontology - Series A Biological Sciences and Medical Sciences, 75*(11), 2193–2199. https://doi.org/10.1093/gerona/glz271

Park, S., Kwon, E., & Lee, H. (2017). Life course trajectories of later-life cognitive functions: Does social engagement in old age matter? *International Journal of Environmental Research and Public Health, 14*(4). https://doi.org/10.3390/ijerph14040393

Potter, G. G., & Steffens, D. C. (2007). Contribution of depression to cognitive impairment and dementia in older adults. *Neurologist, 13*(3), 105–117. https://doi.org/10.1097/01.nrl.0000252947.15389.a9

Prince, M. J., Reischies, F., Beekman, A. T. F., Fuhrer, R., Jonker, C., Kivela, S. L., Lawlor, B. A., Lobo, A., Magnusson, H., Fichter, M., Van Oyen, H., Roelands, M., Skoog, I., Turrina, C., & Copeland, J. R. M. (1999). Development of the EURO-D scale -

A European Union initiative to compare symptoms of depression in 14 European centres. *British Journal of Psychiatry, 174*(4), 330–338. https://doi.org/10.1192/bjp.174.4.330

Quinn, T. J., Fearon, P., Noel-Storr, A. H., Young, C., McShane, R., & Stott, D. J. (2021). Informant Questionnaire on Cognitive Decline in the Elderly (IQCODE) for the detection of dementia within community dwelling populations. *Cochrane Database of Systematic Reviews, 2021*(7). https://doi.org/10.1002/14651858.CD010771.pub3

R Core Team (2022). *R: A language and environment for statistical computing.* R Foundation for Statistical Computing. https://www.R-project.org/

Rammstedt, B., & John, O. P. (2007). Measuring personality in one minute or less: A 10-item short version of the big five inventory in English and German. *Journal of Research in Personality, 41*(1), 203–212. https://doi.org/10.1016/j.jrp.2006.02.001

Rashid, A., Manan, A. A., & Rohana, S. (2016). The influence of social support on cognitive impairment in the elderly. *Australasian Medical Journal, 9*(8), 262–269. https://doi.org/10.4066/AMJ.2016.2657

Rast, P. (2017). Learning in older adults. In: N. Pachana, ed., *Encyclopedia of Geropsychology* (1356-1363). Springer.

Reichenheim, M., Dos Santos Sanchez, M. A., & Lourenço, R. A. (2015). Re-assessing the dimensional structure of the Informant Questionnaire on Cognitive Decline in the Elderly (IQCODE): Empirical evidence for a shortened Brazilian version Neurology, stroke and cognition. *BMC Geriatrics, 15*(1), 1–12. https://doi.org/10.1186/s12877-015-0098-9

Rey, A. (1964). *L'examen clinique en psychologie* [Clinical tests in psychology]. Presses Universitaires de France.

Ritchie, S. J., Bates, T. C., & Deary, I. J. (2015). Is education associated with improvements in general cognitive ability, or in specific skills? *Developmental Psychology, 51*(5), 573–582. https://doi.org/10.1037/a0038981

Roberts, A. R., & Adams, K. B. (2018). Quality of Life Trajectories of Older Adults Living in Senior Housing. *Research on Aging, 40*(6), 511–534. https://doi.org/10.1177/0164027517713313

Roldán-Tapia, L., García, J., Cánovas, R., & León, I. (2012). Cognitive reserve, age, and their relation to attentional and executive functions. *Applied Neuropsychology: Adult, 19*(1), 2–8. https://doi.org/10.1080/09084282.2011.595458

Rowe, J. W., & Kahn, R. L. (1997). Successful Aging. *The Gerontologist, 37*(4), 433–440. https://doi.org/https://doi.org/10.1093/geront/37.4.433

Rowe, J. W., & Kahn, R. L. (2015). Successful aging 2.0: Conceptual expansions for the 21st century. *Journals of Gerontology - Series B Psychological Sciences and Social Sciences, 70*(4), 593–596. https://doi.org/10.1093/geronb/gbv025

Rowe, J. W., & Khan, R. (1987). Human Aging: Usual and successful. *Science, 237*(4811), 143-149. https://doi.org/10.1126/science.3299702

Rubinstein, R. L., & de Medeiros, K. (2015). "Successful Aging," Gerontological theory and neoliberalism: A qualitative critique. *The Gerontologist, 55*(1), 34–42. https://doi.org/10.1093/geront/gnu080

Russell, D., Peplau, L. A. & Cutrona, C. E. (1980). The revised UCLA Loneliness Scale: concurrent and discriminant validity evidence. *Journal of Personality and Social Psychology, 39*(3), 472-480. https://doi.org/10.1037/0022-3514.39.3.472

Russell, D., Peplau, L. A., & Ferguson, M. L. (1978). Developing a measure of loneliness. *Journal of Personality Assessment, 42*(3), 290–294. https://doi.org/10.1207/s15327752jpa4203_11

Ruthruff, E. & Lein, M. C. (2017). Aging and attention. In: N. Pachana, ed., *Encyclopedia of Geropsychology* (166-172). Springer.

Sabia, S., Marmot, M., Dufouil, C., & Singh-Manoux, A. (2008). Smoking history and cognitive function in middle age from the Whitehall II study. *Archives of Internal Medicine, 168*(11), 1165–1173. https://doi.org/10.1001/archinte.168.11.1165

Scarmeas, N., & Stern, Y. (2003). Cognitive reserve and lifestyle. *Journal of Clinical and Experimental Neuropsychology, 25*(5), 625–633. https://doi.org/10.1076/jcen.25.5.625.14576

Scherpenzeel, A., Axt, K., Bergmann, M., Douhou, S., Oepen, A., Sand, G., Schuller, K., Stuck, S., Wagner, M., & Börsch-Supan, A. (2020). Collecting survey data among the 50+ population during the COVID-19 outbreak: The Survey of Health, Ageing and Retirement in Europe (SHARE). *Survey Research Methods, 14*(2), 217-221.

Schneider, S. L. (2008). *The International Standard Classification of Education (ISCED-97). An evaluation of content and criterion validity for 15 European countries*. MZES.

Schröder, M. (2011). *Retrospective Data Collection in the Survey of Health, Ageing and Retirement in Europe. SHARELIFE Methodology*. MEA.

Seeman, T. E., Miller-Martinez, D. M., Merkin, S. S., Lachman, M. E., Tun, P. A., & Karlamangla, A. S. (2011). Histories of social engagement and adult cognition: midlife in the U.S. Study. *The Journals of Gerontology Series B: Psychological Sciences and Social Sciences, 66*, 141-152. https://doi.org/10.1093/geronb/gbq091

Shafto, M. A., & Tyler, L. K. (2014). Language in the aging brain: The network dynamics of cognitive decline and preservation. *Science, 346*, 583–587. https://doi.org/10.1126/science.1254404

Shi, D., DiStefano, C., Maydeu-Olivares, A., & Lee, T. (2020). Evaluating SEM Model Fit with Small Degrees of Freedom. *Multivariate Behavioral Research*, 1–36. https://doi.org/10.1080/00273171.2020.1868965

Sims, R. C., Hosey, M., Levy, S. A., Whitfield, K. E., Katzel, L. I., & Waldstein, S. R. (2014). Distinct functions of social support and cognitive function among older adults. *Experimental Aging Research, 40*(1), 40–59. https://doi.org/10.1080/0361073X.2014.857551

Sontheimer, N., Konnopka, A., & König, H. H. (2021). The Excess Costs of Dementia: A Systematic Review and Meta-Analysis. *Journal of Alzheimer's Disease, 83*(1), 333–354. https://doi.org/10.3233/JAD-210174

Staub, B., Doignon-Camus, N., Després, O., & Bonnefond, A. (2013). Sustained attention in the elderly: What do we know and what does it tell us about cognitive aging? *Ageing Research Reviews*, *12*, 459-468.

Steffens, D. C. (2012). Depressive symptoms and mild cognitive impairment in the elderly: An ominous combination. *Biological Psychiatry, 71*(9), 762–764. https://doi.org/10.1016/j.biopsych.2012.02.002

Steinerman, J. R., Hall, C. B., Sliwinski, M. J., & Lipton, R. B. (2010). Modeling cognitive trajectories within longitudinal studies: A focus on older adults. *Journal of the American Geriatrics Society, 58*(S2), 313–318. https://doi.org/10.1111/j.1532-5415.2010.02982.x

Stella, F., Radanovic, M., Balthazar, M. L. F., Canineu, P. R., De Souza, L. C., & Forlenza, O. V. (2014). Neuropsychiatric symptoms in the prodromal stages of dementia. *Current Opinion in Psychiatry, 27*(3), 230–235. https://doi.org/10.1097/YCO.0000000000000050

Stern, Y. (2002). What is cognitive reserve? Theory and research application of the reserve concept. *Journal of the International Neuropsychological Society, 8*(3), 448–460. https://doi.org/10.1017/S1355617702813248

Stern, Y. (2012). Cognitive reserve in ageing and Alzheimer's disease. *The Lancet Neurology, 11*(11), 1006–1012. https://doi.org/10.1016/S1474-4422(12)70191-6

Stowe, J. D., & Cooney, T. M. (2015). Examining rowe and kahn's concept of successful aging: Importance of taking a life course perspective. *The Gerontologist, 55*(1), 43–50. https://doi.org/10.1093/geront/gnu055

Stuss, D. T. (2011). Functions of the frontal lobes: Relation to executive functions. *Journal of the International Neuropsychological Society, 17*(5), 759–765. https://doi.org/10.1017/S1355617711000695

Sun, W., Matsuoka, T., Oba, H., & Narumoto, J. (2021). Importance of loneliness in behavioral and psychological symptoms of dementia. *International Journal of Geriatric Psychiatry, 36*(4), 540–546. https://doi.org/10.1002/gps.5450

Suzuki, T., Shimada, H., Makizako, H., Doi, T., Yoshida, D., Ito, K., Shimokata, H., Washimi, Y., Endo, H., & Kato, T. (2013). A Randomized Controlled Trial of Multicomponent Exercise in Older Adults with Mild Cognitive Impairment. *PLoS ONE, 8*(4). https://doi.org/10.1371/journal.pone.0061483

Tan, L., & Ward, G. (2000). A recency-based account of the primacy effect in free recall. *Journal of Experimental Psychology: Learning, Memory and Cognition, 26*(6), 1589-1625. https://doi.org/10.1037//0278-7393.26.6.1589

Tanaka, J. S. (1993). Multifaceted conceptions of fit in structural equation models. In K. A. Bollen & J. S. Long (Eds*.), Testing Structural Equation Models (10-39)*. Sage.

Tavares, A. I. (2022). Life expectancy at 65, associated factors for women and men in Europe. *European Journal of Ageing, 0123456789*. https://doi.org/10.1007/s10433-022-00695-1

Taylor, W. D., Aizenstein, H. J., & Alexopoulos, G. S. (2013). The vascular depression hypothesis: Mechanisms linking vascular disease with depression*. Molecular Psychiatry, 18*(9), 963–974. https://doi.org/10.1038/mp.2013.20

Teipel, S. J., Cavedo, E., Lista, S., Habert, M. O., Potier, M. C., Grothe, M. J., Epelbaum, S., Sambati, L., Gagliardi, G., Toschi, N., Greicius, M. D., Dubois, B., Hampel, H., Audrain, C., Auffret, A., Bakardjian, H., Baldacci, F., Batrancourt, B., Benakki, I., … Vlaincu, M. (2018). Effect of Alzheimer's disease risk and protective factors on cognitive trajectories in subjective memory complainers: An INSIGHT-preAD study. *Alzheimer's and Dementia, 14*(9), 1126–1136. https://doi.org/10.1016/j.jalz.2018.04.004

Terrera, G. M., Brayne, C., & Matthews, F. (2010). One size fits all? Why we need more sophisticated analytical methods in the explanation of trajectories of cognition in older age and their potential risk factors. *International Psychogeriatrics, 22*(2), 291–299. https://doi.org/10.1017/S1041610209990937

Thorslund, M., Wastesson, J. W., Agahi, N., Lagergren, M., & Parker, M. G. (2013). The rise and fall of women's advantage: A comparison of national trends in life expectancy at age 65 years. *European Journal of Ageing, 10*(4), 271–277. https://doi.org/10.1007/s10433-013-0274-8

Tilvis, R. S., Routasalo, P., Karppinen, H., Strandberg, T. E., Kautiainen, H., & Pitkala, K. H. (2012). Social isolation, social activity and loneliness as survival indicators in old age; A nationwide survey with a 7-year follow-up. *European Geriatric Medicine, 3*(1), 18–22. https://doi.org/10.1016/j.eurger.2011.08.004

Tolppanen, A. M., Solomon, A., Kulmala, J., Kåreholt, I., Ngandu, T., Rusanen, M., Laatikainen, T., Soininen, H., & Kivipelto, M. (2015). Leisure-time physical activity from mid- to late life, body mass index, and risk of dementia. Alzheimer's and Dementia, 11(4), 434-443.e6. https://doi.org/10.1016/j.jalz.2014.01.008

Tomás, J. M., Torres, Z., Oliver, A., Enrique, S., & Fernández, I. (2022). Psychometric properties of the EURO-D scale of depressive symptomatology: Evidence from SHARE wave 8. J*ournal of Affective Disorders, 313*(15), 49–55. https://doi.org/10.1016/j.jad.2022.06.079

Truong, Q. C., Choo, C., Numbers, K., Merkin, A. G., Sachdev, P. S., Feigin, V. L., Brodaty, H., Kochan, N. A., & Medvedev, O. N. (2021). Enhancing precision of the 16-item Informant Questionnaire on Cognitive Decline in the Elderly (IQCODE-16) using Rasch methodology. *International Psychogeriatrics*. https://doi.org/10.1017/S1041610221002568

Tu, L., Lv, X., Yuan, C., Zhang, M., Fan, Z., Xu, X., Zeng, Y., Yu, X., & Wang, H. (2020). Trajectories of cognitive function and their determinants in older people: 12 years of follow-up in the Chinese Longitudinal Healthy Longevity Survey. *International Psychogeriatrics, 32*(6), 765–775. https://doi.org/10.1017/S1041610220000538

Unger, K., & Karbach, J. (2017). Executive functions. En: N. Pachana, ed., *Encyclopedia of Geropsychology* (853-862). Springer.

Van Aken, L., Kessels, R. P. C., Wingbermühle, E., Van Der Veld, W. M., & Egger, J. I. M. (2015). Fluid intelligence and executive functioning more alike than different? *Acta Neuropsychiatrica, 28*(1), 31–37. https://doi.org/10.1017/neu.2015.46

van der Nest, G., Lima Passos, V., Candel, M. J. J. M., & van Breukelen, G. J. P. (2020). An overview of mixture modelling for latent evolutions in longitudinal data: Modelling approaches, fit statistics and software. *Advances in Life Course Research, 43*, 100323. https://doi.org/10.1016/j.alcr.2019.100323

Vreugdenhil, A., Cannell, J., Davies, A., & Razay, G. (2012). A community-based exercise programme to improve functional ability in people with Alzheimer's disease: A randomized controlled trial. *Scandinavian Journal of Caring Sciences, 26*(1), 12–19. https://doi.org/10.1111/j.1471-6712.2011.00895.x

Wahl, H. W., Deeg, D., & Litwin, H. (2016). Successful ageing as a persistent priority in ageing research. *European Journal of Ageing, 13*(1), 1–3. https://doi.org/10.1007/s10433-016-0364-5

Walsh, M. M., & Lovett, M. C. (2016). The cognitive science approach to learning and memory. In: S. E. F. Chipman, ed., *The Oxford Handbook of Cognitive Science.* Oxford University Press. https://doi.org/10.1093/oxfordhb/9780199842193.013

Wang, J. & Wang, X. (2012). *Structural Equation Modeling: Applications using MPlus* (1st ed.). Higher Education Press.

Wang, L., Krasich, K., Bel-Bahar, T., Hughes, L., Mitroff, S. R., & Appelbaum, L. G. (2015). Mapping the structure of perceptual and visual–motor abilities in healthy young adults. *Acta Psychologica, 157*, 74-84. https://doi.org/10.1016/j.actpsy.2015.02.005

Ward, M., McGarrigle, C. A., & Kenny, R. A. (2019). More than health: quality of life trajectories among older adults—findings from The Irish Longitudinal Study of Ageing (TILDA). *Quality of Life Research, 28*(2), 429–439. https://doi.org/10.1007/s11136-018-1997-y

Weber, D., & Loichinger, E. (2022). Live longer, retire later? Developments of healthy life expectancies and working life expectancies between age 50–59 and age 60–69 in Europe. *European Journal of Ageing, 19*(1), 75–93. https://doi.org/10.1007/s10433-020-00592-5

Weber, D., Skirbekk, V., Freund, I., & Herlitz, A. (2014). The changing face of cognitive gender differences in Europe. *Proceedings of the National Academy of Sciences of the United States of America, 111*(32), 11673–11678. https://doi.org/10.1073/pnas.1319538111

Welsh, K., Breitner, J., & Magruder-Habib, K. (1993). Detection of dementia in the elderly using the telephone interview for cognitive status. *Neuropsychiatry, Neuropsychology, and Behavioral Neurology, 6*(2), 103–110.

Weyh, C., Krüger, K., & Strasser, B. (2020). Physical activity and diet shape the immune system during aging. *Nutrients, 12*(3), 1–17. https://doi.org/10.3390/nu12030622

WHOQOL Group (1995). The World Health Organization Quality of Life assessment (WHOQOL): position paper from the World Health Organization. *Social Science & Medicine, 41*(10), 1403-1409. https://doi.org/10.1016/0277-9536(95)00112-k

Widaman, K. F. (1993). Common Factor Analysis Versus Principal Component Analysis : Differential Bias in Representing Model Parameters ? *Multivariate Behavioral Research, 28*(3), 263-311. http://doi.org/10.1207/s15327906mbr2803_1

Williams, B. D., Pendleton, N., & Chandola, T. (2022). Does the association between cognition and education differ between older adults with gradual or rapid trajectories of cognitive decline? *Aging, Neuropsychology, and Cognition, 29*(4), 666–686. https://doi.org/10.1080/13825585.2021.1889958

World Health Organization (1984). *Health promotion: a discussion document on the concept and principles: Summary report of the Working Group on Concept and Principles of Health Promotion, Copenhagen, 9-13 July 1984*. WHO Regional Office for Europe. Available in https://apps.who.int/iris/handle/10665/107835

World Health Organization (2022). The top 10 causes of death. World Health Organization. https://www.who.int/news-room/fact-sheets/detail/the-top-10-causes-of-death

World Health Statistics (2022). *Monitoring health for the SDGs, sustainable development goals*. World Health Organization. Licence: CC BY-NC-SA 3.0 IGO.

Wu, J. T., Leung, K., Bushman, M., Kishore, N., Niehus, R., de Salazar, P. M., Cowling, B. J., Lipsitch, M., & Leung, G. M. (2020). Estimating clinical severity of COVID-19 from the transmission dynamics in Wuhan, China. *Nature Medicine, 26*(4), 506–510. https://doi.org/10.1038/s41591-020-0822-7

Wu, Z., Woods, R. L., Wolfe, R., Storey, E., Chong, T. T. J., Shah, R. C., Orchard, S. G., McNeil, J. J., Murray, A. M., & Ryan, J. (2021). Trajectories of cognitive function in community-dwelling older adults: A longitudinal study of population heterogeneity. *Alzheimer's and Dementia: Diagnosis, Assessment and Disease Monitoring, 13*(1), 1–12. https://doi.org/10.1002/dad2.12180

Xue, H., Huang, C., Zhu, Q., Zhou, S., Ji, Y., Ding, X., Zhang, D., & Gu, D. (2022). Relationships Among Cognitive Function, Frailty, and Health Outcome in Community-Dwelling Older Adults. *Frontiers in Aging Neuroscience*. https://doi.org/10.3389/fnagi.2021.790251

Yágüez, L., Shaw, K. N., Morris, R., & Matthews, D. (2011). The effects on cognitive functions of a movement-based intervention in patients with Alzheimer's type dementia: A pilot study.

International Journal of Geriatric Psychiatry, 26(2), 173–181. https://doi.org/10.1002/gps.2510

Yam, A., Gross, A. L., Prindle, J. J., & Marsiske, M. (2014). Ten-year longitudinal trajectories of older adults' basic and everyday cognitive abilities. *Neuropsychology, 28*(6), 819–828. https://doi.org/10.1037/neu0000096

Yassuda, M. S., Lopes, A., Cachioni, M., Falcao, D. V. S., Batistoni, S. S. T., Guimaraes, V. V., & Neri, A. L. (2012). Frailty criteria and cognitive performance are related: Data from the Fibra study in Ermelino Matarazzo, Sao Paulo, Brazil. *Journal of Nutrition, Health and Aging, 16*(1), 55–61. https://doi.org/10.1007/s12603-012-0003-6

Yeh, S. C. J., & Liu, Y. Y. (2003). Influence of social support on cognitive function in the elderly. *BMC Health Services Research, 3*(1), 9. https://doi.org/10.1186/1472-6963-3-9

Youden, W. J. (1950). Index for rating diagnostic tests. *Cancer, 3*, 32-35. https://doi.org/10.1002/1097-0142

Yu, L., Boyle, P. A., Segawa, E., Leurgans, S., Schneider, J. A., Wilson, R. S., & Bennett, D. A. (2015). Residual decline in cognition after adjustment for common neuropathologic conditions. *Neuropsychology, 29*(3), 335–343. https://doi.org/10.1037/neu0000159

Zaninotto, P., Falaschetti, E., & Sacker, A. (2009). Age trajectories of quality of life among older adults: Results from the English longitudinal study of Ageing. *Quality of Life Research, 18*(10), 1301–1309. https://doi.org/10.1007/s11136-009-9543-6

Zenebe, Y., Akele, B., W/Selassie, M., & Necho, M. (2021). Prevalence and determinants of depression among old age: a systematic review and meta-analysis. *Annals of General Psychiatry, 20*(1), 1–19. https://doi.org/10.1186/s12991-021-00375-x

Zhang, W., Wang, T., & Wang, A. (2022). Impact of physical activity intensity on longitudinal trajectories of cognitive function and depressive symptoms in middle-aged and older Chinese adults: Eight-year prospective study. *Journal of Affective Disorders, 315*(305), 64–69. https://doi.org/10.1016/j.jad.2022.07.012

Zhang, Y. B., Li, Y., Geng, T. T., Pan, X. F., Zhou, Y. F., Liu, G., & Pan, A. (2022). Overall lifestyles and socioeconomic inequity in mortality and life expectancy in China: The China health and nutrition survey. *Age and Ageing, 51*(7), 1–10. https://doi.org/10.1093/ageing/afac167

Zhou, J., Yu, J. T., Wang, H. F., Meng, X. F., Tan, C. C., Wang, J., Wang, C., & Tana, L. (2015). Association between stroke and Alzheimer's disease: Systematic review and meta-analysis. *Journal of Alzheimer's Disease, 43*(2), 479–489. https://doi.org/10.3233/JAD-140666