Processing speed as Predictor of Face Name Associative Memory Exam Performance

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Abstract

Background: The Face Name Associative Memory Exam (FNAME) is a neuropsychological test for early signs of Alzheimer's Disease (AD). This thesis examines the influence of processing speed (PS) on FNAME performance in older individuals with Subjective Cognitive Decline (SCD) and amnestic Mild Cognitive Impairment (aMCI) in the Netherlands. Associative memory (AM) is among the first cognitive domains to decline already at the precursor stages of AD. Another domain, PS decreases in aging, especially with underlying pathology. *Objective:* this thesis seeks to: 1) assess the impact of PS on FNAME performance, thereby enhancing understanding of AM deficits, 2) examine the FNAME's convergent validity with 15WT, and 3) evaluate the internal consistency of newest version of FNAME, which includes four new subtests. *Method and Results:* A simple linear regression analysis was conducted which revealed a moderate effect of PS on FNAME performance, explaining 21% of variance. Convergent validity with the 15WT was evaluated through Pearson R correlations showing moderate to strong relationships, except for two new FNAME subscales. Internal consistency was of FNAME was analyzed with Pearson R correlation analysis which yielded significant, strong correlations for all subscales but two of the new subscales. *Discussion:* This analysis contributes valuable insights into the interplay between PS and FNAME and refines our understanding of FNAME as a neuropsychological instrument. The addition of "Free Name Recall" and "Face-Name Matching" are valuable additions to the test, while the “Face Recognition” and “Name Recognition” scales provided no new insights and could potentially be removed. *Conclusion:* The analysis showed that the FNAME has a good internal consistency and convergent validity with 15WT. The investigation on PS showed that it can indeed influence FNAME performance and this should be taken into account when assessing AM performance, by controlling for it statistically.

Keywords: Alzheimer’s Disease, amnestic Mild Cognitive Impairment, Subjective Cognitive Decline, FNAME, Associative Memory, Processing Speed.

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Alzheimer's Disease

Alzheimer's Disease is a neurodegenerative disorder impacting the lives of millions of people all around the world. In developed countries, AD stands as the leading cause of dementia, with an astounding estimation of 55 million cases worldwide, constituting a significant public health concern with aging populations (Chen et al., 2022; World Health Organization, 2023). AD has an insidious and gradual onset, which involves cognitive and behavioral impairments; in the beginning it is characterized by memory loss and later in the disease progression AD disorientation, language deficits, and difficulties in carrying out tasks of daily living become more apparent (Alzheimer's Association, 2023). Nowadays the challenge lies in the early detection of this condition, as recent research suggests that pathology manifests in the early stages of AD, even before noticeable cognitive or behavioral symptoms emerge (Gu et al., 2015; Kemppainen et al., 2008). Early diagnosis of AD is crucial to guide preventive disease management and early intervention (Flores-Vázquez 2022; Kormas et al., 2020).

Early Detection and Treatment of Alzheimer's Disease

Although there is currently no cure for AD, appropriate medications such as cholinesterase inhibitors and behavioral and adaptation intervention techniques can enhance the quality of life for individuals affected by the condition and their families, but they cannot treat or reverse AD (Ziekte van Alzheimer: Alzheimer Nederland (n, d); Alzheimer's Association, 2023). Recently, new medications have been introduced, Donanemab and Aducanumab have been shown to be able to reduce the amount of beta-amyloid plaques in the brain and to slow down the progression of AD when the medication is started in early stages of AD (Rahman et al., 2023; Shcherbinin et al., 2023). These so-called MAB medications are able to pause the progression towards AD, but little is known about their impact on specific

neuropsychological domains. These medications seem very promising in the hurdle of AD research, as no other medication so far has proven to be able to stop or delay AD. However, this line of research is still in its early days and requires more randomized clinical trials (Rahman et al., 2023; Shcherbinin et al., 2023).

Precursor stages of AD; Mild Cognitive Impairment and Subjective Cognitive Decline

Old age, as well as amnestic Mild Cognitive Impairment (aMCI), which is a subtype of Mild Cognitive Impairment (MCI) have been identified as risk factors for developing AD (Petersen et al., 1999). Individuals with MCI exhibit cognitive performance below age-related norms in one or more domains, yet they can still manage their daily activities independently (Alzheimer's Association, 2023). Even though aMCI is a risk factor for developing AD, not all individuals do go on to develop AD, some individuals stay stable over time or revert back to normal functioning, while others convert to AD (Chen et al., 2022; Farias et al., 2009). Approximately 10-15% of individuals diagnosed with aMCI convert to AD annually. After receiving a diagnosis of aMCI 46.7% will convert to AD within four years (Farias et al., 2009, McGrattan et al., 2022).

Another condition that has requires attention in AD research is Subjective Cognitive Decline (SCD) which is viewed as an even earlier precursor stage to AD compared to aMCI, and as the earliest risk factor and sign for AD (Neto & Nitrini, 2016). While SCD is lacking a consensus on its definition, it can be characterized as self-reported worsening of memory, memory loss or confusion that cannot be objectified with formal testing (Neto & Nitrini, 2016). Similarly to aMCI, not everyone who with SCD will decrease in cognitive functioning to reach a diagnosis of MCI or develop AD (Neto & Nitrini, 2016). Although SCD and MCI are similar in that not everyone will convert to AD, the distinguishing factor between the two is that in individuals with SCD will appear to function normally on neuropsychological testing, while MCI show evident impairments in at least one cognitive function. When these

complaints become evident in neuropsychological testing, the person can be reclassified as having MCI. If their complaints continue to progress to more pronounced and serious deficits, then they can be diagnosed with dementia, in which episodic memory deficits are most prominent, as AD.

Associative Memory in AD

Episodic memory can be described as conscious memories of everyday events and recollections of important life events in their context of time and place of those events. Previous research has observed vulnerabilities in episodic memory and especially its subcomponent associative memory in individuals with AD and its precursor stages, which makes it an interesting domain for the assessment of one's risk for developing AD in the future (Flores-Vázquez 2021; Rubiño & Andrés 2020; Rentz et al., 2011). Associative memory involves linking unrelated pieces of information such as faces and names of new acquaintances and is affected in the precursor stages of AD (Greene & Naveh-Benjamin, 2020).

Face Name Associative Memory Exam (FNAME)

FNAME is a tool developed for early diagnosis of AD (Rentz et al., 2011). Originally, FNAME featured 16 Face-Name and Face-Occupation pairs for associative memory testing. However, it was later discovered that Face-Occupation pairs were not informative for detecting memory impairments and thus they were removed. Face-Name pairs, being more challenging and abstract for participants, effectively differentiate between cognitively normal and aMCI individuals, and between healthy older adults and AD individuals (Papp et al., 2014; Samaroo et al., 2020). The test was later on reduced to 12 Face-Name pairs with comparable psychometric properties (Papp et al., 2014).

There is evidence that poor FNAME performance is correlated with AD biomarkers, including beta-amyloid and tau proteins in frontal areas (R^2 = 0.29) and posterior cingulate and lateral parietal cortices (R^2 = 0.26) (Papp et al., 2015; Rentz et al., 2011; Sanabria et al., 2017). Moreover it has been demonstrated that FNAME has the ability to differentiate between aMCI, SCD, and healthy older adults, although there are also studies that failed to replicate this finding (Flores-Vázquez et al., 2022; Kormas et al., 2020). These results suggest that FNAME can detect subtle AD-related changes in precursor stages, such as MCI and possibly SCD (Papp et al., 2015; Rubiño & Andres, 2018).

Processing Speed Decreases in Healthy Aging and Especially When Aging with Pathology

In 1985, processing speed was proposed by Salthouse to be a major contributing factor to age related cognitive decline in older individuals based on his theory about cognitive aging. Processing speed is has been identified to deteriorate in the early stages of AD to a bigger extent than it does in healthy aging (Amieva et al., 2019). Processing speed can be defined by as the fluency or rate in which one can process relatively simple perceptual and automatic information, and is often measured under time pressure (Salthouse, 1996). While a gradual decline in processing speed is observed during healthy aging, individuals with psychiatric and/or neurological disorders, including depression, schizophrenia, and dementias, experience a more accelerated deterioration in this aspect (Amieva et al., 2019).

Papp and colleagues (2015) have examined whether there are group differences in processing speed between cognitively healthy individuals who are deemed to have a high risk for AD that were divided in four groups based on varying biomarker stages; (1) no biomarkers found, (2) beta-amyloid found but no neurodegeneration, (3) neurodegeneration found but no beta-amyloid, (4) both beta-amyloid and neurodegeneration were found. The comparison found no group differences between the individuals on processing speed measures, which

indicates that processing speed might be well preserved in the preclinical stages of AD (Papp et al., 2015). A notable point in this study is that their participants were deemed at risk for AD based on familial history and they had no control group with individuals that were not at a particular risk of AD (Papp et al., 2015).

Research has established that processing speed plays a crucial role in one's functioning in various other cognitive domains and it might serve as a confounding factor in various forms of neuropsychological testing, especially for older adults with and without neurocognitive disorders (Roye et al., 2022). Slowing of processing speed is often associated with lower scores on other cognitive domains, especially in executive functions (EF), this means that when processing speed has decreased, it can influence our performance in other cognitive domains negatively, leading to poorer scores on neuropsychological testing (Amieva., 2019; Hedden et al., 2005). In a study by Albinet and colleagues (2012) found that 2-Choice Reaction Time (CRT) which is a measure of processing speed had a significant partial correlation of ($r = .44$, $p < .05$) with task switching performance. Therefore, decreased performance in processing speed should gain more attention in future research, as decreased processing speed performance can be a potentially confounding variable in some neuropsychological domains.

The neural basis of slowed processing speed is associated with diffuse or global deterioration of the white matter integrity throughout the brain (Albinet et al., 2012; Amieva et al., 2019). Prior studies have established that processing speed has can impact on EF, but it is yet unclear if, and to what extent processing speed can influence associative memory performance (Amieva et al., 2019; Hedden et al., 2005; Karr et al., 2018; Roye et al., 2022). In order to make accurate predictions as to whether one is at risk for developing AD, it is important to investigate and eliminate processing speed as a potential confound to associative memory.

Research Questions

Firstly, this thesis aims to examine the influence of processing speed on FNAME performance. This potential impact of processing speed on FNAME and associative memory performance is currently unknown. Evidence suggests that processing speed is connected to various cognitive domains, implying that it potentially could influence associative memory and likely FNAME performance (Hedden et al., 2005; Roye et al., 2020). The impact of processing speed on FNAME will be evaluated in a sample consisting of individuals with either SCD or aMCI.

Secondly, the convergent validity between FNAME12-NL and the 15 Word Test (15WT) is evaluated to replicate earlier results of Amariglio and colleagues (2012). Convergent validity assesses the correlation between measures designed to evaluate the same construct. Given that associative memory is a subcomponent of episodic memory, tests measuring episodic memory should exhibit a strong correlation with associative memory assessments. The 15WT is the Dutch version of more known instrument called Rey Auditory Verbal Test (RAVLT), is an accepted measure of episodic memory and is often used as a part of AD assessments.

Finally, the internal consistency of the latest Dutch FNAME version is assessed. Previous studies in the USA and the Netherlands have demonstrated favorable results (Flores-Vázquez et al., 2020; Papp et al., 2014). This reevaluation is necessary due to the introduction of four additional subscales exclusive to the Dutch FNAME12-NL version: Face Recognition, Name Recognition, Free Name Recall, and Face-Name Matching (Enriquez-Geppert et al., 2021; Florez-Vasquez et al., 2022).

H1

Processing speed is a significant predictor of FNAME performance.

H0. Processing speed does not predict FNAME performance significantly.

H2

Strong convergent validity with at least 0.5 positive correlation between the Dutch version of FNAME and 15WT.

H0. Poor evidence for convergent validity with correlations lower than 0.5 between the subscales of FNAME and 15WT.

H3

Good internal consistency with at least 0.5 positive correlations between the subtests of FNAME.

H0. FNAME subscales have low intercorrelations with each other.

Method

Recruitment

The study was approved by the Ethical Committee of the University of Groningen and conducted in accordance with Declaration of Helsinki. All participants gave their informed consent prior to participating in the study. Data collected in the study will be stored according to the General Data Protection Regulation (GDPR). The participants were recruited by the ongoing Cogmax study at the University Medical Center Groningen (UMCG) located in the Netherlands by posting ads in local newspapers and on TV looking for candidates that suspect to have memory problems. The aim of Cogmax study is to assess the impact of transcranial alternating current stimulation (tACS) on cognitive decline in individuals diagnosed with aMCI. For this thesis, the baseline data collected by the Cogmax study is analyzed consisting of a sample of individuals that were deemed to have SCD and individuals that were deemed to have aMCI.

Neuropsychological assessment

The neuropsychological assessment was conducted in session and it lasted approximately 2.5-3 hours. Multiple tests were included in the assessment (for the full list see

Table 1). The neuropsychological tests that are most relevant to the aim of this thesis will be explained in more detail including; FNAME, 15WT, Digit Symbol Substitution Test (DSST), Trail Making Test (TMT), and Stroop Color Word Test (SCWT).

Table 1.
A list of neuropsychological tests and checklists that were included in the assessment

Test	Domain
Face-Name Associative Memory Exam	Associative memory
15 Word Test	Verbal episodic memory
Trail Making Test	Processing speed, Executive functions
Digit Symbol Substitution Test	Processing speed
Stroop Color Word Test	Processing speed, Executive functions
BADS– Key Search	Planning, Executive functions
WAIS – Digit Span	Working memory, Attention, Set-shifting
WAIS – Arithmetic	Calculation, Working memory
Verbal Fluency	Word retrieval
Mild Behavior Impairment Checklist	Symptom checklist, Behavioral impairment
Behavioral Dysexecutive Syndrome Inventory	Symptom checklist, Executive functions
Functional Activity Test	Functioning in daily life activities
Cognitive Reserve Index	Descriptive features of work and leisure time
Geriatric Depression Scale	Depressive symptoms
Mini-Mental State Examination	Orientation, Attention, Verbal memory

Note: WAIS refers to Wechsler Adult Intelligence Scale, BADS refers to Behavioral Assessment of the Dysexecutive Syndrome.

Face Name Associative Memory Exam

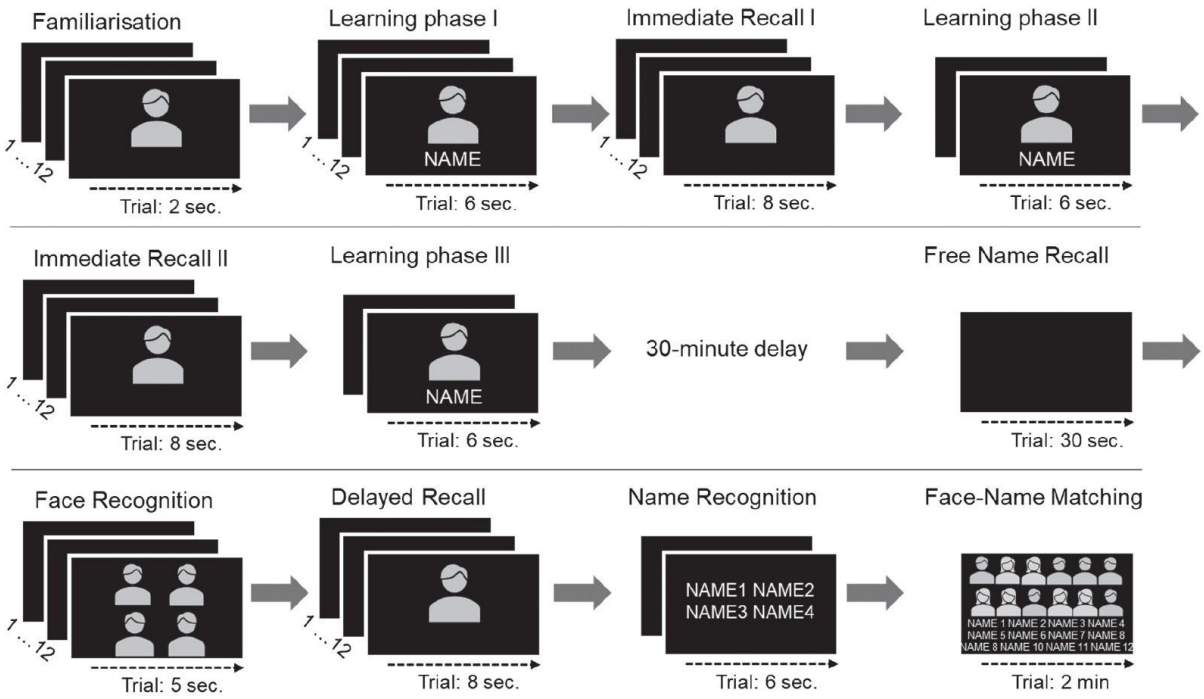
The latest version of the Dutch FNAME12-NL was conducted in the Cogmax study, developed by Enriquez-Geppert and colleagues (2021), based on the original test in American English from Rentz and colleagues (2011). See Figure 1 to find a pictorial presentation of the procedure of FNAME (Flores-Vázquez et al., 2021). The FNAME is a neuropsychological test instrument measuring associative memory and it can be described as following: it consists

of 12 Face-Name pairs and in total 12 subparts. FNAME is conducted on a computer with PowerPoint.

The 12 stages can be explained briefly as: 1. Familiarization: the test taker is presented with each of the 12 faces one by one for 2 sec per face. 2. Learning phase I: the test taker is presented with the 12 faces one by one, this time paired up with a name for six sec per pair. 3. Immediate Recall I: the test takers are asked to name each of the 12 faces that were presented to them within eight sec. 4. Learning phase II: Now, the test takers are shown only the faces and names of the people that they did not remember for six sec each. In the unlikely event of the participant already identifying all 12 face-name pairs correctly, this stage is skipped 5. Immediate Recall II: the participants are shown each of the 12 faces again and they are given eight sec per face to recall the name of the person. 6. Learning Phase III: Again, the test takers are shown only the faces and names of the people that they did not remember for six sec each. In case the participant already identifies all 12 face-name pairs correctly, this stage is skipped 7. 30-minute delay: After Learning Phase III, there is a 30-minute delay, during which other tests or tasks were performed (see Table 1). 8. Free Name Recall: After the delay, the participants are asked to remember all 12 names within 30 sec without seeing the faces 9. Face Recognition: In the Face Recognition phase the participants are given a multiple-choice task: one familiar face out of the 12 is shown with three distractor faces, participants are asked to point at the familiar face within a five second time limit, this is repeated for all 12 faces. 10. Delayed Recall: Now, the participants are again shown each of the 12 faces individually for eight sec and they are asked to provide a name for each person. 11. Name Recognition: The participants are shown one familiar name and three distractor names for six sec at a time and they are asked to read out the name that is the familiar one, this is repeated for all 12 faces. 12. Face-Name Matching: Finally, the participants are given two minutes to match together all 12 Face-Name pairs while all of them are shown on the screen at the same time.

Figure 1

Full procedure of FNAME in a pictorial presentation (picture from Flores-Vázquez et al., 2021)



Note: This figure from Flores-Vázquez and colleagues (2021) demonstrates the subtests of FNAME procedure starting at Familiarization and ending at Face-Name Matching, including the time that participants were given in each subtest and representations of how the faces and names are displayed to the test taker during each subtest in the assessment.

Digit Symbol Substitution Test

Originally developed by Wechsler, DSST is a measure of processing speed where the participant is presented with a sheet with numbers from one to nine that are combined with a corresponding symbol (Jaeger, 2018; Wechsler, 1944). The participant is given a practice round, after which they have 90 seconds to fill in the sheet where only the numbers are

displayed in a random order, and they are to draw the correct corresponding symbol below. The score consists of the correctly drawn symbols in 90 seconds.

DSST is frequently used and a highly validated measure of processing speed, while it also requires motor functions, attention and visuoperceptual functions, (Jaeger, 2018). Furthermore, DSST has gone under rigorous reliability and validity testing as a part of Wechsler Adult Intelligent Scale (WAIS) (Jaeger, 2018). Moreover, DSST is highly sensitive in detecting brain pathology and it differentiates between different patient groups such as AD, Major Depression and Korsakoff's syndrome (Glosser et al., 1977; Jaeger, 2018).

Trail Making Test

TMT is another measure of processing speed, but also executive functions consisting of two parts (Reitan, 1958; Salthouse, 2011). In part A the participant is presented a sheet with numbers from one to 25, and they are asked to connect the numbers with a pen as quickly as they can, from one ending at 25 in the correct order (Reitan, 1958). The score consists of the seconds the participant took to finish the task (Reitan, 1958). Part B was not included in this thesis as it measures executive functions.

Wang and colleagues report strong reliability of TMT part A with intraclass correlation coefficient of .82 (Wang et al., 2018). Furthermore, validity of TMT is considered to be good by several authors (Cangöz et al., 2009; Sánchez-Cubillo et al., 2009).

Stroop Color Word Test

The SCWT originally developed in 1935 by Stroop is likewise a measure of processing speed and executive functions and consists of three subtests. Only the first two subtests were included in this study as measures of processing speed, while the third part was left out due to it measuring executive functions. In the first block the participants are asked to read out the names of colors from a sheet with the words printed out in black ink as fast as they can, the number of seconds the participant took to finish the task results as the score of

this subtest (Stroop, 1935). In the second part, the participants are presented with a sheet where there are blocks printed on a paper in different colors and participants are asked to name the colors as quickly as they can, the number of seconds they took to finish the task constitutes the score of this subtest (Stroop, 1935).

Test-retest reliability of SCWT has been reported between .73-.89 by Golden and colleagues (1978). Wang and colleagues (2009) have also assessed the reliability of SCWT with intraclass correlation coefficient of .91 indicating strong reliability. The validity of SCWT has been assessed by Kang and colleagues (2012) using multiple versions of the test with generally good results.

15 Word Test

15WT is the Dutch version of Rey Auditory Verbal Learning Test (RAVLT), and it is a measure of verbal episodic memory (Rey, 1941; van der Elst et al., 2005). The administrator of the test reads out 15 words after which the participant is asked to immediately recall (van der Elst et al., 2005). This is repeated four more times for a total of five rounds of Immediate Recall. Finally, there is a 30-min delay after which the participant is asked to repeat the 15 words for the last time. The scoring is based on the number of words correctly remembered in each subtest.

RAVLT has been under constant validation since it was developed (de Sousa Magalhaes et al., 2012). The convergent validity of RAVLT has been evaluated in comparison with Benton Visual Retention Test (BVRT) and California Verbal Learning Test (CVLT) with good results (de Sousa Magalhaes et al., 2012). The strength of test-retest reliability of RAVLT has been estimated to be moderate with intraclass correlation coefficient of .74 (Lemay et al., 2004). Van der Elst and colleagues (2005) suggest that the Dutch version of the test, 15WT has similar psychometric properties as it's English counterpart RAVLT.

Statistical Analysis

Before conducting the initial analysis, the assumptions were checked. Firstly, the normality was assessed by Shapiro-Wilk tests, which unfortunately yielded significant results, meaning that normality assumptions were violated. Departures from normality were estimated also by using Q-Q plots which showed approximate normality for all measures used. Homoscedasticity of FNAME and the processing speed composite was evaluated with a residual plot, which revealed a violation. Linearity assumption was tested with a scatterplot, which indicated a linear relationship between FNAME and the processing speed composite. Multicollinearity was deemed appropriate based on VIF = 1. Due to the robustness of simple linear regression against normality violations, the regression analysis was conducted regardless of the violations.

H1

To investigate the first hypothesis, the impact of processing speed on FNAME performance, a simple linear regression analysis was conducted. TMT A, SCWT 1 and SCWT 2 scores had to be reversed before computing the composite scores due to the fact that a high score in these tests indicates a poor performance, while a high score is indicative of good performance in the FNAME and DSST. To make all of the test scores interpretable in the same direction, each test score was deducted from the observed maximum score to reverse the scores. After the reversion was completed, the scores of DSST, TMT A and SCWT 1 & 2 a composite score was calculated, after which it was standardized with t-score standardization. The t-standardized composite score of processing speed was the single predictor in the model with a t-standardized FNAME full score as the dependent variable.

H2

To assess the convergent validity of FNAME and 15WT, a Pearson r correlation analysis was conducted using the FNAME subtests and full score together with 15WT subtests and full score including the significance of each correlation using t-test. To be able to

correlate the two tests, the scores were standardized by using the proportion of correct answers of each subtest of FNAME and 15WT. The standardization was followed by Pearson r correlation. The strength and significance of the correlations are evaluated with the standards of Cohen (1988) and Gignac and Szodorai (2016).

H3

Finally, the internal consistency of FNAME was evaluated by a correlation analysis of all subtests of FNAME, using Pearson r correlation including the significance of the correlation with a t-test. For the correlation analysis of FNAME alone, unstandardized FNAME scores were used. Furthermore, the strength and significance of the correlations are evaluated using the standards of Cohen (1988) and Gignac and Szodorai (2016).

The statistical analysis was conducted using IBM SPSS software 28.

Results

Participants

Originally 233 participants participated in the study, of which 16 were excluded due to incomplete responding or technical difficulties during the assessment, which lead to a total of 217 participants that were included in the study. Initially, 94 participants were found to have aMCI based on having a scoring below 9th percentile in the 15WT, 122 participants were deemed to have subjective cognitive decline due to 15WT scores within the normal range. The larger group of 122 were classified as having SCD based on the recruiting process where people were invited to participate if they suspected memory problems.

Of the participants 40.6% were women, 47.2% had completed higher education, 38.7% had completed high school or vocational education, and their mean age was 72.12 (*SD* = 7.93). All participants are residing in the Netherlands and are Dutch speaking.

H1 Testing the effects of processing speed on FNAME

The first research question was examined by using a simple linear regression analysis with FNAME total score as the dependent variable and as the independent variable the Processing Speed composite score. The fitted regression model was the following:

$$FNAME_i = 27.07 + .46\ ProcessingSpeed_i + \varepsilon_i$$

(error term is normally distributed). The processing speed composite significantly predicted FNAME performance ($\beta_1 = .46$, $p < .001$). The model explained approximately $R^2 = .21$ of the variability yielding statistically significant results ($F(1,216) = 57.27$, $p < .001$). This result supports the hypothesis that processing speed has an impact on FNAME performance with a moderate effect size indicated by 21% variance explained by the single predictor processing speed composite (Cohen, 1988).

H2 Convergent validity of FNAME with 15WT

As the second research question, the convergent validity of FNAME with 15WT was evaluated. A Pearson r correlation analysis conducted with the proportions of correct answers of FNAME and 15WT, revealed moderate to strong correlations between the subtests and total scores (Cohen, 1988). The correlations between the different subtests were all found to be highly significant ($p < .001$). The Immediate Recall subtests of both FNAME and 15WT showed moderate correlations with each other, which is below what was hypothesized (Cohen, 1988). The Delayed Recall subtests, on the other hand, have strong correlations between each other, as well as the totals of FNAME and 15WT (Cohen, 1988). The data supports my second hypothesis of high convergent validity for FNAME and 15WT. The proportions of correct answers of FNAME subtests and Full Score can be found in Table 2., see Table 3. for proportion of correct responses for 15WT subtests, Immediate Recall Total Score and Full Score. See Table 4. for the full correlation matrix of FNAME and 15WT subscales and total scores.

Table 2.

Proportion of correct responses in FNAME subtests and Total Score

FNAME	*M*	*SD*
Immediate Recall 1	.35	.23
Immediate Recall 2	.50	.27
Free Name Recall	.49	.25
Face Recognition	.94	.12
Delayed Recall	.49	.30
Name Recognition	.91	.15
Face-Name Matching	.58	.30
FNAME Total Score	.60	.20

Table 3.

Proportion of correct responses in 15WT subtests, Immediate Recall Total and 15WT Total Score

15WT	*M*	*SD*
Immediate Recall 1	.31	.12
Immediate Recall 2	.44	.15
Immediate Recall 3	.52	.16
Immediate Recall 4	.57	.18
Immediate Recall 5	.60	.19
Immediate Recall Total	.48	.14
Delayed Recall	.43	.23
15WT Total Score	.48	.15

H3 Internal consistency of FNAME12-NL

The Pearson r correlation analysis on FNAME subtests revealed overall high correlations supporting the final hypothesis of good internal consistency (Gignac & Szodorai, 2016). Furthermore, all intercorrelations were highly significant (p <.001). However, two subtests, namely Face Recognition and Name Recognition had only weak to moderate correlations with other subtests (Gignac & Szodorai, 2016). See Table 5. for the full correlation matrix including descriptive statistics of FNAME subscales and total score. The two Recognition subtests were showed ceiling effects, meaning that, most participants had a high scores or all pairs correct on these two subtests, even when they performed poorly on other subtests.

Table 4.

Correlation matrix of FNAME and 15WT, where FNAME subtests are displayed on the vertical axis, and 15WT subtests are displayed on the horizontal axis

	Immediate Recall 1	Immediate Recall 2	Immediate Recall 3	Immediate Recall 4	Immediate Recall 5	Immediate Recall Total Score	Delayed Recall	15WT Total Score
Immediate Recall 1	.35**	.39**	.42**	.47**	.48**	.47**	.53**	.52**
Immediate Recall 2	.40**	.49**	.48**	.56**	.57**	.59**	.59**	.62**
Free Name Recall	.38**	.47**	.47**	.57**	.57**	.56**	.64**	.61**
Face Recognition	.16**	.24**	.31**	.29**	.26**	.30**	.32**	.32**
Delayed Recall	.39**	.47**	.47**	.57**	.55**	.57**	.59**	.61**
Name Recognition	.30**	.40**	.35**	.44**	.37**	.42**	.51**	.47**
Face-Name Matching	.38**	.43**	.48**	.59**	.56**	.55**	.58**	.59**
FNAME Total Score	.42**	.51**	.53**	.61**	.59**	.61**	.65**	.66**

Note: On the horizontal axis: 15WT subtests, and on the vertical axis: FNAME subtests. ** indicates $p < .001$.

Table 5.

Correlation matrix of FNAME subtests including mean and standard deviation of untransformed FNAME scores

Variable	*M*	*SD*	Immediate Recall 1	Immediate Recall 2	Free Name Recall	Face Recognition	Delayed Recall	Name Recognition	Face-Name Matching	FNAME Total Score
Immediate Recall 1	4.19	2.77	1							
Immediate Recall 2	6.11	3.23	.79**	1						
Free Name Recall	5.93	2.98	.66**	.76**	1					
Face Recognition	11.22	1.49	.35**	.38**	.38**	1				
Delayed Recall	5.84	3.57	.80**	.89**	.82**	.42**	1			
Name Recognition	10.95	1.77	.45**	.54**	.59**	.46**	.57**	1		
Face-Name Matching	6.93	3.59	.76**	.83**	.72**	.38**	.85**	.50**	1	
FNAME Total Score	50.78	16.44	.87**	.92**	.86**	.51**	.94**	.66**	.90**	1

Note: ** indicates $p < .001$.

Discussion

The aim of this thesis was to evaluate the impact of processing speed on FNAME performance, as well as investigating the convergent validity of FNAME with 15WT and internal consistency of FNAME. A Simple Linear Regression analysis was conducted with FNAME as the dependent variable, and as the independent variable a processing speed composite score that was computed using scores of tests measuring processing speed (DSST, TMT A, SWCT1-2). A significant effect was found, processing speed explains 21% of variance in FNAME performance. A Pearson r correlation analysis was conducted which supported the hypothesis of good convergent validity of FNAME with 15WT, excluding the scales measuring recognition (Cohen, 1988; Gignac & Szodorai, 2016). Finally the subtests of FNAME were analyzed in a Pearson r correlation analysis with respect to the final research question of internal consistency supported the hypothesis of good internal consistency excluding the measures of recognition (Cohen, 1988; Gignac & Szodorai, 2016).

Processing Speed as an Influential Neuropsychological Function

This investigation of the impact of processing speed on FNAME was motivated by the notion that processing speed may serve as a significant domain influencing other neuropsychological domains, despite limited existing literature on how strong this influence might be (Amieva et al., 2019; Roye et al., 2022), especially as this impact of processing speed has now yet been investigated on associative memory. Some researchers have postulated that processing speed has the potential to affect other neuropsychological domains, particularly executive functions (EF) and memory functions like visual working memory (VWM) (Brown et al., 2012; Karr et al., 2018; Roye et al., 2020). However, while these sources suggest the statistical control of processing speed when assessing EF functions, they do not thoroughly explore or quantify its magnitude of impact on EF (Karr et al., 2018; Roye

et al., 2020). Brown and colleagues (2012) on the other hand report that processing speed has a significant effect on VWM (R^2 = .35) in a population of older adults.

The investigation into the impact of processing speed on FNAME performance unveiled that a significant portion of the variance in performance can be attributed to processing speed, with a moderate effect size observed in individuals with either SCD or aMCI (Cohen, 1988; Gignac & Szodorai 2016). This result goes in line with the hypothesis that processing speed can influence FNAME performance and therefore associative memory performance. Based on the literature, this result was expected as earlier mentioned, processing speed has also been associated with decreased WM performance (Brown et al., 2012; Hedden et al., 2005). These earlier results together with this current thesis suggest that the effect of processing speed on WM and associative memory could be further examined in order to differentiate the causality of the impact, is it processing speed impacting WM which in turn impacts associative memory performance, or is WM the factor impacting processing speed? Further, it would be important to assess what is the impact of WM on associative memory based on these findings, and whether WM should be controlled statistically as well.

The Performance in FNAME and in 15WT Are Highly Correlated with Each Other

The correlations between FNAME and 15WT revealed moderate to high correlation with one another supporting the second hypothesis of good convergent validity, replicating the results of Amariglio and colleagues (2012). The lowest correlations for the current version of Dutch FNAME were found for measures of recognition which will be discussed later in detail.

Prior to this thesis, convergent validity of FNAME has been assessed with FCSRT by with the American English version of the test which yielded a strong correlation (r = .54) between a composite of FNAME and a composite of FCSRT (Amariglio et al., 2012). The results of this thesis in combination with prior research supports the hypothesis that FNAME

and SRT as well as 15WT measure the same underlying construct, episodic memory (Amariglio et al., 2012). This outcome is promising for the prospective use of FNAME in its primary role of identifying individuals at risk of Alzheimer's Disease (AD). Such assessments play a pivotal role in facilitating early intervention within potentially pathological trajectories, although currently the options for intervention are limited, assessments like FNAME support not only the current (rare) options but provide a valuable building block for the invention of additional interventions for AD, which are vital for combatting AD in the future.

Internal consistency of FNAME is generally good with some exceptions

The third and final hypothesis in this thesis was that the latest form of Dutch FNAME has good internal consistency. Two of the newly added scales namely Face-Name Matching and Free Name Recall had high intercorrelations with other subtests, while the recognition scales had weaker correlations to other subtests. Based on these results, most subscales were highly correlated with each other which indicates high internal consistency when disregarding the recognition scales.

The findings of this thesis align with previous studies on internal consistency of FNAME (Flores-Vázquez et al., 2020; Papp et al., 2014). Notably, this investigation contributes novel insights by advocating for the retention of the Free Recall and Face-Name Matching components while recommending that the "Face Recognition" and "Name Recognition" could potentially be excluded from the Dutch version of FNAME, if in further research no evidence is found for their utility. It is possible that in a population with more significant decrements of associative memory they could be more useful, while this sample did not include individuals that reach the diagnosis of AD.

Recognition and recall as a function of associative memory

The research questions assessing the convergent validity of FNAME with 15WT as well as internal consistency of FNAME revealed some new insights about recognition as a

tool to detect associative memory deficits. In both correlation analyses it was evident that Face Recognition and Name Recognition had weaker correlations with any 15WT scale, but also with other FNAME scales. This observation holds significant implications; recognition tasks are significantly different from recall tasks, as in they are significantly easier items than recall. It is evident that recognition seems to be easy for this type of population of aMCI and SCD individuals which is supported by ceiling effects, characterized by high scores for recognition scales (see Table 5).

It has been postulated that recall and recognition are distinct processes, as per dual-processing theories, remains a subject of debate. When an individual encounters a face that they might have seen before, two cognitive components of associative memory come into play: recognition (is this face familiar?) and recall (what is this person called?) (Koen & Yonelinas, 2016; Yonelinas, 2002). Existing research has demonstrated that recognition is an automatic and effortless process, while recall requires a conscious effortful processing (Fine at al., 2020; Quamme et al., 2004; Yonelinas, 2002). Moreover, recognition and recall are have different neurophysiological correlates and recall is more susceptible in pathological conditions than recognition (Quamme et al., 2004; Yonelinas, 2002). In the context of healthy older adults, it has been observed that aging primarily affects recall processes, while recognition abilities remain relatively intact (Koen & Yonelinas, 2016). Additionally, a study by Fine and colleagues (2018) found evidence that recognition is often preserved in aMCI and only small decreases are observed in AD. Earlier research by Caruso and colleagues (2020) had similar conclusions about the usefulness of recognition for individuals with AD. Their test using recall was successful in differentiating between healthy and AD groups, while their recognition test failed to do so (Caruso et al., 2020). In prior studies it has been observed that face recognition declines in AD, but these changes in recognition occur later on in the AD progression (Mazzi et al., 2020). These results further indicate that recognition might not be

useful in detecting memory decline in the precursor stages of AD, namely SCD and aMCI. Consequently, removing these recognition scales could shorten the time required for administration of the FNAME when assessing individuals at risk for AD.

Face-Name Matching Is More Complex Than Mere Recognition

In Face-Name Matching the participant is displayed all 12 faces with all 12 names at the same time on the screen, and they are asked to connect the pairs correctly. This makes Face-Name Matching seem similar to the recognition scales, because to connect the pairs, the individual needs to recognize the face and the name. Based on the results, this task was more difficult for the participants compared to the recognition subscales due to a lower proportion of correct answers observed compared to recognition scales (see Table 3 for proportion of correct answers in FNAME subscales). Although recognition and Face-Name Matching may appear similar on the surface, the latter involves a more intricate process (Fine et al., 2018). Matching faces to names necessitates not only recognizing individual elements but also successfully connecting them, which poses a greater cognitive challenge, as highlighted by Fine and colleagues (2018). This indicates that Face-Name Matching is indeed a more complex item and thus valuable to retain in FNAME.

Implications and future research

The findings presented in this paper hold important implications for the future application of the Face Name Associative Memory Exam (FNAME). Specifically, the observed influence of processing speed on FNAME performance underscores the necessity of considering processing speed when making inferences about associative memory deficits. Consequently, it is advisable to incorporate statistical controls for processing speed when using FNAME as a tool for assessing associative memory performance for individuals potentially at risk for AD.

Furthermore, the results pertaining to internal consistency and convergent validity suggest a prudent course of action: the removal of recognition scales from the FNAME assessment. By doing so, the duration required for neuropsychological evaluation can be reduced, enhancing the efficiency of the testing process and freeing more resources in healthcare.

Another important area of research would be creating evidence-based interventions for people who are at risk to develop AD, as currently options for interventions are limited. FNAME is developed as measure that can identify precursor and early stages AD, on top of having a test to detect these stages, tools are needed to interfere while an individual is in these early stages. One of the potential interventions could be the medications mentioned earlier in this thesis, namely the MAB medications, which have been seen to be able to stop the progression towards AD (Rahman et al., 2023; Shcherbinin et al., 2023).

Limitations

Applicability of the results regarding impact of processing speed on FNAME performance is limited to this population of SCD and aMCI as there were no healthy participants in this sample. In order to answer the question of how much processing speed impacts associative memory performance in healthy individuals, remains a question. In further research the impact of processing speed could be evaluated with a sample including individuals without cognitive complaints to get more information about whether processing speed impacts similarly individuals that are cognitively healthy, or if this is impact of processing speed is related only to cognitive decline, objectified or subjective only. This thesis was predicated on the analysis of archival data, thus entailing a lack of influence over the recruitment process for participants or the specifics of the administered neuropsychological assessments.

Another limitation pertains to the omission of an analysis regarding potential group differences in the influence of processing speed on FNAME performance within the context of this thesis. This decision was guided by the thesis' primary focus on examining the psychometric attributes of the FNAME, as opposed to investigating group-specific distinctions. While this analysis wasn't conducted in this study, exploring potential variations between aMCI, SCD and healthy individuals in processing speed and its effect on FNAME performance, could provide valuable insights. It would shed light on whether processing speed affects FNAME performance to a similar degree in healthy individuals as it does in those with SCD, and whether it exerts a more pronounced influence on aMCI compared to SCD. Analysis of these potential group differences could be insightful as to explore the when processing speed declines in relation to AD progression.

A further limitation pertains to the choice of statistical methodologies employed in this thesis. Notably, despite the detection of non-normality and some degree of heteroscedasticity indicated by the Shapiro-Wilk's tests as well as residual plots, the decision was made to retain a substantial number of observations to maintain robust effect sizes, rather than opting for data exclusion. Additionally, Simple Linear Regression was selected due to its resilience in handling minor violations of normality assumptions. Another option could have been to use non-parametric tests, but due to visually approximate normality as well as the large sample size, approximate normality was assumed (Fischer, 2011).

Conclusions

In conclusion, evidence was found that processing speed is indeed an influential neuropsychological domain that has the potential to impact associative memory performance, meaning that decreased processing speed might inflate scoring on associative memory assessments. Additionally, the results of the statistical analysis executed indicated a good convergent validity and internal consistency for the Dutch version FNAME, which goes in

line with earlier research on the test, excluding the domain of recognition. These results indicate that that FNAME12-NL continues to show promising psychometric properties as well as potential to be used in clinical practice to predict an individual's risk for developing AD.

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