The Advanced Activities of Daily Living: a tool allowing the evaluation of subtle functional decline in Mild Cognitive Impairment

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Running title: functional decline in MCI

Abstract:

Objectives

Assessment of advanced activities of daily living (a-ADL) can be of interest in establishing the diagnosis of Alzheimer's disease (AD) in an earlier stage, since these activities demand high cognitive functioning and are more responsive to subtle changes. In this study we tested a new a-ADL tool, developed according to the International Classification of Functioning, Disability and Health (ICF). The a-ADL tool is based on the total number of activities performed (TNA) by a person and takes each subject as his own reference. It distinguishes a total Disability Index (a-ADL-DI), a Cognitive Disability Index (a-ADL-CDI), and a Physical Disability Index (a-ADL-PDI), with lower score representing more independency. We explored whether these indices allow distinction between cognitively

healthy persons, patients with Mild Cognitive Impairment (MCI) and patients with mild AD.

Methods

Participants were on average 80 years old (SD 4.6; 66-90), were community dwelling, and were diagnosed as (1) cognitively healthy subjects (n=26); (2) patients with MCI (n = 17), or (3) mild AD (n = 25), based upon extensive clinical evaluation and a set of global, cognitive, mood and functional assessments. The a-ADL-tool was not part of the clinical evaluation.

Results

The a-ADL-CDI was significantly different between the three groups ($p<.01$). The a-ADL-DI was significantly different between MCI and AD ($p<.001$). The tool had good psychometrical properties (inter-rater reliability; agreement between patient and proxy; correlations with cognitive tests). Although the sample size was relatively small, ROC curves were computed for the a-ADL-DI and a-ADL-CDI with satisfactory and promising results.

Conclusion

The a-ADL-CDI and a-ADL-DI might offer a useful contribution to the identification and follow up of patients with mild cognitive disorders in an older population.

Conflict of interest declaration: none

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Introduction

Mild Cognitive Impairment (MCI) has been defined as a condition of cognitive deterioration that is more pronounced than expected for age, but clearly not as severe as in dementia [1-3]. While activities of daily living (ADL) are most often impaired in dementia, they should remain relatively intact in MCI. Nevertheless, several studies have demonstrated subtle but obvious problems in MCI patients for more complex ADL [4-7]. Therefore, the extent of limitations in ADL is part of the diagnostic differentiation between normal cognitive ageing, MCI and dementia.

ADL can be stratified according to difficulty and complexity in three levels of functioning [8]. Basic ADL (b-ADL) are defined as the activities meeting the basic physiological and self maintenance needs. Instrumental ADL (i-ADL) are essential, together with b-ADL, to maintain independent living. Advanced ADL (a-ADL) are more sophisticated activities, beyond those necessary to live independently. When trying to establish the diagnosis of Alzheimer's disease (AD) in an early stage, assessment of a-ADL can be of great interest since these activities demand high cognitive functioning and are, therefore, more responsive to subtle changes [9-11]. However, at this moment it is still uncertain which domains of functioning may be impaired and to what extent. While b-ADL and i-ADL tend to be rather stable across populations, a-ADL are highly culture and gender specific and influenced by personal choices, making them difficult to evaluate [8]. Moreover, it should be ascertained that a-ADL impairment is due to cognitive deficits, and not to co-morbidities and physical impairments, commonly present in older patients [2], or to social or environmental circumstances [12]. With the increased use of new technologies in housekeeping and other activities [13], there is a need for assessment tools with up-to-date items. Presently, the commonly used instruments often fail to capture the subtle impairments encountered in MCI. Although several relevant studies were carried out the past years [4, 11, 14-20], at this moment there are neither age-specific norms for levels of functioning, nor normal rates of functional decline available.

The on-going study reports on an up-to-date tool to evaluate a-ADL aiming to contribute to the identification of MCI. It was designed according to the International Classification of Functioning, Disability and Health (ICF), the leading framework and facilitator for clinical practice and research [12, 21-23]. Here we evaluate this new a-ADL tool for its (1) feasibility, (2) content validity, (3) reliability of the scoring system, (4) construct validity and (5) predictive validity.

Participants and methods

Participants and data-collection

Three groups of consecutive participants were recruited: (1) apparently cognitively healthy older persons, (2) patients with MCI and (3) patients with mild AD. All participants attended the geriatric day hospital at the Universitair Ziekenhuis Brussel or Ghent University Hospital, were 65 years of age or older, and community dwelling. Exclusion criteria were: any acute pathology, sensory or communicative impairments which precluded them from participating, and any other pathology of the central nervous system.

The study was approved by the local Ethical Committee of the involved hospitals and all patients gave written informed consent. All data were collected in accordance with the Declaration of Helsinki.

Patients with MCI or AD

Forty-two consecutive patients with a clinical diagnosis of MCI (n = 17) or mild AD (n = 25) were included. For the MCI group, the criteria as defined by the International Working Group on MCI [2] were used. The AD group met the criteria for dementia according to Diagnostic and Statistical Manual of Mental Disorders Forth version (DSM-IV) [24] or National Institute of Neurological and Communicative Disorders and Stroke and the Alzheimer's Disease and Related Disorders Association (NINCDS-ADRDA) [25]. All patients underwent a complete diagnostic procedure [26] and were evaluated with Mini Mental State Evaluation (MMSE) [27], Cambridge Examination for mental disorders of the elderly, Cognitive part (CamCog) [28], Geriatric Depression Scale (GDS) [29], Neuropsychiatric Inventory Questionnaire (NPI-Q) [30], b-ADL according to Katz et al. [31], (modified version, with scores expressed as percentage where 100% represents complete dependency) and i-ADL according to Lawton et al. [32, 33], (a modified gender specific version, expressed as percentage where 100 % represents complete dependency; for men a 6 item version (ability to use telephone, shopping, transportation, handling medication, handling finances an handyman work), for women a 8 item version (food preparation, housekeeping, laundry, ability to use telephone, shopping, transportation, handling medication and finances)), completed with a physical evaluation, inventory of co-morbidities and medication use, extensive laboratory blood testing and imaging of the brain (CT scan or MRI).

Cognitively healthy older people

The control group (n=26) was a sample of apparently cognitively healthy volunteers recruited in the community. They were assessed with the same evaluation methods as

the patients, except for the NPI-Q [30], extensive laboratory blood testing and imaging of the brain (CT scan or MRI). For their physical status, self-reports were used (co-morbidities and medication use). Exclusion criteria were any objective functional or cognitive deficit which could be suggestive for the diagnosis of MCI or AD (MMSE <25/30; CamCog <80/105).

Procedure

For the patient groups, assessments were performed by the usual professional workers at the day hospitals. The a-ADL tool under investigation was not part of the diagnostic process and was carried out by trained investigators who were blinded for the results of the other tests and the diagnosis of the subject. Preferably, data should also be obtained from the proxies since in cognitive assessment, informant report is considered as reliable [14], but for study purposes, data were obtained from both patients and proxies in order to evaluate the agreement between them. In random order, assessments of patient and proxy were performed by the same assessor. The apparently cognitively healthy volunteers were evaluated by the researchers, for the a-ADL tool and for the other tests.

The a-ADL measurement tool

Items of the a-ADL measurement tool

The measurement tool (see table 1) encompasses 49 activities, divided in 15 clusters according to the ICF [12], which were identified in a previous qualitative study of functional decline in a population with MCI [34]. The tool takes into account that a-ADL are highly individual and offers the possibility to evaluate activities, other than the 49 key a-ADL, that subjects might report.

Interview protocol

To guarantee the standardization of the instrument, an instruction session (approximately 1 hour) was organized for all raters, during which the structured interview guide and the scoring system were presented and also some interview techniques were clarified (e.g. use eliciting probes to let participants elaborate on their performance). First, the subject and/or proxy is asked whether the activity was ever performed during the years preceding the present problems (we suggested by thinking back to the years before problems occur). In this way, each of the 49 items is rated for its relevance for the individual in question. The activity is considered relevant if it is currently performed or if it was performed previously. Next, the subject is asked how the activities that have been identified as relevant are performed and, the observer assigns a score. Finally, the underlying cause of limited performance is rated, based on this story. In this study, the assessment was done by occupational therapists, but it can also be

administered by other health care workers with experience and knowledge on functionality in geriatrics.

Scoring of the a-ADL items

The rating system adopted the performance qualifiers of the ICF [12], a five-point scale, ranging from 0 (no difficulty to perform) to 4 (complete difficulty). Based on the results of the previous qualitative study [34], the qualifiers were operationalised (see table 2).

Underlying causes of limited performance

If performance scores are >0, the underlying reason (intrinsic or extrinsic) for the limitation is rated. Intrinsic factors are distinguished as cognitive (e.g. memory problems), intra-personal (e.g. switch in field of interest) or physical (e.g. mobility problems). The extrinsic factors are social (e.g. loss of partner) or environmental (e.g. car sold) reasons. It is possible to attribute more than one cause to the reported limitation in performance.

Indices

First, a 'global disability index' (a-ADL-DI) is calculated, taking into account the total number of activities (TNA) found relevant, the number of activities that are limited (LA) and the severity of the limitation (ICF scores). A 'cognitive disability index' (a-ADL-CDI) and 'physical disability index' (a-ADL-PDI) are computed, considering exclusively the activities that are limited because of respectively cognitive and physical problems. Activities in which the limitation is partly due to physical and partly due to cognitive reasons are included in both indices (a-ADL-CDI and a-ADL-PDI). As an example, the cognitive index reflects the proportion of limited activities due to cognitive reasons, multiplied by the severity of the limitations, relative to the TNA. The indices are expressed as percentages, with lower scores indicating less disability.

$$\text{a-ADL-DI}=\left(1-\left(\frac{TNA*4-\sum_{i=1}^{LA}LimAct_i*ICFscoreAct_i}{TNA*4}\right)\right)*100$$

$$\text{a-ADL-CDI}=\left(1-\left(\frac{TNA*4-\sum_{i=1}^{LA}LimActC_i*ICFscoreActC_i}{TNA*4}\right)\right)*100$$

$$\text{a-ADL-PDI}=\left(1-\left(\frac{TNA*4-\sum_{i=1}^{LA} LimActP_i * ICFscoreActP_i}{TNA*4}\right)\right)*100$$

with $LimAct_i$=the *i-th* limited activity (C=cognitive, P=physical), $ICFscoreAct_i$=the ICF-score corresponding to the *i-th* limited activity.

Example: a person previously performed 25 a-ADL activities (TNA-25). Score 0 is assigned to 5 of them, score 1 is assigned to 15 activities due to cognitive problems and score 4 is assigned to 5 other activities due to physical factors. This person's LA is 20. His a-ADL-DI is 35% (all limited activities are taken into account), the a-ADL-CDI is 15% (only the activities limited due to cognitive reasons are taken into account) and the a-ADL-PDI is 20%.

Clinimetric properties

Feasibility was checked by evaluating time use, transparency and comprehensibility in a sample of the first 30 subjects. Content validity was checked by calculating the prevalence of the reported a-ADL-items (expressed as a percentage) for the whole study group (N=68). The reliability of the scoring system was checked by (1) evaluating the agreement between patient and proxy for a-ADL-assessments of 11 MCI and 16 AD patients as they were present in the hospital (12 children, 12 partners, 3 missing), based on separate questioning of patient and the proxy; and by (2) assessing the inter-rater reliability by comparing the simultaneous observation of the a-ADL interview by two independent raters in a sample of 24 participants (11 healthy controls, 1 MCI patient, 6 AD patients and 6 proxies). In the absence of a true golden standard, construct validity was checked by (1) calculating correlations between the a-ADL-indices and the scales reflecting cognitive functioning (MMSE and CamCog) (N=68); we assumed that a-ADL-DI and a-ADL-CDI would show stronger relationships than a-ADL-PDI; and (2) evaluating differences between groups (N=68). We hypothesised for both indices that healthy persons would show less disability than people with MCI and the latest less than people with AD, but that the a-ADL-CDI would differ more than the a-ADL-DI. Predictive validity was evaluated by calculating the specificity and sensitivity for the indices (N=68).

Statistical analysis

Statistical analyses were done using IBM SPSS statistics 19.0 (SPSS Inc, Illinois, USA). Data are reported as medians and interquartiles. Since most datasets were not-normally distributed (Kolmogorov-Smirnoff Goodness of Fit test $p<.05$) or expressed on ordinal scales (b-ADL, i-ADL), non-parametric tests were used.

Patient-proxy agreement and inter-rater reliability were evaluated by computing intra class correlation coefficients (ICC, model 2, 1). Confidence intervals of 95 % are reported. The relationships between a-ADL indices and clinical outcomes were assessed using a Spearman's correlation coefficient. Differences between groups were tested by Kruskal-Wallis, Mann-Whitney U, Wilcoxon Signed Ranks or Chi-square Test. ROC curves were computed for the predictive validity. Significance was set a priori at two sided $p<0.05$. We considered a significance of 0.05 until 0.10 as a tendency.

Results

The participants

Table 3 shows the characteristics of the participants. Twenty-three men and forty-five women were included; thirty-three participants were living alone; there were no significant differences for gender and housing state between the three groups. Significant differences between the groups were observed for education (higher in control and AD compared to the MCI subjects); medication use (less in the control compared to MCI and AD subjects); co-morbidities (less in control than in AD); i-ADL (the controls being more independent than the MCI and the AD group and the MCI group being more independent than the AD group); and b-ADL (the healthy control group was less dependent than the AD group).

Prevalence of a-ADL items and distribution of the limitation scores

Table 1 shows the various a-ADL reported by the respondents. More than 50% of the participants reported at least 22 of the 49 a-ADL items as relevant. To play a music instrument was the activity with the lowest prevalence (4.4%). No extra a-ADL other than the 49 included in the list were reported. In table 3 the distribution of ICF scores compared to respectively TNA (ICF 0) or LA (ICF 1-4) within the diagnostic groups is shown. Score 0 and 3 differed significantly between the AD group and the other groups and score 1 showed a significant difference between all groups.

The indices

The results for the indices are shown in table 3. Healthy controls performed more activities (TNA) than patients with MCI or with AD; for patients with MCI there was a tendency towards having more activities than AD patients ($p=.070$). LA was significantly higher in AD patients than in the healthy controls and in MCI patients. The a-ADL-DI showed a significant difference between the AD group and the healthy controls and MCI group; between healthy controls and MCI patients a tendency was observed ($p=.099$). The a-ADL-CDI differed significantly between all groups with the healthy controls having

a better score than the MCI patients and the latter better than the AD patients. The a-ADL-PDI showed no significant difference between the groups.

Receiver Operating Characteristics Curves

Although preliminary due to small sample size, ROC curves were computed for a-ADL-DI and a-ADL-CDI, but not for the a-ADL-PDI since no significant difference between the groups was shown. For the a-ADL-DI the optimal cut-off was 24.7 % for distinguishing healthy controls from MCI yielding a sensitivity of 65 % and a specificity of 62 % (AUC .650); for MCI versus AD the optimal cut-off was 38.5 % yielding a sensitivity of 96 % and a specificity of 71 % (AUC .854); the optimal cut-off was at 42.4 % for distinguishing healthy controls from AD yielding a sensitivity of 92 % and a specificity of 92 % (AUC .965). For the a-ADL-CDI the optimal cut-off was 16.5 % for distinguishing healthy controls from MCI yielding a sensitivity of 71 % and a specificity of 73 % (AUC .724); for MCI versus AD the optimal cut-off was 32.8 % yielding a sensitivity of 79 % and a specificity of 71 % (AUC.809); the optimal cut-off was 23.3 % for distinguishing healthy controls from AD yielding a sensitivity of 92 % and a specificity of 100 % (AUC .982).

Time use and comprehensibility

Questioning took on average 33 ± 9 minutes (range 15-50), with higher interview times in the AD-group ($p<.01$). The investigators reported no problems with comprehensibility or tiredness of the subjects. All participants reported to have enjoyed the assessment.

Inter-rater reliability

The inter-rater reliability (n=24) was excellent for the a-ADL-DI ICC=.996, ($p<.001$; CI 95%:.991-.998), the a-ADL-CDI ICC=.979 ($p<.001$;CI 95%:.952-.991), and a-ADL-PDI ICC=.975 ($p<.001$;CI 95%:.942-.989). No significant difference between raters was observed (a-ADL-DI: rater 1 65; SD 19.4; rater 2 65.9; SD 20.5; a-ADL-CDI: rater 1: 16.7; SD 14.9; rater 2: 16.6; SD 14.3; a-ADL-PDI: rater 1: 9.6; SD 8.2; rater 2: 9.6; SD 8.2).

Agreement between patient and proxy

The overall agreement (a-ADL-DI) between patient and proxy (n=25) showed an ICC=.908 ($p<.001$;CI 95%: .792-.960), for the MCI-group (n=11) ICC=.825 ($p<.01$:CI 95%: .350-.953) and for the AD-group (n=14) ICC=.839 ($p<.01$;CI 95%: .498-.948).

Relationships of a-ADL indices with cognitive outcomes

As shown in table 4, the a-ADL-DI and a-ADL-CDI scores were strongly inter-related. The a-ADL-DI and a-ADL-CDI were significantly strongly related to the cognitive tests scores (MMSE, CamCog); the a-ADL-PDI score was weakly correlated to cognition. There was a significant correlation between the i-ADL and the a-ADL-DI and the a-ADL-CDI scores. Correlational analysis for each group separately did not show any significant correlations.

Discussion

In this study we tested a new a-ADL tool that was designed to be used in a population with mild cognitive disorders. The a-ADL evaluation tool results in a set of indices, based on the TNA and the extent of functional limitations. This technique has the advantage that it takes each subject as his own reference. The main point of interest was whether these indices allow distinction between cognitively healthy persons, patients with MCI and patients with mild AD. The a-ADL-DI showed a significant difference between MCI and AD and a tendency for a difference between the healthy controls and the MCI's. The a-ADL-CDI showed a significant difference between the three groups. The ROC curves, although preliminary due to the relatively small sample size, showed that it is possible to detect differences between healthy controls, persons with MCI and with AD. As expected, the a-ADL-CDI appears to be the more promising index for the identification of patients with MCI in an older population. The sensitivity and specificity of both indices has to be used with caution, but they are promising enough to warrant further research. Since MCI constitutes a heterogeneous group it also remains to be elucidated in a longitudinal study if the indices can predict who remains stable and who will convert to dementia or AD.

We, as well as others, assumed that a mild decline in cognitive capacities is accompanied by a certain decline in complex functioning [9-11]. In this study we found that a-ADL decline, measured by the a-ADL-DI and a-ADL-CDI correlated with cognitive decline as measured by MMSE and CamCog. As expected, the correlation was less pronounced with the physical index (a-ADL-PDI). Although the indices of the tool are based on the underlying nature of the impairment, the frequent coexistence of physical and cognitive disorders in an older population can be a difficulty in identifying the precise origin of the limitations. In order to reflect this clinical reality, activities can be assigned to different indices. Nevertheless, excellent values for the inter-rater ICC (all >.95) for the indices were found, indicating that the qualifiers were well operationalised, the scoring guidelines were clear and the instructions for the raters were sufficient.

Of the 49 a-ADL listed in the tool, 22 concerned the majority of the participants, while only 7 items were relevant for less than 20% of them. There were no extra,

unlisted a-ADL reported by our respondents. Nevertheless, the possibility to mention unlisted a-ADL, offered by blank fields in the questionnaire, may be useful for subjects with particular interests and anticipates the introduction of new technologies in daily life. Since all participants could rate at least 11 activities (TNA ranging from 11 to 40), the a-ADL tool can be used in a wide variety of subjects, regardless of gender, educational level or age. Moreover, the questioning was perceived by the participants as agreeable.

The scores for the various a-ADL differed between the diagnostic groups as expected. In general, higher ICF scores were observed in the AD group while mild scores were mainly observed in the healthy control group and MCI group. ICF4 appeared in all the groups because 'not performing at all' was mainly due to environmental factors, which occurred in all the groups equally. This underlines the importance of taking into account the underlying reason of limited performance and the separated indices in this tool. In future research the usefulness of the indices (e.g. the a-ADL-PDI) could be investigated in other populations such as sarcopenia, etc.

The TNA varied between groups, with the cognitively healthy persons mentioning more activities than the MCI patients, who mentioned more activities than those in the AD group. It has been reported that a diminished performance in cognitively demanding activities (e.g. reading books, playing games) is associated with increased risk for MCI [17]. Since here we explicitly asked the subjects if they had performed the activities in the years preceding their problems, our results are somehow surprising. One would, indeed, expect the TNA to be the same in the three groups. A possible explanation might be found in the brain/cognitive reserve theory [35], which states that the cognitive reserve protects against AD. Also, engaging in a-ADL could be seen as a marker for a healthy life-style and, therefore, performing a-ADL might have a beneficial influence by delaying the development of cognitive impairments. On the other hand, a potential recall bias might have led to an underestimation of the TNA in some of the patients. Another potential bias could be related to the fact that the data obtained from the healthy control group were all self-reported, whereas the data from the patient groups were also obtained from the proxies. This explanation seems less likely, given the high level of agreement between patients and proxies (ICC values >.80), which is also in line with results of other studies [14]This could be an important advantage in clinical practice, where a proxy is not always available. Another possible factor of influence on the TNA might have been the higher educational level observed in the healthy control group, which could have had an impact on the number of high-level activities.

We conclude that the scoring system of this new a-ADL tool allows capturing the mild changes in functioning occurring in mild cognitive problems. Taking into account the underlying reasons of functional problems and the weight of these problems, it can

distinguish normal aging-related decline from that seen in MCI and AD. Functional assessment is of utmost importance in the diagnosis of mild cognitive disorders. At this moment, to our knowledge, there is no other tool allowing reliable evaluation of the a-ADL. In clinical practice, evaluation of a-ADL is mainly done in a subjective way. Moreover, assessment of high level functioning might constitute an important predictor of conversion towards AD. Future research should address this issue.

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Table 1: advanced ADL-clusters with ICF-codes and description, scale items and N (%) performing the activity

	Cluster of activities	Description	Scale items	N (%) performing the item
1	Sophisticated kitchen activities d6301	Advanced cooking, complex meals with a large number of ingredients, using complex methods of preparation or making dinner with several courses; baking bread, cakes	Freezing or pickling vegetables	32 (47.1)
			Baking bread, cakes	23 (33.8)
			Cooking complex meals	45 (66.2)
			Try out new dishes	27 (39.7)
			Making jam	24 (35.3)
2	Household appliances and daily technology d6403	The use of electronically equipment inside and outside the house, including reading and understanding manuals	Magnetron	49 (72.1)
			Dish washer	26 (38.2)
			Oven	49 (72.1)
			Coffee machine	55 (80.9)
			Kitchen aid	20 (29.4)
			Washing machine	50 (73.5)
			Drying machine	33 (48.5)
			Radio / CD	59 (86.8)
			TV	64 (94.1)
			Video / DVD	38 (55.9)
			Camera	29 (42.6)
			Lawn mower	22 (32.4)
			Electric saw	13 (19.1)

			High pressure cleaner	9 (13.2)
			Use of manuals explaining daily technology	61 (89.7)
3	High level gardening d6505	To cultivate vegetables and special or rare plants		26 (38.2)
4	Cognitive stimulating activities or intellectual activities d166 & d9200	Playing games, reading books, etc…; to read professional literature, books and magazines in other languages, use of computer programs, use of an agenda	Puzzles and brainteasers	43 (63.2)
			PC programs	17 (25)
			Use of internet	15 (22.1)
			Use of agenda	51 (75)
			Reading books	47 (69.1)
			Reading professional or educational literature, other languages	14 (20.6)
			To write books, poems, articles	7 (10.3)
5	Craftwork and arts d6500 & d9203	Knitting, sewing, repairing clothes, reattaching buttons and fasteners; practicing arts like painting, sculpturing and others, playing music instruments	Crafts	25 (36.8)
			Playing music instrument	3 (4.4)
			Practicing arts	8 (11.8)
6	Complex economic activities or transactions d865	To be involved in some form of complex economic transactions like trading in commodities, the use of bank cards, 'money out the wall' system, PC-banking	Electronically banking, to pay electronically, to use money out of the wall system	60 (88.2)
			Complex administration and banking	43 (63. 2)
7	To communicate by using devices or techniques d360	The use of cell phones, corresponding through email	Using a cell phone	52 (76.5)
			Writing a mail or a letter	40 (58.8)

8	Sports d9201	To be engage in informal or organized sports: group activities and sporting on your own, e.g. fishing, ride a bicycle	Sports	18 (26.5)
			Riding bicycle	31 (45.6)
9	Transportation by motorized vehicles d475	To drive a car, motorcycle		49 (72.1)
10	Self development/self realization/self educational activities d9202 & d 810	To develop one self by formal or informal learning: attending a course, going to lectures, consuming arts (visiting exhibitions, musical performances)		42 (61.8)
11	To go on a holiday d920	Going on holiday, in an own cottage or participating in group trips		62 (91.2)
12	Caring for or assisting others d660 & d6506	To care for household members (mostly the partner), often by helping to handle medication, helping with bathing, dressing or assisting in transfers; or caring for (grand)children and to provide help in household tasks, to take care of pets, by feeding and cleaning them and exercising them	To help (in the business of) the children	11 (16.2)
			To take care of partner	7 (10.3)
			To take care of (great) grand children	27 (39.7)
			To take care of pets	28 (41.2)
13	Caring for household objects d560	Activities like painting, wallpapering rooms, fixing furniture, plumbing in the own place or in that of others		18 (26.5)
14	Semi professional work d855	To work as a volunteer, engaged in non-remunerative employment and performing 'semi professional work': social jobs, administration, accountancy, often as a continuation of ones profession		24 (35.3)
15	Engagement in organized social live or leisure activities d910 & d9250	Active participation in organized communities or societies by taking part in meetings, being member of the board, organizing activities for others or by participating in activities organized by others, like short trips and coffee moments; to be engaged in forms of activity only for amusement or relaxation, like to go out for diner with partner, children, friends and to visit family. All activities clustered in this category encompass a social factor by doing things just for the fun of being together, socializing	Organising events	52 (76.5)
			To make and keep appointments	67 (98.5)

			To take part in meetings, conversations	55 (80.9)
	Other			0 (0)

Table 2: scoring guidelines for the ICF qualifiers

ICF-Score	**Description**
0=NO problem	The activity is carried out completely independently; no help from others is needed. There are no limitations, the person carries out the activity in a normal frequency, is adequate, flexible, inventive and creative (e.g. the person is able to use all functions of technologic equipment).
1=MILD problem	The activity is carried out completely independently; no help from others is needed but mild limitations are present: less frequent use, more simplified form of the activity (e.g. only few functions of technologic equipment). The person needs more time, is slower, less energetic and has difficulties to learn something new. The person is less flexible, inventive and creative, more rigid.
2=MODERATE problem	The activity is carried out independently but sometimes help is needed. There are moderate limitations in performance; the person is less result oriented, less adequate. There are faults in performance.
3=SEVERE problem	The activity is carried out completely dependently; continuous help (guiding, support or effective help) from others is needed. The person experiences severe problems in performance.
4=COMPLETE problem	The person does not perform the activity at all.

Table 3: Participants' characteristics

median (inter quartile)	Healthy control n=26	MCI n=17	AD n=25
Age	79.5 (6.0)	77.7 (5.4)	82.7 (8.8)
Education in years	12.0 (6.0)	9.0 (3.0)^{A2}	9.0 (3.0)^{B2,C2}
Medication	2.0 (2.0)	5.0 (4.0)^{A3}	6.0 (7.0)^{C2}
Co morbidities	2.0 (2.5)	4.0 (3.0)^{A1}	5.0 (3.0)^{C2}
MMSE	29.0 (2.0)	27.0 (3.5)^{A3}	21.0 (3.5)^{B3,C3}
CamCog	95.0 (6.0)	85.5 (9.5)^{A3}	73.0 (18.5)^{B3,C3}
GDS-15	2.0 (2.0)	2.0 (2.0)	3.0 (5.0)
NPI-Q	/	8.5 (10.2)	15.5 (25.8)
b-ADL	25.0 (0.0)	25.0 (4.2)	25.0 (8.3)^{C1}
i-ADL	0.0 (4.2)	11.1 (15.3)^{A3}	25.0 (21.5)^{B2,C3}
TNA	30.5 (10.0)	24.0 (7.0)^{A3}	23.0 (8.5)^{C3}
LA	12.5 (6.0)	14.0 (10.0)	17.0 (6.5)^{B2,C2}
ICF0(%)	59.4 (13.7)	46.1 (37.2)	25.0 (19.5)^{B3,C3}
LA ICF1(%)	50.0 (43.6)	(23.5 (27.5)^{A1}	14.3 (23.5)^{B1,C3}
LA ICF2 (%)	13.4 (14.4)	14.3 (14.8)	16.7 (24.7)
LA ICF3(%)	0.0 (5.5)	0.0 (10.4)	14.3 (13.4)^{B2,C3}
LA ICF4(%)	25.0 (42.1)	42.8 (30.8)	50.0 (34.4)
a-ADL-DI	23.0 (9.6)	35.2 (32.2)	58.8 (24.7)^{B3,C3}
a-ADL-CDI	11.5 (10.7)	21.6 (28.3)^{A2}	46.0 (22.8)^{B2,C2}
a-ADL-PDI	4.3 (5.7)	10.2 (11.6)	11.2 (15.1)

MCI: Mild Cognitive Impairment; AD: Alzheimer's disease; MMSE: Mini Mental State Examination; CamCog: Cambridge Examination for mental disorders of the elderly, cognitive part; GDS-15: geriatric depression scale - 15 items; NPI-Q: Neuropsychiatric Inventory Questionnaire; ICF: International Classification of Functioning, Disability and Health score; b-ADL measured by Katz-scale; i-ADL as measured by Lawton-scale; TNA: Total number of activities; LA: Number of limited activities; ICF0(%): average proportion of activities without limitations; LA ICF1(%): average proportion of activities with a mild problem; LA ICF2(%): average proportion of activities with moderate problem; LA ICF3(%): average proportion of activities with a severe problem: LA ICF4(%): average proportion of activities with complete problem; a-ADL-DI: advanced Activities of Daily Living-Disability Index ;a-ADL-CDI: advanced Activities of Daily Living-Cognitive Disability Index; a-ADL-PDI: advanced Activities of Daily Living-Physical Disability Index; SD: standard deviation; † lower than normal scores for 1 participant due to a low education level.
Differences between groups tested with Kruskal-Wallis test, group by group tested with Mann-Whitney U test;
Differences between healthy control and MCI: ^{A}; Differences between MCI and AD: ^{B}; Differences between healthy control and AD: ^{C} ; Level of significance ^{1}: p<.05, ^{2}: p<.01, ^{3}: p<.001

Table 4: correlations between cognitive tests, b-ADL, i-ADL and a-ADL-indices

	MMSE	**CamCog**	**b-ADL**	**i-ADL**	**a-ADL-DI**	**a-ADL-CDI**	**a-ADL-PDI**
MMSE	1.00						
CamCog	.881**	1.00					
B-ADL	-.305*	-.261*	1.00				
I-ADL	-.799**	-.775**	.504**	1.00			
a-ADL-DI	-.714**	-.688**	.260*	.717**	1.00		
a-ADL-CDI	-.713**	-.688**	.196	.722**	.888**	1.00	
a-ADL-PDI	-.344**	-.309*	.133	.303*	.497**	.349**	1.00

MMSE: Mini Mental State Examination; CamCog: Cambridge Examination for mental disorders of the elderly, cognitive part; b-ADL: basic activities of daily living measured by Katz-scale; i-ADL: instrumental activities of daily living as measured by Lawton-scale; a-ADL-DI: advanced Activities of Daily Living-Disability Index ;a-ADL-CDI: advanced Activities of Daily Living-Cognitive Disability Index; a-ADL-PDI: advanced Activities of Daily Living-Physical Disability Index; * Spearman's correlation coefficient p<.05;**Spearman's correlation coefficient p<.01