D3.5.2 & D3.5.3
Integration of Multimodal Analytics

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1 Executive Summary

The integration of multimodal analytics as being conceptualised and implemented in Task 3.5, such as, from psychosocial, sensorimotor, gaze and emotion analytics, considers the definition of a state of human well-being, mental processes and performance and will provide the basis for diagnostic analytics as well as underlie the rule base of the recommender system (Task 4.5). JRD and GGZ will define in this deliverable the dementia relevant features for state definition features and JRD will implement the interface to the front-end and back-end systems.

This deliverable determines firstly the basic health care oriented and neuropsychological considerations that will underlie the continuous assessment of the mental and physical state of a PwD under intervention, and secondly describes the specific information that is provided by several components of the PLAYTIME suite for multimodal data driven analytics. Furthermore, the lines of integration of the information from individual analytical components are described. Finally, an implementation plan provides the milestones and functionalities of next system integration steps for the purpose of multimodal analytics.

2 Introduction

The integration of multimodal analytics, such as, from psychosocial, sensorimotor, gaze and emotion analytics, considers the definition of a state of human well-being, mental processes and performance and will provide the basis for diagnostic analytics as well as underlie the rule base of the recommender system (Task 4.5).

JRD and GGZ will define the dementia relevant features for state definition features and JRD will implement the interface to the front-end and back-end systems.

3 Analytics of MMA in combination with MIRA

3.1 Indications on cognitive assessment using MMA App

The MMA App provides exercises with multimodal character, such as, cognitive training and physical training units. The first investigation about the results from multimodal intervention therefore is on the MMA App itself.

3.1.1 Descriptive statistics

Tablet-PC-based intervention was applied within 10 weeks in Austria, engaging persons with dementia (PwD) with Alzheimer's disease (AD) living at home in terms of playful multimodal training and activation. 20 users were engaged, however. Digital data of 8 PwD were captured to play 'MMA', a suite of cognitive exercises (puzzle, memory, text gap filling). The games were introduced and assisted by trainers, some PwD learned to play alone.

3.1.2 Anderson-Darling test for normal distribution check

The Anderson-Darling test is commonly used to test whether a data sample comes from a normal distribution. The decision to reject or not reject the null hypothesis is based on comparing the p-value for the hypothesis test with the specified significance level, not on comparing the test statistic with the critical value.

The null hypothesis of the test is the assumption that the frequency distribution of the data in the sample corresponds to the given hypothetical probability distribution, such as, the normal distribution. A p-value of less than 0.05 as a result of the Anderson-Darling test is therefore to be interpreted as a significant deviation from the given distribution. In contrast, a p-value greater than 0.05 does not necessarily mean that the frequency distribution of the data corresponds to the given distribution.

3.1.3 Pearson correlation between MMA and MoCA score

In a first investigation about the normal distribution character of the MMA score and the MoCA score, the following results were obtained: the Anderson-Darling test (ADT) for the MMA score resulted in $p=0.0806$ which is > 0.05 and therefore no rejection on the normal distribution hypothesis. For the MoCA score the ADT was also applied and resulted in $p=0.9486$ which is > 0.05 and as well results in no rejection of the normal distribution hypothesis. As a conclusion, MMA and MoCA score can therefore be correlated using the Pearson correlation function which resulted in $rho=0.6974$, $p = 0.0545$. This demonstrates that there are statistical dependencies but not sufficiently strong, of course there number of participants is very low to have reasonable conclusions from the data.

Table 1. Participants in the FT2 study (N=8), with MMA and MoCA store, and average number of exercises played per day.

code	MMA score	MoCA score	exercises/day
120	**0.9285714**	0.7	3.78
108	**0.9198157**	0.67	144.03
105	**0.9618563**	0.87	113.17
106	**0.8527132**	0.47	4.45
113	**0.7837259**	0.63	14.62
100	**0.9374262**	0.8	44.58
118	**0.8030303**	0.5	4.71
111	**0.9333333**	0.6	30.00

3.1.4 Rank correlation between MMA and questionnaires

In a second investigation the rank correlation measure Spearman was applied for any significant statistical relation between MMA score and questionnaire scores. A rank correlation measures an ordinal association, i.,e., the relationship between rankings of different ordinal variables or different rankings of the same variable, where a "ranking" is the assignment of the ordering labels "first", "second", "third", etc. to different observations of a particular variable. A rank correlation coefficient measures the degree of similarity between two rankings, and can be used to assess the significance of the relation between them.

Table 2 depicts the rank correlations (Spearman) between the MMA score and the most important questionnaire score that were estimated in field test FT2 in Austria.

Table 2. Participants in the FT2 study (N=8), with several scores and correlation measures between MMA score and questionnaires MMSE, GDS, CDR and CDT.

code	MMA score	MoCA score	MMSE	GDS	CDR	CDT
120	**0.93**	**0.7**	26	0	0.5	7
108	**0.92**	**0.67**	26	1	0.5	7
105	**0.96**	**0.87**	29	0	0	7
106	**0.85**	**0.47**	27	0	0.5	3
113	**0.78**	**0.63**	27	0	0.5	5
100	**0.94**	**0.8**	30	1	0.5	7
118	**0.80**	**0.5**	25	2	1	5
111	**0.93**	**0.6**	29	1	2	7
Spearman's Rho correlation with MMA score		.7545	.6220	-.0853	-.3842	.7883
p-value		.0377*	.1063	.8786	.3869	.0357*

The results clearly demonstrate a statistically significant ranked correlation between the MMA score and the MoCA score (rho=.75, p=.04). Furthermore, there is a correlation with the CDT (clock drawing test; rho=.79, p=.04) which demonstrates that there could be even better results if more than 8 participants would have been measured.

3.1.5 Level and frequency of play

Table 3 demonstrates the statistics of players' level selection and frequency of play. This table clearly demonstrates that level 2 was the preferred level played by the persons with dementia with MMSE as displayed in Table 2.

On average, the users played on 22.5 days with the Tablet, with an average frequency of 49.3 exercises per day. The number of exercises played in total was 953 on average.

Table 3. Statistics of players' level selection and frequency of play.

No	userId	exercises / difficulty level				exercises total	days played	exercises per day
		1	2	3	4			
01	120		**154**	20		174	46	**3.8**
02	108		**3255**		1642	4897	34	**144.0**
03	105		**1573**	1030		2603	23	**113.2**
04	106		**129**			129	29	**4.4**
05	107			262		262	24	10.9
06	113		**467**		30	497	34	**14.6**
07	100		**847**			847	19	**44.6**
08	118		**66**			66	14	**4.7**
09	111		**30**			30	1	**30.0**
10	109	25				25	1	25.0
Mean						**953.0**	**22.5**	**39.5**
Standard deviation						1590.2	14.4	49.3

3.1.6 Conclusions on MMA App general results

In general, the MMA play score results demonstrate a high potential in possible correlation with several questionnaires for neuropsychological performance scoring. This nourishes the hypothesis that playing the MMA App itself would bear the potential to provide a qualitatively good estimate of cognitive assessment.

In the next Section, we investigate the correlation with scores of specific cognitive impairments in more detail.

3.2 Functional Impairment Matrix

3.2.1 Functional Matrix of Analytical Assessments

Functional impairments referred to in the psychological tract are now listed in Table 4. The table represents a functional matrix relating individual analytical assessments via PLAYTIME serious game components (columns) versus clustered functional impairments in dementia (rows).

This table is fundamental in the sense that assessment from the individual components will **indicate** about the status of individual functional impairments. This indication in principle informs which aspects of cognitive performance could be targeted through training.

Table 4. Functional matrix of analytical assessments via PLAYTIME serious game components (row) versus clustered functional impairments in dementia.

Functional impairment	MMA	SERES	MIRA	MOVE
Attention			√	
Mood affect		√	√	
Language	√			
Visual perception	√		√	
Explicit memory	√			
Executive functions			√	√[1]
Comportment		√		
Activities of daily living (ADL)				√

The aspect of a highly **individual distribution** on the set of potential **functional impairments** in dementia is emphasized particularly using the aforementioned measured data, classifications and associations. Being able to identify a specific **individual pattern** as set of potential **functional impairments** in turn enables to perform a **functional personalisation of the training** on the basis of this information.

3.2.2 Playful dementia training and functional impairments

In the following, we demonstrate results of the investigation on the indication of specific functional cognitive impairments by means of MMA scoring. These functional impairments are represented by MoCA subscores, such as, (1) Visuospatial executive, (2) naming, (3) attention, (4) language, (5) abstraction, (6) recall and (7) orientation. These subscores are calculated from the following general functional categories, as follows

- Orientation: Knowing the day, date, and your present location.
- Short-term memory: Ability to hear a word and repeat it back a short time later.

[1] If performed as dual task.

- Focus and spatial awareness: Connect numbered dots in sequence, and draw 3-dimensional shapes.
- Language: Ability to speak and understand whole sentences, and remember the names of well-known animals or objects.
- Concentration: Repeating simple sequences forward and backward.
- Clock Drawing Test: Famous for evaluating dementia warning signs.

From the results it became obvious that the overall MMA score was not sufficiently discriminative to correlate with specific subscores. Table 6 demonstrates that the p-values of the respective correlation measures are always beyond 0.05 and therefore the correlations are not statistically significant.

Therefore we decided to select specific clusters of exercises, and even selected single, most representative ones, and correlated their score with the related subscores of MoCA. This endeavor was motivated by the observations outlined in D3.1 on the neuropsychological profile in Alzheimer, as well as by communication between JRD and GEU and conclusions provided into D3.2.

The association between the selection of exercises and the subscore category was done by a psychologist of the partner SVDL. Table 5 depicts the resulting attribution of functional impairments from MoCA subscores to specific exercise types that are covered in the MMA App. All related exercise types are signed by a ‘1’ in the matrix whenever they provide a relevance to a specific MoCA subscore type. The most representative exercise type is highlighted for every moCA subscore type.

Table 5. Attribution of functional impairments from MoCA subscores to specific exercise types that are covered in the MMA App.

		MoCA Subscores						
ExerciseType	**SVDL notion**	**Visuospatial Executive (1)**	**Naming (2)**	**Attention (3)**	**Language (4)**	**Abstraction (5)**	**Recall (6)**	**Orientation (7)**
KnowledgeText	Quiz mit Text	0	0	0	**1**	1	1	0
Puzzle	Puzzle	1	0	**1**	0	0	1	1
BoxFinder	Kästchen	1	0	1	0	0	1	**1**
GapFill	Lückentext / Lückenwort	0	0	1	1	0	1	0
Step Sequence	Reihenfolge	1	0	0	1	0	1	0
Math	Rechenaufgabe	0	0	1	0	1	1	0
Memory	Bildpaare	1	0	0	0	0	**1**	0
Outsider	Außenseiter	0	0	0	1	**1**	1	0
Knowledge ImageClip	Bildausschnitt	1	0	1	0	0	0	1
Acoustic Knowledge	Höraufgabe	0	0	0	0	1	1	0
Difference Puzzle	Fehler Suchaufgabe	**1**	0	1	0	0	0	1
Movement	Bewegungs-videos	1	0	0	0	0	1	0
Number Series	Zahlenreihe	1	0	1	0	1	0	0

Table 6. MoCA subscores and pass-rates under investigation of normal distribution and correlation measures. The correlation between MMA score and individual MoCA subscores is interesting but not statistically significant with respect to the related p-values.

UserId	Visuo/Exec (1)		Attention		Lang.		Abstract.		Recall	
	MoCa subscore	cat. MMA Pass-Rate	MoCa subscore	MMA Pass-Rate	MoCa subscore	MMA Pass-Rate	MoCa subscore	MMA Pass-Rate	MoCa subscore	MMA Pass-Rate
100	1	0.91	0.83	0.96	1	0.91	1	0.94	0.2	0.94
105	1	0.94	0.83	0.98	1	0.95	1	0.96	0.4	0.96
106	0.4	0.93	0.5	0.85	0.33	0.67	0	0.9	0	0.84
108	0.6	0.9	0.83	0.92	0.33	0.93	1	0.92	0.4	0.91
111	0.4	0.89	0.83	0.95	0.33	0.91	0.5	0.93	0.2	0.96
113	0.6	0.78	0.83	0.82	0.33	0.7	1	0.77	0	0.79
118	0.4	0.75	0.83	0.82	0.33	0.83	0.5	0.8	0	0.8
120	0.8	0.92	1	0.93	0.67	0.95	1	0.91	0	0.94
Rho (Spearman)	**0.5065**		0.2195		**0.6261**		0.3024		**0.6377**	
p-value	0.2012		0.7143		0.1190		0.4643		0.1143	
Anderson-Darling test p-value	0.1374	0.0172	0.0005	0.1958	0.0016	0.0309	0.0033	0.0434	0.0257	0.0832
Normal distribution	yes	no	no	yes	no	no	no	no	no	yes

Table 7. MoCA subscores vs. performance of related serious game exercises with check on normal distribution and correlation measures..

UserId	Visuo/Exec (1)		Attention (3)		Language (4)		Abstraction (5)		Recall (6)		Orientation (7)	
	MoCa subscore	difference puzzle passed	MoCa subscore	Puzzle pass-rate	MoCa subscore	knowledge text pass-Rate	MoCa subscore	outsider played	MoCa subscore	memory passed	MoCa subscore	Box finder pass rate
120	0.8	4	1	1	0.67	0.87	1	5	0	10	0.67	0.75
108	0.6	12	0.83	0.62	0.33	0.9	1	110	0.4	220	0.83	0.94
105	1	29	0.83	0.9	1	0.9	1	49	0.4	102	1	1
106	0.4	0	0.5	0	0.33	0.75	0	4	0	10	0.83	0.67
113	0.6	7	0.83	0.67	0.33	0.58	1	16	0	22	0.83	0.57
100	1	11	0.83	0.85	1	0.87	1	27	0.2	57	1	0.85
118	0.4	0	0.83	0.67	0.33	0.88	0.5	3	0	2	0.5	0.5
111	0.4	0	0.83	1	0.33	0.67	0.5	1	0.2	1	1	1
Rho (Spearman)	**0.8355**		0.7178		0.3757		**0.7835**		0.6209		**0.7806**	
p-value	**0.0155***		0.0714		0.3810		**0.0357***		0.1095		**0.0304***	

3.2.3 Representative MMA exercises and MoCA subscores

Representative exercises identified in Table 5 are finally correlated with statistical significance with MoCA subscores. The interpretation of this correlation refers to the specific indication that these selected exercises provide towards a selected cognitive deficit as indicated by the MoCA subscore (1)-(7).

Table 7 provides insight into the evidence that, in particular, specific exercises clearly indicate the following cognitive deficits: (1) Visuospatial executive, (5) abstraction, and (7) orientation. The correlation is individually very high (higher than .78) and the p-value is in every of these cases below .05.

3.3 MMA in combination with MIRA

In a further stage of investigation, we were interested whether the combination of MMA and MIRA Apps could provide an improved coverage of MoCA subscore predictions based exclusively on App scores, i.e., from MMA and from MIRA.

3.3.1 Descriptive statistics

Tablet-PC-based intervention was applied within 10 weeks in Austria, engaging persons with dementia (PwD) with Alzheimer's disease (AD) living at home in terms of playful multimodal training and activation (n=15, age M=81.7 years, MoCA score M=17.9). PwDs interacted with an integrated version of two serious games: (a) 15 PwD played 'MIRA', a playful version of the anti-saccade task, and (b) 8 PwD played 'MMA', a suite of cognitive exercises (puzzle, memory, text gap filling). The games were introduced and assisted by trainers, some PwD learned to play alone.

3.3.2 Playful indication of cognitive deficit

The score of gaze-based MIRA showed significant correlation with MoCA score (Rho= .713**) and enabled individual MoCA score estimates with errors of less than M=2.6 MoCA points. MMA showed correlation with MoCA (Rho=p=.755*) and further MoCA subscores so that the neuropsychological profile could be established including impairments in:

- visuospatial executive (MMA; MIRA),
- Attention (MMA),
- Abstraction (MMA)
- Orientation (MMA),
- Language (MIRA),
- Naming (MIRA).

3.3.3 Conclusion about MMA and MIRA combined

As a conclusion, MMA and MIRA together are able to provide a statistically significant relation to 6 out of 7 functional impairment categories, only recall is a deficit with which a correlation currently seems not feasible. In future developments we will target also the seventh MoCA subscore category in order to enable a full coverage of estimates from game score to deficit categories.

The work outlined within the EU project PLAYTIME indicates successful steps towards daily use of gaze-based games. MIRA together with the MMA training enables continuous estimates of Alzheimer's mental state in general but also to estimate individual neuropsychological profiles to identify personal impairments and their course over time. The playful training app was very well accepted by PwD users and offers, with its pervasive mental assessment tool, a large potential for future long-term monitoring in numerous AD care services.

4 Associations in other components

Further potential for the exploitation of multimodal analytics can in theory be developed from within the PLAYTIME suite of games. Table 8 depicts, for example, which PLAYTIME component contributed data to those 8 users who were analysed in detail for MMA based assessment. It demonstrates that only a few out of the group of all MMA users are also supported by additional data from other components. We anticipate for the future that there will be more data from MMA, MIRA and SERES, also emotional information, and that could be used to conclude in a dedicated way about more profound cognitive assessment.

However, the PLAYTIME project focused on multimodal assessment with the focus on the correlation with MoCA subscores, which limited the resources to tackle further objectives.

From the scientific point of view, the association of game scores with neuropsychological profiling appeared to be most exciting, and particularly also from the business model since this association can be easily built from MMA and MIRA scores. The positive results of this investigation point towards a promising future of using the specific impairment assessments for fine-tuned training, as well as for personalized characterisations of dementia types.

Table 8. Multimodal data analytics based on PLAYTIME ecosuite components: availability of joint data vectors.

UserId	MMA	MIRA	SERES	AffSlider
100	Yes	-	Yes	-
105	Yes	-	Yes	Yes
106	Yes	Yes	Yes	Yes
108	Yes	Yes	Yes	Yes
111	Yes	Yes	-	-
113	Yes	Yes	Yes	Yes
118	Yes	Yes	-	-
120	Yes	Yes	Yes	Yes

5 Conclusions

This Deliverable provides first evidence about the usefulness of combining different modules in a systematic manner in order to achieve estimates about functional categories of cognitive impairment, such as, represented by the different categories of the MoCA subscore.

In order to combine scores of MMA and MIRA with other PLAYTIME components, the population numbers in the main study were not sufficiently large and the main target of the study was not to enable large-scale correlation measures but instead to receive feedback about the usability of the technological and service oriented approach.

The combined approach in terms of estimating detailed cognitive assessment categories was scientifically and from the product side the most interesting approach so far. The following publication is the result of this investigation:

(Paletta et al., 2020) Paletta, L., Russegger, S., Pszeida, M., Murg, S., Orgel, T., Dini, A., Jos, A., Schuster, E., Koster, E.H.W., Steiner, J., and Fellner, M. (2020). Playful Multimodal Activation with Assessment of Neuropsychological Profiles in Alzheimer's Disease, *Alzheimer's & Dementia, abstracts AAIC 2020*, 2020, in print.

6 Abbreviations

Table 1. *Abbreviations.*

Abbreviation	Description
MMA	Multimodal Activation (App)
MIRA	Mobile Instrumental Review of Attention (App)
MMSE	Minimental State Examination
GDS	Geriatric Depression Scale
CDT	Clock Drawing Test
CDR	Clinical Dementia Rating (CDR) Scale
PwD	Person with dementia

7 Bibliography

(**Anderiesen et al., 2015**) Anderiesen, H., et al. (2015). Play experiences for people with Alzheimer's disease. Int. J. of Design, 9(2), 155-165.

(**Army, 1994**) Army Individual Test Battery. Manual of Directions and Scoring. War Department, Adjutant General's Office, Washington, DC (1994).

(**Atkinson, 1957**) Atkinson, J.W. (1957). Motivational determinants of risk-taking behavior. Psychological Review, 64, 359-372.

(**Berry et al., 2015**) Berry SM, Connor JT, Lewis RJ. The platform trial: An efficient strategy for evaluating multiple treatments. JAMA 2015;313:1619–20.

(**Betella & Verschure, 2016**) Betella A, Verschure (2016) The Affective Slider: A Digital Self-Assessment Scale for the Measurement of Human Emotions. PLoS ONE 11 (2): e0148037. doi:10.1371/journal.pone.0148037.

(**Brodaty et al., 2014**) Brodaty, H., Woodward, M., Boundy, K., Ames, D., & Balshaw, R. (2014). Prevalence and predictors of burden in caregivers of people with dementia. The American Journal of Geriatric Psychiatry : Official Journal of the American Association for Geriatric Psychiatry, 22(8), 756–765 http://doi.org/10.1016/j.jagp.2013.05.004

(**Burns & Iliffe, 2009**) Burns, A., and Iliffe, S (2009). Dementia, BMJ (Clinical research ed.) 338.

(**Carrie et al., 2012**) Carrie I, van Kan GA, Gillette-Guyonnet S, Andrieu S, Dartigues JF, Touchon J, et al. Recruitment strategies for preventive trials. The MAPT study (Multidomain Alzheimer Preventive Trial). J Nutr 2012;16:355–9.

(**Cerejeira et al., 2012**) J. Cerejeira,1, L. Lagarto, and E. B. Mukaetova-Ladinska, Behavioral and Psychological Symptoms of Dementia, Front Neurol. 2012; 3: 73.

(**Collette et al., 1999**) Collette, Fabienne et al. (1999). Phonological loop and central executive functioning in Alzheimer's disease. Neuropsychologia. 37. 905-18

(**Crawford et al., 2005**) Crawford, T.J., Higham, S., Renvoize, T., Patel, J., Dale, M., Suriya, A. et al. (2005). Inhibitory control of saccadic eye movements and cognitive impairment in Alzheimer's Disease. Biological Psychiatry, 57, 1052–1060.

(**Crutcher et al., 2009**) Crutcher MD, et al. Eye tracking during a visual paired comparison task as a predictor of early dementia. Amer. J. Alzh. Disease & Other Dem. 2009.

(**Desmet et al., 2012**) Desmet, P.M.A., Vastenburg, M.H., Van Bel, D., & Romero, N. (2012) Proceedings of 8th International Design and Emotion Conference London 2012 Central Saint Martins College of Art & Design, 11-14 September 2012.

(**Fishbein & Ajzen, 1975**) Fishbein, M., & Ajzen, I. (1975). Belief, attitude, intention, and behavior: an introduction to theory and research. Reading, Mass.: Addison-Wesley Pub.

(**Fletcher & Sharpe, 1988**) W. A. Fletcher, J. A. Sharpe, Smooth pursuit dysfunction in Alzheimer’s disease, Neurology 38 (1988)

(**Forbes et al., 2013**) Forbes, Dorothy; et al. (2013a): Exercise programs for people with dementia. In: Cochrane Database Syst Rev 12/CD006489

(**Graessel et al., 2011**)Graessel, E. et al. (2011): Non-pharmacological, multicomponent group therapy in patients with degenerative dementia: a 12-month randomizied, controlled trial. In: BMC Med 9/129.

(**Kanske & Kotz, 2011**) P Kanske, SA Kotz. Human brain mapping 32 (2), 198-208, 2011

(**Kasl-Godley & Gatz, 2000**) Kasl-Godley J1, Gatz M. (2000) Psychosocial interventions for individuals with dementia: an integration of theory, therapy, and understanding dementia.

(**Kaufmann et al., 2010**) L. D. Kaufman, et al. Antisaccades: A probe into the dorsolateral prefrontal cortex in Alzheimer’s disease. a critical review, .J.of Alzheimer’s Disease..

(**Kivipelto et al., 2013**) Kivipelto M, Solomon A, Ahtiluoto S, Ngandu T, Lehtisalo J, Antikainen R, et al. The Finnish Geriatric Intervention Study to Prevent Cognitive Impairment and Disability (FINGER): Study design and progress. Alzheimers Dement 2013;9:657–65.

(**Korczak et al., 2013**) Korczak, D. et al. (2013): Wirksamkeit von Ergotherapie bei mittlerer bis schwerer Demenz. HTA-Bericht 129, Köln.

(**Kuskowski, 1988**) M. A. Kuskowski, Eye movements in progressive cerebral neurological disease, in: Neuropsychology of Eye Movements, Hillsdale, N.J., c.w. johnston and f.j. pirozzolo, editors edition, 1988, p. 146176.

(**Lagun et al., 2011**) Lagun, D., Manzanares, C., Zola, S.M., Buffalo, E.A., Agichtein, E. (2011). Detecting cognitive impairments by eye movement analysis using automatic classification algorithms, Journal of Neuroscience Methods, pp. 196-203.

(**McCallum et al., 2013**) McCallum, Simon; Boletsis, Costas. "Dementia Games: A Literature Review of Dementia-Related Serious Games". Serious Games Development and Applications - Lecture Notes in Computer Science 2013; Springer.

(**Milner & Ettlinger, 1972**) Milner, A. D., & Ettlinger, G. (1972). Response latencies in go, no-go discrimination performance by monkeys. Neuropsychologia. Vol., 10(3), 375-378.

(**Naglie et al., 2011**) Naglie, G., Hogan, D. B., Krahn, M., Black, S. E., Beattie, B. L., Patterson, C., … Tomlinson, G. (2011). Predictors of family caregiver ratings of patient quality of life in Alzheimer disease: cross-sectional results from the Canadian Alzheimer’s Disease Quality of Life Study. The American Journal of Geriatric Psychiatry : Official Journal of the American Association for Geriatric Psychiatry, 19(10), 891–901. http://doi.org/10.1097/JGP.0b013e3182006a7f

(**National Collaborating Centre for Mental Health, 2011**) National Collaborating Centre for Mental Health. (2011). Dementia: The NICE – SCIE Guideline on Supporting People with Dementia and their Carers in Health and Social Care. Practice (Vol. 2011). The British Psychological Society.

(**Ngandu et al., 2015**) Ngandu T, Lehtisalo J, Solomon A, Levalahti E, Ahtiluoto S, Antikainen R, et al. A 2 year multidomain intervention of diet, exercise, cognitive training, and vascular risk monitoring versus control to prevent cognitive decline in at-risk elderly people (FINGER): A randomised controlled trial. Lancet 2015;385:2255–63.

(**Norton et al., 2014**) Norton, S.; et al. (2014): Potential for primary prevention of Alzheimer's disease: an analysis of population-based data. In: Lancet Neurol 2014/13.

(**Olanrewaju et al., 2015**) Olawale Olanrewaju, Linda Clare, Linda Barnes, Carol Brayne (2015). A multimodal approach to dementia prevention: A report from theCambridge Institute of Public Health, Alzheimer's & Dementia: Translational Research & Clinical Interventions 1 (2015) 151-156.

(**Reitan, 1958**) Reitan RM. Validity of the Trail Making test as an indicator of organic brain damage. Percept Motor Skills 1958; 8: 271-276.

(**Richard et al., 2009**) Richard E, Van den Heuvel E, Moll van Charante EP, Achthoven L, Vermeulen M, Bindels PJ, et al. Prevention of dementia by intensive vascular care (PreDIVA): A cluster-randomized trial in progress. Alzheimer Dis Assoc Disord 2009;23:198–204.

(**Shafiq-Antonacci et al., 2003**) Shafiq-Antonacci, R., Maruff, P., Masters, C., & Currie, J. (2003). Spectrum of saccade system function in Alzheimer disease. Arch Neurol, 60(9), 1272-1278.

(**Simpkins, 2008**) Simpkins, L. K., Antisaccades: A Probe Into the Dorsolateral Prefrontal Cortex in Alzheimer's Disease, Master's Thesis, University of Toronto, 2008.

(**Stroop, 1935**) R. Stroop: Studies of interference in serial verbal reactions. Journal of Experimental Psychology 18 (1935) 643–662.

(**Sütterlin et al., 2011**) Sütterlin, Sabine; Hoßmann, Iris; Klingholz, Reiner; Entwicklung, Berlin-Institut für Bevölkerung und (2011): Demenz-Report, Berlin.

(**White et al., 1983**) O. B. White, J. A. Saint-Cyr, R. D. Tomlinson, J. A. Sharpe, Ocular motor deficits in Parkinson's disease, Brain 106 (1983) 571 –587.