Table 1. Demographic variables of the two patient groups

	DLB	AD	p value
Age at examination (y)	80.3 ± 5.8	78.5 ± 7.0	0.277
Education (y)	8.9 ± 2.8	9.7 ± 2.7	0.262
Sex (male:female)	18:11	8:25	0.004
MMSE	18.0 ± 6.7	17.3 ± 7.1	0.697
CDR	1.4 ± 0.8	1.4 ± 0.9	0.821
UPDRS (Part 3)	22.6 ± 20.9	6.9 ± 8.1	0.000
NPI	15.4 ± 13.2	11.8 ± 11.8	0.268
Fluctuations (N:Y)	14:15	25:8	0.035
Neuroleptics (N:Y)	17:12	30:3	0.006
Antiparkinsonians (N:Y)	25:4	32:1	0.176

Mean ± SD or N; MMSE = Mini-mental State Examination; CDR = clinical dementia rating; UPDRS = Unified Parkinson disease Rating Scale; NPI = neuropsychiatric inventory.

score, UPDRS score, NPI, and product score for each item between the two groups.

After comparing the product score for each item between the two groups, multiple regression analysis was conducted in order to investigate factors that most affected each eating problem item. In the stepwise multiple regression analysis, we assumed each item score to be a dependent variable and assumed that age, sex, MMSE score, CDR score, NPI score, UPDRS score, fluctuation, and usage of neuroleptic drugs were independent variables.

Results

Demographic variables of the two patient groups are summarized in Table 1. There were significant differences in the sex ratio, UPDRS score, presence of fluctuations in cognitive functioning, and use of neuroleptic drugs between the two groups. All the neuroleptic drugs used in both groups were atypical neuroleptics such as quetiapine. There was no significant difference in present body weight between the two groups. The scores (frequency × severity) for each symptom items between the two groups are summarized in Table 2. DLB patients scored significantly higher in items for "difficulty in swallowing foods," "difficulty in swallowing liquids," "coughing or choking when swallowing," "taking a long time to swallow," "suffering from sputum," "loss of appetite," "needs watching or help," and "constipation." There were no items for which AD patients scored significantly higher than DLB patients.

Multiple regression analysis was conducted for each of the items in which DLB patients scored significantly higher than AD patients. The results of the stepwise multiple regression analysis are summarized in Table 3. The UPDRS score significantly affected the "difficulty in swallowing foods" score; the UPDRS score, NPI score and CDR score significantly affected the "difficulty in swallowing liquids" score; no significant independent variable affected the "coughing or choking when swallowing" score; and the UPDRS score significantly affected the "taking a long time to swallow" score. No significant independent variables affected the "suffering from sputum" scor; the NPI score significantly affected the "loss of appetite" score; the UPDRS score significantly affected the "needs watching or help" score; and no significant independent variable affected "constipation" score.

Discussion

Our results indicated that DLB patients showed a higher incidence of eating/swallowing problems than AD patients, when matched for age, MMSE score, CDR score and education. As expected, most of the problems were involved in the swallowing domain: "difficulty in swallowing foods," "difficulty in swallowing liquids," "coughing or choking when swallowing," "taking a long time to swallow," "suffering from sputum," along with some problems in other domains such as "loss of appetite," "needs watching or help," and "constipation." Except for "needs watching or help", no problems in the eating habits domain and food preference domain were noted.

"Difficulty in swallowing foods" was affected only by UPDRS score, whereas "difficulty in swallowing liquids" was affected by UPDRS score, NPI score, and CDR score. This difference between swallowing foods (solid) and swallowing liquids (fluid) may reflect the difference in the underlying mechanism. Liquid has a shorter oral stage than solids, and the speed of flow into the pharynx

Table 2. The scores (frequency × severity) for each symptom domain in the two groups

	DLB	AD	p value
Swallowing problems			
Difficulty in swallowing food	1.71	0.03	0.002
Difficulty in swallowing liquids	0.61	0.03	0.043
Coughing or choking when swallowing	0.96	0.24	0.013
Taking a long time to swallow	1.57	0.00	0.000
Placing food in mouth but not chewing it	0.29	0.00	NS
Chewing food but not swallowing it	0.04	0.03	NS
Suffering from sputum	0.86	0.12	0.011
Fluctuation in swallowing ability	0.18	0.00	NS
Appetite change			
Loss of appetite	1.79	0.15	0.000
Increase in appetite	0.04	0.33	NS
Seeking out food between meals	0.00	0.64	NS
Overeating at meal time	0.07	0.03	NS
Reporting hunger or requesting more food	0.04	0.03	NS
Reporting being overfull	0.00	0.00	NS
Needs to limit food	0.00	0.12	NS
Fluctuation in appetite	0.64	0.03	NS
Food preference			
Preferring sweet foods more than before	0.07	0.18	NS
Drinking more soft or sweet drinks	0.07	0.06	NS
Drinking more tea/coffee or water	0.18	0.24	NS
"Taste" in food changed in some way	0.00	0.00	NS
Adding more seasoning to their food	0.04	0.00	NS
Developing other food fads	0.00	0.00	NS
Hoarding foods	0.00	0.00	NS
Drinking more alcohol	0.11	0.00	NS
Eating habits			
Wanting to cook or eat the same food every day	0.04	0.21	NS
Tending to eat foods in the same order	0.00	0.03	NS
Wanting to eat at the same time every day	0.00	0.00	NS
Decline in table manners	0.36	1.12	NS
Eating with hands	0.18	0.52	NS
Taking a long time to eat	1.32	0.42	NS
Getting drowsy at meal time	0.39	0.03	NS
Needs watching or help	2.32	0.00	0.000
Other eating behaviors			
Tending to overfill mouth	0.00	0.24	NS
Chewing or sucking without trying to eat	0.00	0.00	NS
Eating non-edible foodstuffs	0.25	0.18	NS
Tending to snatch or grasp any food items	0.00	0.27	NS
Becoming a heavier smoker or taking up smoking	0.00	0.00	NS
Episodes of vomiting	0.04	0.00	NS
Fever with a meal	0.21	0.00	NS
Constipation	3.39	0.21	0.000

is fastter (Logemann, 1988). Initiation of the deglutition reflex is likely to be delayed when swallowing liquids. It is difficult to swallow if the flow speed is faster than the swallowing movement. Difficulty in swallowing liquids is likely to occur in neuromuscular disease and pharyngeal disease (Feinberg and Ekberg, 1994). Our results for the relationship between NPI/CDR score and difficulty in swallowing liquids may suggest problems at the anticipatory stage in DLB patients. This idea is supported by the view that patients with attention disturbances have problems at the anticipatory stage and tend to develop swallowing difficulties (Feinberg *et al.*, 1992). The "difficulty in swallowing foods" item scored higher than the "difficulty in swallowing liquids" item indicating that problems in swallowing foods are more common than problems in swallowing liquids. However, swallowing liquids may require more accurate control of muscles and nerves than swallowing solids. Clinicians should

Table 3. Factors affecting each eating questionnaire item

DEPENDENT VARIABLES	SIGNIFICANT INDEPENDENT VARIABLES	β	p value
Difficulty in swallowing foods	UPDRS	0.501	0.009
Difficulty in swallowing liquids	UPDRS	0.72	0.000
	NPI	0.62	0.001
	CDR	−0.53	0.009
Coughing or choking when swallowing	–		
Taking a long time to swallow	UPDRS	0.435	0.026
Suffering from sputum	–		
Loss of appetite	NPI	0.435	0.027
Needs watching or help	UPDRS	0.529	0.001
Constipation	–		

CDR = clinical dementia rating; UPDRS = Unified Parkinson disease Rating Scale; NPI = neuropsychiatric inventory.

be aware of this difference in the mechanism, and should ask caregivers which problems are dominant when managing DLB patients.

It was noteworthy that only the NPI score affected "appetite loss." Visual hallucinations, which are the most common psychiatric symptom in DLB, may lessen a patient's appetite. It has been pointed out that visual hallucinations disturb patients' concentration while eating food (Kindell, 2002), which may explain why the NPI score affected "appetite loss." However, future assessment of the mechanism whereby psychiatric symptoms according to the NPI affect patients' appetite is required.

Multiple regression analysis demonstrated no significant independent variables affecting the "coughing or choking when swallowing" and "suffering from sputum" scores. EPS, psychiatric symptoms and severity of dementia did not affect these scores, and they may reflect some other mechanism such as autonomic dysfunction. No significant independent variables affected the "constipation" score, because constipation may be the direct result of autonomic dysfunction (Thaisetthawatkul *et al.*, 2004). A previous study noted that 83% of patients with pathologically confirmed DLB showed constipation (Horimoto *et al.* 2003), and our results also support this high frequency of constipation in DLB patients.

There are a few methodological issues that should be taken into consideration when interpreting our results. First, although we compared DLB and AD patients, we did not compare DLB and patients with Parkinson's disease without dementia. Therefore, it is still unclear whether our results are DLB-specific problems or problems common to both PD and DLB. Secondly, significantly more neuroleptic drugs were used in DLB patients. As DLB patients are very sensitive to such drugs, which may produce EPS and other adverse reactions (McKeith *et al.*, 1996; Ballard *et al.*, 1998), this use of neuroleptic drugs may result in a high frequency of swallowing and eating problems in DLB patients. However, use of neuroleptic drugs did not affect any items in the multiple regression analysis, and did not provoke severe neuroleptic sensitivity reactions under close supervision. For accuracy, we need to conduct further research comparing DLB and AD patients who do not use any drugs and their swallowing and eating problems, although it would be very difficult in a clinical and hospital-based setting. Thirdly, longitudinal changes in patients' weight were not recorded, and therefore we cannot discuss the difference in weight loss between the two groups in this study.

In conclusion, eating and swallowing problems were more frequent in patients with DLB than in patients with AD. Eating problems were relatively few in AD patients, at least at the mild stage, and this result is consistent with previous studies (Bozeat *et al.*, 2000; Ikeda *et al.*, 2002). Although DLB patients show many eating problems, the causes of each problem vary, and are not solely dependent on the severity of dementia or parkinsonism. It is necessary to be cautious about swallowing and eating problems in order to prevent accidents when managing DLB patients. For caregivers, it may be more difficult to understand eating/swallowing problems in neurodegenerative disorders than those related to vascular disease. Education of family caregivers and care staff about eating/swallowing problems in DLB patients is also important for clinicians.

Conflict of interest

None.

Description of authors' roles

S. Shinagawa collected the data, carried out the statistical analysis, and wrote the manuscript. H.

Adachi, Y. Toyota and T. Mori collected the data. I. Matsumoto and R. Fukuhara provided critical comments on an earlier draft of the paper. M. Ikeda designed the study and provided critical comments for an earlier draft of the paper.

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Regular Article

Correlation between a reduction in Frontal Assessment Battery scores and delusional thoughts in patients with Alzheimer's disease

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Aims: The purpose of the present study was to investigate the relationship between delusional thoughts (delusional ideation or misidentification) and frontal lobe function using the Japanese version of the Frontal Assessment Battery (FAB) bedside screening neuropsychological test in early stage Alzheimer's disease (AD) patients.

Methods: Forty-eight probable AD patients with Mini-Mental State Examination score ≧18 points and a clinical dementia rating score of either 0.5 or 1.0 were divided into two groups based on data obtained from interviews with their caregivers: a delusional thought group ($n = 19$) and a non-delusional thought group ($n = 29$). The FAB total and subtest scores were then compared for the two groups.

Results: Significant differences were found between the FAB total ($P < 0.01$) and subtest scores (similarities, motor series, conflicting instructions; $P < 0.05$) for the two groups. Multiple regression analysis showed that delusional thought was significantly associated with the FAB total score.

Conclusions: In addition to episodic memory disorders, a reduction in the FAB score may reflect frontal lobe dysfunctions, including executive function, in patients with AD, leading to delusional ideation.

Key words: Alzheimer's disease, delusional ideation, Frontal Assessment Battery, misidentification.

ALZHEIMER'S DISEASE (AD) is mainly characterized by episodic memory disorders, visuospatial impairments, and executive dysfunction.[1,2] With the progression of neuropathology or cognitive decline, delusional ideation or misidentification are frequently seen as behavioral and psychological symptoms of dementia (BPSD).[3] AD with psychosis (delusional ideation or misidentification and hallucination) occurs in approximately 30–60% of patients with AD.[4–6] Regarding the type of delusion experienced by AD patients, several studies have reported delusions of theft, persecution, infidelity, and abandonment.[4–7] Delusional misidentifications such as believing that one's house is not one's home, that one's spouse is an imposter, and that televised images are actually present in the house have also been reported.[4–7] Delusions in AD patients can create a distressful burden on their caregivers and can trigger or predict nursing home placement or death.[8,9]

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Therefore, the assessment of delusions in AD patients is considered important, and some studies have investigated the incidence and risk factors for delusions in AD patients.[10,11]

In demented patients, the manifestation of psychosis, such as delusional thought or hallucination, is considered to result from the development of executive dysfunction.[12–14] Frontal lobe function involves executive function and, reportedly, is significantly correlated with the total Frontal Assessment Battery (FAB) score.[15–17] A previous study reported that the FAB score reflects frontal lobe dysfunction, including executive dysfunction, and is an easily administered test that can be completed at the bedside within 10 min.[15,17] The FAB screening neuropsychological test consists of six subtests involving comparatively simple tasks that do not require any tools.[17] FAB scores significantly differed between patients with frontotemporal dementia and those with AD, but MMSE scores did not, therefore the validity of FAB reflected frontal lobe function, as indicated in a study of two different types of brain region degeneration.[18]

With regards to neuroimaging, studies using single-photon emission computed tomography have found hypoperfusion in the bilateral dorsolateral frontal cortex, right anterior cingulate gyrus, inferior–middle temporal cortices, and right posterior parietal region in AD patients with delusional thoughts or psychosis.[19–21] Blackwood *et al.* reviewed and stated that the presence of 'reality distortion', which leads to persecutory delusions, was correlated with the cerebral blood flow in the left lateral prefrontal cortex, ventral striatum, superior temporal gyrus, and parahippocampal region,[22] and a positron emission tomography study found hypometabolism in the right prefrontal cortex and left medial occipital region in AD patients with delusional thoughts.[23,24] Although various disputable results have been demonstrated in such previous studies, some neuroimaging studies support a relationship between neuropsychological frontal lobe dysfunction and delusional thoughts in patients with AD.[23,20]

The FAB has not been previously reported as a tool for performing neuropsychological evaluations in AD patients with delusional thoughts. In the present study we used the Japanese version of the FAB[25] to investigate the relation between the manifestation of delusional thoughts and frontal lobe dysfunction in patients with AD.

METHODS

Participants

Forty-eight consecutive Japanese subjects (16 men, 32 women; average age, 77.2 ± 7.0 years; range, 59–88 years) who had been referred to the Jikei University Kashiwa Hospital outpatient clinic were enrolled in this study. All patients were diagnosed as having probable AD based on the National Institute of Neurology and Communicative Disorder and Stroke/Alzheimer disease and Related Disorder Association (NINCDS/ADRDA) criteria;[26] all diagnoses were made after evaluations of the patients' past medical history, physical or neurological examinations, routine blood tests, and magnetic resonance imaging findings. To recruit patients with early stage AD, we selected patients with a clinical dementia rating (CDR) of either 0.5 or 1.0 and a Mini-Mental State Examination (MMSE) score of ≥18 points.[27] The subjects were then divided into two groups: a delusional thought (DT) group, and a non-delusional thought (NDT) group. The manifestation of delusions was assessed based on information obtained from a structured interview with each patient's caregiver, and the delusions were rated using the delusion scale of Behavioral Pathology in Alzheimer Disease (Behave-AD).[28] Patients were excluded if history of other neurological disease, brain injury, substance abuse, major depressive or psychotic disorder, epilepsy, delirium, metabolic disorder or treatment with acetylcholine esterase inhibitor were noted.[29] The present study was approved by the Ethics Committee of the Jikei University School of Medicine, and informed consent was obtained from all the subjects or their caregivers.

Assessment of delusional thought

To determine whether the patients had delusional thoughts, we utilized the delusional scale of Behave-AD (total behavioral or psychological problems scale). This scale was completed based on the results of an interview with each patient's caregiver, who was asked whether the patient had experienced any of the following delusions in the previous 4 weeks: (i) 'people are stealing things'; (ii) 'my house is not my home'; (iii) 'my spouse (or other caregiver) is an imposter'; (iv) delusion of abandonment; (v) delusion of infidelity; (vi) suspiciousness of other people; and (vii) any other delusions.

Table 1. Subject characteristics (mean ± SD)

	DT ($n = 19$)	NDT ($n = 29$)	P
Sex (M/F)	8/11	12/17	n.s.
Age (years)	77.7 ± 8.0	77.7 ± 7.5	n.s.
Education (years)	10.4 ± 3.0	11.6 ± 1.8	n.s.
Duration of illness (months)	19.4 ± 14.3	20.3 ± 17.2	n.s.
MMSE score	22.0 ± 2.7	23.3 ± 2.2	n.s.
FAB score*	11.6 ± 2.8	13.9 ± 2.5	<0.01

*Significant difference: $P < 0.01$ (t-test).
Sex ratio was analyzed on χ^2 test.
DT, delusional thought; FAB, Frontal Assessment Battery; MMSE, Mini Mental State Examination; NDT, non-delusional thought.

FAB assessment

The Japanese FAB version consists of six subtests: (i) similarities (conceptualization); (ii) lexical fluency (mental flexibility); (iii) motor series (programming); (iv) conflicting instructions (sensitivity to interference); (v) go–no go (inhibition control); and (vi) prehension behavior (environmental autonomy). Each subtest is rated from 3 to 0, with the total score therefore ranging from 18 to 0.

Statistical analysis

Data were analyzed using SPSS 11.0 J for Windows (SPSS Japan Inc). Age, education (years), duration of illness (months), MMSE score, and FAB scores were compared between the two groups using unpaired independent sample t-tests. The sex ratio was assessed using a χ^2 test. Logistic regression analysis was conducted to examine delusional thought, with age, sex, education, duration of illness, FAB total score, and MMSE score as independent variables.

RESULT

Patient characteristics

The 48 AD patients were divided into a DT group ($n = 19$) and an NDT group ($n = 29$). These two groups were not significantly different with regard to sex, age, duration of illness (months), education (years), or MMSE scores (Table 1).

FAB total and subtest scores

The FAB total scores were significantly different between the two groups, whereas the other examined variables were not ($P < 0.01$; Table 1). The FAB total score of the DT group was 11.6 ± 2.8 (mean ± SD), while that in the NDT group was 13.9 ± 2.5 (mean ± SD). Furthermore, several FAB subtest scores (similarities, motor series, and conflicting instructions) were significantly lower in the DT group than in the NDT group ($P < 0.05$; Table 2). Logistic regression showed that the FAB scores ($P = 0.048$), but not the MMSE scores ($P = 0.507$), significantly influenced the manifestation of delusional thoughts in an independent manner (Table 3).

Table 2. FAB subtest scores (mean ± SD)

	DT	NDT	P
Similarities*	0.73 ± 1.04	1.48 ± 1.12	<0.05
Lexical fluency	1.84 ± 0.90	2.03 ± 0.90	n.s.
Motor series*	1.68 ± 1.29	2.51 ± 0.78	<0.05
Conflicting instructions*	2.47 ± 0.70	2.90 ± 0.409	<0.05
Go–no go	1.47 ± 1.17	2.00 ± 1.22	n.s.
Prehension behavior	2.84 ± 0.38	2.82 ± 0.54	n.s.

*Significant difference: $P < 0.05$ (t-test).
DT, delusional thought; FAB, Frontal Assessment Battery; NDT, non-delusional thought.

Subtypes of delusional thought

The subtypes of delusional thought are listed in Table 4. Although 19 patients had experienced delusional thoughts, most of the patients had experienced several types of delusional thoughts. Among the 19 patients with delusional thoughts, the 'people are stealing things' delusion (12 patients) was the most frequent delusion. 'Suspiciousness' ideation was

Table 3. Multiple logistic regression analysis: influence on delusional thoughts

Variable	OR	95% CI	P
Age	0.991	0.895–1.098	0.867
Sex	1.883	0.402–8.820	0.422
Education (years)	1.094	0.846–1.414	0.494
Duration of illness (months)	1.030	0.981–1.081	0.239
MMSE score	1.111	0.862–1.432	0.417
FAB score*	1.287	1.008–1.643	0.043

*Significant difference: $P < 0.05$.
CI, confidence interval; FAB, Frontal Assessment Battery; MMSE, Mini Mental State Examination; OR, odds ratio.

Table 4. Types of delusional ideation

Delusional ideation	No. patients
1. 'People are stealing things' delusion	12
2. 'One's house is not one's home' delusion	0
3. 'Spouse is an imposter' delusion	0
4. 'Delusion of abandonment'	3
5. 'Delusion of infidelity'	4
6. 'Suspiciousness' ideation	10
7. Other delusion	7

reported in 10 patients, 'delusion of infidelity' was reported in four patients, and 'delusion of abandonment' was reported in three patients. None of the patients in the present series experienced delusional misidentification: either 'one's house is not one's home' or 'spouse (or other caregiver) is an imposter'. 'Other' delusions experienced by the patients were envy delusion in four patients, hypochondriac delusion in two patients, erotomania in one patient, and TV syndrome ('images on the television are actually present in the house') in one patient.

DISCUSSION

The present results showed that the FAB total and subtest scores (Similarities, Motor series, and Conflicting instructions) were significantly lower in AD patients with delusional thoughts than in those without delusional thoughts. Dubois *et al.* reported that the FAB scores were significantly correlated with the number of criteria and the number of perseverative errors on the Wisconsin Card Sorting Test (WCST), which was established to measure executive function.[17] The WCST is considered to be sensitive to executive dysfunction[30] and evaluates both conceptual ability and behavioral regulation.[31]

In previous studies, dementia patients with psychosis were characterized as having greater executive and visuoperceptual impairments in their neuropsychological functioning patterns.[13,14] The present study showed that a decrease in the FAB score, including executive dysfunction, but not the MMSE score, was related to delusional thoughts. The MMSE has a few items of executive function but is heavily weighted toward orientation or memory items.[18] Therefore, impairments in frontal lobe function, including executive function, rather than episodic memory or orientation disorder might be strongly related to the manifestation of delusional thoughts.

Of the six FAB subtests, the Similarities subtest includes the function of abstract reasoning, which can also be investigated using card-sorting tasks and proverb interpretation.[17] Subjects have to conceptualize or integrate the links between some objects from the same category. In previous studies, patients with psychosis showed specific impairments on task requiring complex integration, that is, the capacity to form an overall impression by holding various fragments of information.[31,32] Therefore, AD patients with delusional thoughts might manifest as the result of inaccurate memory with poor insight related to executive dysfunction, leading to errors in logic and comparing internal experiences with reality.[13,23] The Motor series subtest measures the capacity to execute a sequence of actions successively in separate tasks; it resembles the 'first-palm-edge' task in Luria's motor series.[17] The Conflicting instruments subtest resembles the Stroop test task and requires the capacity to perform a contrary reaction to each of two pattern directions.[17] In order to carry out both tasks effectively, self-correcting or monitoring capacity that evaluates whether subject himself could perform the tasks accurately are required. Previous studies reported that alternations in self-monitoring were associated with psychosis with evidence of specificity for delusional ideation.[31,33,34] Therefore, such impairments of self-correcting system might lead to delusion in AD patients in the present study.

Regarding the subtypes of delusional thoughts, the present study indicated that the 'people are stealing things' delusion and 'suspiciousness' ideation occurred frequently, similar to that found in previous studies.[20,23] In contrast, typical delusional misidentification, such as 'one's house is not one's home' and 'one's spouse is an imposter', were not reported in the present study. Previous studies have reported that approximately 40–50% of delusional thoughts in patients with AD are delusional misidentifications.[4,20,35] Lower levels of cognitive functions and lower average scores on cognitive tests, such as the MMSE, have been reported for AD patients with delusional misidentifications, compared with those with persecutory delusions.[4,35]

The limitations of the present study included the relatively small sample size and the use of only two neuropsychological tests: the FAB and the MMSE. If simple scales or tests measuring attentional, visuospatial function, or semantic memory had also been used, significant differences might have been obtained. The present study was limited to subjects with early stage AD whose MMSE scores were ≧18 points and who had a CDR of either 0.5 or 1.0 because even though the FAB tasks can be performed without tools or instruments, the tasks do contain relatively complex question forms that include several steps.

In spite of these limitations, the present study supports the hypothesis that frontal lobe dysfunction might be related to delusional ideation or misidentifications in patients with AD, supporting the results of neuropsychological and neuroimaging studies. Moreover, these results suggest that a simple neuropsychological screening test reflecting frontal lobe function and including mainly executive function – such as the FAB – might be useful for predicting the manifestation of delusional thoughts in patients with AD, providing important information regarding the selection of treatment stages that will reduce the early burden of caregivers.

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ORIGINAL ARTICLE

Differentiation between amnestic-mild cognitive impairment and early-stage Alzheimer's disease using the Frontal Assessment Battery test

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Abstract

Background: Previous research has described the executive dysfunction that occurs in patients with amnestic-mild cognitive impairments (A-MCI) and early-stage Alzheimer's disease (EAD), which are comparatively similar stages of dementia. The aim of the present cross-sectional study is to evaluate executive dysfunction using the Frontal Assessment Battery (FAB) screening test in two groups and to investigate the interaction with other cognitive impairments.

Methods: Among 170 consecutive patients with Alzheimer's disease or A-MCI, we recruited 48 subjects who were under 75 years of age and had been diagnosed as having either A-MCI or EAD. We then compared the total and the subtest scores of the mini-mental state examination (MMSE) and the FAB between the two groups. Moreover, we investigated the statistical interactive associations of the FAB subtest scores with the influential MMSE subtest scores or the diagnosis (A-MCI or EAD).

Results: No significant differences in the age, sex ratio, duration of illness, and education years were observed between the two groups. However, significant differences in the FAB total and subtest scores (conflicting instructions and go/no-go) were found between the two groups. Furthermore, significant differences in the MMSE total and subtest scores (orientation, memory delayed recall, and attention and calculation) were also noted between the two groups. In a generalized linear model analysis, only two FAB subtest scores (conflicting instructions and go/no-go) were significantly influenced by the diagnosis (A-MCI or EAD) in a manner that was independent of the interaction with the orientation or memory delayed recall.

Conclusion: The present findings suggest that the FAB total score and subtest scores reflecting interference performances (conflicting instructions and go/no-go) significantly declined in patients with EAD, independent of the disorientation and memory disorder. Such characteristics of neuropsychological screening test scores may be useful to clinicians for differentiating EAD and A-MCI at bedside.

Key words: *Alzheimer's disease, amnestic-mild cognitive impairment (A-MCI), executive function, Frontal Assessment Battery (FAB), non-memory.*

INTRODUCTION

Alzheimer's disease (AD) is a progressive neurodegenerative disorder that is mainly characterized by memory disorder (episodic and recent memory), visuospatial and attentional impairment, and executive dysfunction as its core symptoms.[1,2] Amnestic-mild cognitive impairment (A-MCI) is characterized by subjective forgetful complaints and a mild mnemonic reduction in neuropsychological tests; it has been considered as a prodromal state of AD.[3] Longitudinally, about 30% of A-MCI patients progress or develop clinically diagnosable AD within three years, but about 60% of them do not and instead maintain the MCI stage as non-dementia.[4,5] Thus, it may be important to diagnose patients with A-MCI who are at risk of developing AD in order to prevent its conversion into dementia. However, A-MCI is difficult to discriminate clinically from early-stage AD (EAD), which has a similar symptomatic spectrum and represents a similar stage of dementia both cross-sectionally and temporarily.[1,2]

In previous studies investigating executive dysfunction in AD or A-MCI, a significant decline in motor programming and inhibition control among some executive functions was reported in AD patients, compared with patients with A-MCI.[1,6–8] Thus, an evaluation of executive dysfunction among non-memory impairments between A-MCI and AD may be important for effectively diagnosing these disease groups. From neurocognitive aspects, some studies have examined the pathogenesis of executive dysfunction and have investigated the association with other cognitive impairments, although a crucial conclusion has not yet been reached.[1,9]

The Frontal Assessment Battery (FAB), consisting of six main components, is an easily administered screening test that can be completed at bedside within 10 minutes and can be used to measure executive function without tools or instruments.[10] Kugo *et al.* and Nakaaki *et al.* confirmed the validity and reliability of the Japanese version of the FAB for patients with dementia and reported a strongly significant correlation between the FAB and the Wisconsin Card Sorting Test, which is the representative neuropsychological test reflecting executive function.[11,12] Hanyu *et al.* reported significant differences in the FAB total and subtest scores between A-MCI and AD patients in two groups and demonstrated the utility of the FAB for diagnosis of some screening tests.[6]

In the present study, we compared the FAB total and subtest scores between patients with A-MCI and those with EAD so as to differentiate these two groups, which have similar stages of dementia, using a screening test that reflects executive function. Moreover, we investigated the interaction with the mini-mental state examination (MMSE) subtest scores, a representative neuropsychological screening test that reflects disorientation, memory impairment, or attention deficits, and assessed the influence of other cognitive functions on executive function in patients with A-MCI or EAD.

METHODS

Participants

One hundred seventy consecutive patients with AD and A-MCI who had been referred to the Jikei University Kashiwa Hospital (Chiba, Japan) outpatient clinic were enrolled in this study. After an examination of the patients' past medical history, an evaluation of their physical or neurological examination results, routine blood tests, and MRI findings by a geriatric psychiatrist, all the patients were diagnosed as having probable AD or A-MCI according to the National Institute of Neurology and Communicative Disorder and Stroke/Alzheimer Disease and Related Disorder Association criteria or the diagnostic criteria for A-MCI.[3,13] The exclusion criteria were a history of alcohol or other substance abuse, brain injury, major depressive or psychotic disorder, epilepsy, delirium, metabolic disorder, or treatment with acetylcholine esterase inhibitor. Our A-MCI group included both A-MCI-single domain and A-MCI-multiple domain types.[3] Among them, we recruited 48 patients (24 men, 24 women; 48–74 years) with A-MCI (n = 26; A-MCI-single domain, n = 18; A-MCI-multiple domain, n = 8) or EAD (n = 22). To evaluate general cognitive function, the MMSE and Wechsler Memory Scale-Revised (WMS-R) or the Japanese version of the Neurobehavioural Cognitive Status Examination (J-COGNISTAT) were used as a standardized test battery.[14] In the present study, A-MCI was defined as the presence of subjective forgetfulness, a global clinical dementia rating score of 0.5, an MMSE score $\geqq$ 24 points,[15] and either a WMS-R general memory score $\leqq$ 85 or a J-COGNISTAT memory score $\leqq$ 7 (moderate impairment). Moreover, we selected EAD patients whose global clinical dementia rating scores were 0.5 or 1.0 and whose MMSE scores were $\geqq$ 18 points.[1] These neuropsychological tests were administered by two clinical psychologists. Finally, four geriatric psychiatrists discussed the results of all the patients' diagnoses once a month to exclude other forms of dementia, such as vascular dementia, frontotemporal lobar degeneration, Lewy body disease, or idiopathic normal pressure hydrocephalus. The present study was approved by the Ethics Committee of the Jikei University School of Medicine.

FAB and its subtests

The Japanese version of FAB consists of six subtests: (i) similarities (conceptualization); (ii) lexical fluency (mental flexibility); (iii) motor series (programming); (iv) conflicting instructions (sensitivity to interference); (v) go/no-go (inhibition control); and (vi) prehension behaviour (environmental autonomy). Each subtest is rated from 3 to 0, with the total score therefore ranging from 18 to 0.[10]

Statistical analysis

SPSS 19.0J for Windows (SPSS Japan Inc, Tokyo, Japan) was used for all the statistical analyses. Age, years of education, duration of illness, MMSE total and representative five subtest scores reflecting memory impairment or attention deficit ((i) orientation (time and place), (ii) memory registration, (iii) memory delayed recall, (iv) attention and calculation and (v) three-stage commands score), and FAB total and subtest scores score were compared using a one-way ANOVA with Tukey's post-hoc test between the two groups: A-MCI and EAD. The sex ratio was assessed using a χ^2 test. Furthermore, a generalized linear model analysis was performed to examine the contribution or interactions between the MMSE subtest scores and the diagnosis (EAD or A-MCI) as independent variables of the FAB subtest scores. A P-value < 0.05 was considered statically significant.

RESULTS

Patient characteristics

Forty-eight subjects were enrolled in the present study, and Table 1 shows the demographics of this sample and statistical comparisons between the A-MCI and EAD groups. No significant differences in age, sex ratios, duration of illness (months), or education (years) were observed between the two groups. However, the FAB scores ($P < 0.01$) and the MMSE scores ($P < 0.001$) were significantly different between the two groups (Table 1).

The comparison of FAB and MMSE subtest scores

In the FAB subtest, the conflicting instructions ($P < 0.01$) and go/no-go ($P < 0.01$) scores were significantly lower among the patients with EAD than among those with A-MCI (Table 2). Among the four MMSE subtests representatively reflecting memory impairment or attention deficit, three subtest scores, orientation ($P < 0.001$), memory delayed recall

Table 1 Subject characteristics (mean ± SD)

Group	A-MCI (n = 26) (Mean ± SD)	EAD (n = 22) (Mean ± SD)	χ^2 or F score	P-value
Sex (male/female)	15 / 11	9/ 13	0.1343†	0.247
Age	68.7 ± 5.7	69.5 ± 4.9	0.269	0.606
Education (years)	12.9 ± 2.0	12.0 ± 2.5	2.228	0.142
Duration of illness (months)	21.5 ± 20.1	26.4 ± 16.9	0.821	0.37
MMSE score	26.9 ± 2.1	21.5 ± 2.9	56.732	**<0.001*****
FAB score	14.7 ± 2.2	12.3 ± 3.1	10.159	**0.003****

**$P < 0.01$, ***$P < 0.001$ (one-way ANOVA with post-hoc test). †χ^2 score. Sex ratio was analyzed by χ^2 test. A-MCI, amnestic-mild cognitive impairment; EAD, early-stage Alzheimer's disease; FAB, Frontal Assessment Battery; MMSE, mini-mental state examination.

Table 2 FAB subtest scores (mean ± SD)

Subtest	A-MCI (n = 26) (Mean ± SD)	EAD (n = 22) (Mean ± SD)	F score	P-value
Similarities	2.08 ± 1.09	1.68 ± 1.17	1.46	0.233
Lexical fluency	2.23 ± 0.71	1.77 ± 0.87	4.038	0.05
Motor series	2.50 ± 0.91	2.32 ± 0.95	0.461	0.5
Conflicting instructions	2.96 ± 0.20	2.55 ± 0.74	7.643	**0.008****
Go/no-go	2.19 ± 0.80	1.27 ± 1.08	11.473	**0.001****
Prehension behaviour	2.73 ± 0.67	2.73 ± 0.63	0	0.985

**$P < 0.01$ (one-way ANOVA with post-hoc tests). A-MCI, amnestic-mild cognitive impairment; EAD, early-stage Alzheimer's disease; FAB, Frontal Assessment Battery.

Table 3 The MMSE subtest scores (mean ± SD)

Subtest	A-MCI (n = 26) (Mean ± SD)	EAD (n = 22) (Mean ± SD)	F score	P-value
Orientation (time, place)	9.00 ± 1.23	6.71 ± 1.95	2.3898	**<0.001********
Memory registration	2.92 ± 0.27	3.00 ± 0	1.676	0.202
Memory delayed recall	2.38 ± 0.80	1.14 ± 1.21	18.272	**<0.001********
Attention and calculation	3.77 ± 1.11	2.57 ± 1.69	8.547	**0.005****
Three-stage commands	3.00 ± 0.00	2.90 ± 0.3	2.62	0.112

**P < 0.01, ***P < 0.001 (one-way ANOVA with post hoc-tests). A-MCI, amnestic-mild cognitive impairment; EAD, early-stage Alzheimer's disease; MMSE, mini-mental state examination.

Table 4 Association of (a) conflicting construction and (b) go/no-go with memory delayed recall and diagnosis

Statistical comparison	d.f.	Mean-squares	F score	P-value
(a) Memory delayed recall	3	0.295	1.095	0.362
Diagnosis (A-MCI or EAD)	1	1.294	4.813	**0.034***
Memory delayed recall × diagnosis	3	0.454	1.69	0.185
(b) Memory delayed recall	3	0.964	1.03	0.39
Diagnosis (A-MCI or EAD)	1	6.94	7.417	**0.01†**
Memory delayed recall × diagnosis	3	0.151	0.161	0.922

*P < 0.05, R^2 = 0.257. Generalized linear models were used to investigate whether memory delayed recall and diagnosis (A-MCI or EAD) were associated with the conflicting construction scores. †P < 0.05, R^2 = 0.259. Generalized linear models were used to investigate whether memory delayed recall and diagnosis (A-MCI or EAD) were associated with the go/no-go scores. A-MCI, amnestic-mild cognitive impairment; EAD, early-stage Alzheimer's disease.

(P < 0.001), and attention and calculation (P < 0.01), were significantly lower among the patients with EAD than among the patient with A-MCI (Table 3).

Interactive associations of the conflicting instructions and go/no go scores with the MMSE subtest scores or diagnosis (EAD or A-MCI)

To examine whether the MMSE subtest scores and diagnoses were associated with either the conflicting instructions or the go/no-go score as a dependent variable, we defined each MMSE subtest score (orientation, memory delayed recall, and attention and calculation) and diagnosis (A-MCI or EAD) as independent variables and performed a generalized linear analysis (one variable). As a result, we found that both the conflicting instructions and the go/no-go scores were significantly associated with only the diagnosis (conflicting instructions: F = 4.813, d.f. = 1, P = 0.034; go/no-go: F = 7.417, d.f. = 1, P = 0.01), but not with the memory delayed recall score (range: 0–3; conflicting instructions: F = 1.095, d.f. = 3, P = 0.362; go/no-go: F = 1.03; d.f. = 3; P = 0.39) (Table 4). Moreover, the interaction between the delayed recall and diagnosis significantly influenced neither the conflicting instructions nor the go/no-go scores (conflicting instructions: F = 1.69, d.f. = 3, P = 0.185; go/no-go: F = 0.167, d.f. = 3, P = 0.922) (Table 4). Additionally, we divided the subjects into the following three graded groups according to their orientation scores: 0–4 points, severe impairment; 5–7 points, moderate impairment; or 8–10 points, mild impairment. The subjects were also divided according to their attention and calculation scores: 0–1 points, severe impairment; 2–3 points, moderate impairment; or 4–5 points, mild impairment. These scores were regarded as independent variables. The groups were then used in a generalized linear analysis to investigate the association with conflicting instructions and go/no-go scores. The conflicting instructions and the go/no-go scores were significantly associated with only the diagnosis (conflicting instructions: F = 8.092, d.f. = 1, P = 0.007; go/no-go: F = 11.128, d.f. = 1, P = 0.002), but not with the orientation score (conflicting instructions: F = 1.892, d.f. = 2, P = 0.163; go/no-go: F = 1.218; d.f. = 2; P = 0.306) (Table 5). The interaction between the orientation and the diagnosis did not significantly influence either the conflicting instructions or the go/no-go scores (conflicting instructions: F = 0.154, d.f. = 1, P = 0.697; go/no-go: F = 0.149, d.f. = 1, P = 0.702) (Table 5). Neither the conflicting instruments nor the go/no-go scores were significantly associated with attention and calculation (conflicting instructions:

Table 5 Association of (a) conflicting construction and (b) go/no-go with diagnosis and orientation

Statistical comparison	d.f.	Mean-squares	*F* score	*P*-value
(a) Orientation severity (mild, moderate, severe)	2	0.5	1.892	0.163
Diagnosis (A-MCI or AD)	1	2.137	8.092	**0.007****
Orientation × diagnosis	1	0.041	0.154	0.697
(b) Orientation severity (mild, moderate, severe)	2	1.075	1.218	0.306
Diagnosis (A-MCI or AD)	1	9.826	11.128	**0.002††**
Orientation × diagnosis	1	0.131	0.149	0.702

**$P < 0.01$ $R^2 = 0.216$. Generalized linear models were used to investigate whether the orientation severity and diagnosis (A-MCI or AD) were associated with the conflicting construction scores. ††$P < 0.01$, $R^2 = 0.248$. Generalized linear models were used to investigate whether the orientation severity and diagnosis (A-MCI or AD) were associated with the go/no-go scores. Orientation severity: mild, raw score of 8–10; moderate, raw score of 5–7; severe, raw score of 0–4. A-MCI, amnestic-mild cognitive impairment; AD, Alzheimer's disease.

Table 6 Association of (a) conflicting construction and (b) go/no-go with the diagnosis and attention and calculation

Statistical comparison	d.f.	Mean-squares	*F* score	*P*-value
(a) Attention and calculation severity (mild, moderate, severe)	2	0.709	2.775	0.074
Diagnosis (A-MCI or EAD)	1	0.521	2.04	0.16
Attention and calculation × diagnosis	1	0.086	0.335	0.566
(b) Attention and calculation severity (mild, moderate, severe)	2	1.894	2.286	0.114
Diagnosis (A-MCI or EAD)	1	3.329	4.017	0.051
Attention and calculation × diagnosis	1	1.259	1.52	0.224

(a) Generalized linear models were used to investigate whether attention and calculation severity and diagnosis (A-MCI or EAD) were associated with the conflicting construction scores. Attention and calculation severity: mild (raw score: 4 or 5), moderate (raw score: 2 or 3), severe (raw score: 0 or 1). $R^2 = 0.242$. (b) Generalized linear models were used to investigate whether attention and calculation severity and diagnosis (A-MCI or EAD) were associated with the go/no-go scores. Attention and calculation severity: mild (raw score: 4 or 5), moderate (raw score: 2 or 3), severe (raw score: 0 or 1). $R^2 = 0.294$. A-MCI, amnestic-mild cognitive impairment; EAD, early-stage Alzheimer's disease.

$F = 2.775$, d.f. = 2, $P = 0.074$; go/no-go: $F = 2.286$, d.f. = 2, $P = 0.114$) (Table 6). Furthermore, an interaction between the diagnosis and attention and calculation did not influence the conflicting instruments and go/no-go scores (conflicting instructions: $F = 0.335$, d.f. = 1, $P = 0.566$; go/no-go: $F = 1.52$, d.f. = 1, $P = 0.224$) (Table 4).

DISCUSSION

In the present cross-sectional study, we found a significant difference in the total FAB and subtest scores (conflicting instructions and go/no-go scores) between the A-MCI and EAD groups. Significant differences in the MMSE total and subtest scores reflecting attention and memory function were also observed between the two groups. Moreover, the two FAB subtest scores (conflicting instructions and go/no-go) were significantly influenced only by the diagnosis (A-MCI or EAD) and not by the interaction with memory impairment or disorientation. These results support the a previous study's finding that, among the FAB subtest scores, the go/no-go score was significantly different between patients with A-MCI and those with AD, while executive dysfunction in EAD was not influenced by other cognitive impairments.[6,9] On the other hand, some studies have suggested that deficits in responses to the interference or inhibitory tasks might result from psychomotor speed decrements or selective attention deficits.[11,16–19] Therefore, if simple scales or tests measuring attentional function had been administered, significant differences might have been observed. However, the present results may show the usefulness of the go/no-go and conflicting instructions scores among the FAB tests as a screening evaluation for differentiating A-MCI and EAD, without confounding interactions from memory impairment or attention deficit.

Some previous neuropsychological studies have confirmed the reliability and validity of FAB by measuring the executive function in various patients with dementia and comparing them with healthy controls.[11,12] FAB is one of the easiest tests to administer and can be completed at bedside without requiring any tools or instruments; it consists of six main cognitive components that are reportedly associated with different anatomical frontal regions.[10] In several neuroimaging studies using single-photon emission CT and comparing patients with dementia and healthy controls, the FAB scores were significantly correlated with regional cerebral blood flow in the left lateral frontal lobe, right medial frontal lobe, and bilateral callosomarginal area.[20,21] In a cortical volumetric study, we reported that parahippocampal gyrus and entorhinal cortex atrophy in patients with EAD or A-MCI was associated with the go/no-go score among the FAB subtest scores.[22] Collette *et al.* also implied that a disconnection syndrome may exist in EAD patients, based on the results of neuroimaging studies showing an association between inhibitory dysfunction as executive dysfunction and the cerebral regions, except for the frontal lobe.[18,23] While the association between memory impairment in AD patients and hippocampal atrophy has been confirmed in previous studies, the association with executive function continues to be discussed, and a conclusion has not yet been reached.[24–28] Therefore, these pathways of pathogenesis should be elucidated in future studies.

The present study has some limitations. Firstly, among 170 consecutive outpatients, we restrictively selected 48 subjects so as to compare only the neuropsychological test scores between the two groups without any additional statistically confounding factors, such as age, sex, duration of illness, and years of education. Thus, the sample size was comparatively small, and a significant difference in the illness duration (months) between the two groups might not have been apparent. Second, only subjects under the age of 75 years were enrolled. One reason for this limitation was that we used either the J-COGNISTAT (n = 12) or the WMS-R (n = 14) evaluation test to support the diagnosis of A-MCI (n = 26). The WMS-R test is designed for use in subjects between the ages of 16 and 74 years. Moreover, we hoped to recruit comparatively younger homogeneous subjects in two groups and to exclude various physical problems or disadvantageous factors arising from aging because of the explosive increase in the prevalence dementia after the age of 75 years.[29] Thirdly, to support the diagnosis, only one test, either the J-COGNISTAT or the WMS-R, was used, according to the wishes of the patients (who did not desire to spend the time necessary to complete further tests at bedside). Thus, we could not statistically compare any scores other than the FAB and MMSE scores between the two groups. Therefore, we should have used only one neuropsychological test in all the subjects. Finally, the present study has a cross-sectional design, and longitudinal observations of the subjects were not performed. Thus, the use of FAB scores as a risk factor for the conversion of A-MCI to AD should be examined longitudinally in the future.

In conclusion, these results support the findings of previous studies, which cross-sectionally showed significant differences in the FAB total and subtest scores between patients with AD and those with A-MCI. Moreover, among the FAB subtests, the conflicting instructions and go/no go scores were useful for differentiating between EAD and A-MCI, independent of attentional and memory functions. Therefore, in daily examinations, the observation of executive dysfunction as non-memory impairments using the FAB test as a screening tool may be important and helpful for clinicians diagnosing A-MCI and EAD at bedside.

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RESEARCH ARTICLE

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Differences in perceptions regarding driving between young and old drivers and non-drivers in Japan

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Objective: The issue of driving cessation for dementia patients is one of the urgent public health priorities in Japan and is often complicated, with family or social barriers yet to be sufficiently addressed. Because the possibility of dementia or family caregiving can befall anyone, we focused on the disparity in people's perceptions of driving as possible barriers. The present study aimed to assess perceptions of driving among the general public and examine differences in perceptions based on age and driving status.

Methods: A survey was conducted in a sample of the general public aged 40 and over in Japan. Respondents were 1010 people who received a self-administered questionnaire that included questions regarding perceptions about driving and sociodemographic factors.

Results: The drivers that participated in this study tended to highly agree that 'driving is a "right" which we all deserve', compared with the non-drivers. The most common reason for reluctance to stop driving among drivers was the possible loss of personal mobility. Apart from transportation, older drivers were more likely than younger drivers to value the qualitative aspects of driving, for example, driving was viewed as 'a motivating factor in my life'.

Conclusions: These disparities in the general public's perceptions about driving may be possible family or social barriers to driving cessation in the case of drivers with dementia. Our findings also suggest that when addressing the need for driving retirement, not only mobility but also the qualitative aspects of driving be paid more attention. Copyright © 2010 John Wiley & Sons, Ltd.

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Introduction

The number of older drivers has been increasing dramatically as Japan's population ages. People aged 65 and older account for 21% (27 million) of the total population in Japan. The number of licensed drivers over 65 ('older drivers') exceeded 11 million in 2007, accounting for 14% of the total drivers of all ages. The number of drivers in the older population is about 40% which is much lower than the 80% in the younger population under age 60 who drive. However, automobiles are nonetheless a practical form of transportation for older people, and driving can play a key role in maintaining independence.

Given that advanced age is associated with a higher risk of chronic diseases as well as physical, sensory and cognitive impairments, older drivers are considered to be vulnerable to having motor vehicle crashes (Anstey *et al.*, 2005). Indeed, during 2008 in Japan, the traffic accident rate was estimated at 863 cases per 100 thousand older drivers, the third highest after 1685 cases in the 16–24 age group and 1036 cases in the 25–29 age group (Traffic accidents situation, National Police Agency (NPA), 2009). Moreover, the accident rate among drivers under age 65 tended to decrease in the past decade, whereas that among older drivers remained at a high level.

Thus, the Japanese government has enforced a traffic safety campaign targeting older drivers and has paid special attention to older drivers suffering from dementia, who are considered a high-risk group. In 2002, Section 103 of the Road Traffic Act was amended. In the amended Act, dementia was included as a reason for license revocation, stating that if a driver is found to be 'demented', his/her driving license shall be revoked (Arai Y and Arai A, 2005; Arai Y, 2006). Such efforts can lead to raising the national profile of driving and dementia. However, there are several challenges related to implementation of the Act. It is not easy to identify drivers who suffer from dementia without guidelines and mandatory reports from physicians. In addition, without a clear consensus regarding the progressive decline of cognitive functions, it is difficult to decide when drivers should stop driving (Arai Y, 2006; Hirono, 2006). This has raised concern that many drivers may continue to drive after onset of dementia, as reported in previous studies (Odenheimer, 1993; Dobbs *et al.*, 2002; Adler and Kuskowski, 2003; Herrmann *et al.*, 2006).

The NPA reported that nationwide only 192 drivers had their driver's licenses revoked due to dementia over the last four years since the law was amended. Moreover, the most common reason for license revocation was 'concerns of family members' (133 cases), which was followed by 'police activity' (e.g., handling a traffic accident) (59 cases) ('Older drivers: introduction of cognitive assessments' (Japanese), *The Daily Police News*, 20 October 2006). Our previous study regarding family caregivers of current and former drivers who had dementia ($n = 21$) showed that a primary reason for driving cessation among former drivers was because 'family caregivers discovered the patient was driving dangerously' (48%), followed by 'patients and family caregivers were persuaded by physicians' (14%), 'traffic accidents' (14%), and 'other' (2%) (Arai A *et al.*, 2006). Cotrell and Wild (1999) demonstrated that either the patient or caregiver was responsible for decisions regarding driving status in most cases of those with Alzheimer's disease (AD) who stopped driving. Similarly, Perkinson *et al.* (2005) reported from focus-group interviews that most of the stakeholders with respect to driving by persons with AD believed that family members had primary responsibility for identifying and dealing with unsafe drivers. Thus, family members of dementia patients play a pivotal role in decision-making regarding patients' driving and in supporting the eventual goal of driving cessation.

However, the decision of driving cessation is often complicated for longtime drivers, and even more so for those with dementia and their family caregivers for a number of reasons: (1) rejection by drivers due to the symptoms of dementia such as memory impairment or unawareness of deficits; (2) rejection by drivers due to a strong need to drive, i.e., because it is a necessary form of transportation; and (3) conflicts between drivers and their family members due to different perceptions about driving such as opinions as to what driving means to the person who is driving. These reasons, including ones which are not necessarily related to dementia, can hinder driving cessation from occurring at the most appropriate time, jeopardizing personal and public safety.

Although much of the literature has focused on examining the medical and non-medical predictors of driving cessation in older adults with dementia (Wackerbarth and Johnson, 1999; Adler and Kuskowski, 2003; Carr *et al.*, 2005; Herrmann *et al.*, 2006), little is known about what kinds of difficulties exist between dementia patients and family members with respect to patients' driving cessation. As Carr *et al.* (2006) have suggested, research is needed regarding family or social barriers that may delay driving cessation in older adults with dementia.

The family or social barriers might be, in part, the result of disparities of perceptions regarding driving between dementia drivers and family members. Different perceptions about driving may cause family conflicts, posing possible barriers to achieving driving retirement at the most appropriate time. Furthermore, family caregiving can befall anyone; most individuals are susceptible to the possibility of suffering dementia or becoming family caregivers. It is thus important to explore perceptions among the general public, with the expectation that the findings would provide implications for drivers with dementia and their family caregivers. In addition, it can be useful information to allow the public to better understand and get involved in addressing issues of driving and dementia. We therefore aimed to explore the perceptions of driving in a sample of the general population and examine the differences of perceptions from age and driving status viewpoints.

Design and methods

In October 2007, we conducted a survey among the general public aged 40 and over in Japan. Participants were selected from a research panel organized by Social Survey Research Information (SSRI) Co., Ltd. The panelists, who were recruited from the general population and were willing to participate in surveys, included 31 050 persons aged 40 or over. Each person eligible for this panel was competent in reading and answering a series of self-administered questionnaires distributed by the SSRI; therefore, the quality of this research panel was assured and responses were valid and reliable. All panelists lived independently in communities. If we found that more than one panelist resided in the same household, we limited participation to only one member from that household. Of the 1191 who agreed to participate in this study, 1010 were randomly selected to fit into predetermined categories by a quota sampling method (Moser and Kalton, 1989). This quota sampling method has been used in previous studies (Arai Y *et al.*, 2005; Arai Y *et al.*, 2008). The quota controls used in the present study were gender, age group, driving license status, and place of residence (urban: population $\geq$ 500 000, suburban: 100 000 to < 500 000 or rural: < 100 000) based on Japan's national statistics. Although there were similar distributions of most of the sociodemographic characteristics compared with Japanese population statistics, there was a slightly higher proportion of study participants who lived in a household with two or more generations, had higher education, or were or used to be administrative workers.

Each subject received a self-administered questionnaire that requested information about sociodemographic factors (e.g., education, annual household income, employment status, and living arrangement), driving status (drivers: those who had a driver's license and frequently drove, and those who had a driver's license and rarely drove; non-drivers: those who did not have a driver's license), and perceptions related to driving.

Perceptions about driving

We asked all participants including drivers and non-drivers to identify how they perceived 'driving' using the following question based on a previous study by Perkinson *et al.* (2005): 'Do you think that driving is a "right" which we all deserve'? We also asked only the frequent drivers (i.e., those who had a driver's license and frequently drove) about possible barriers to driving cessation using the following question: 'Assuming you have to stop driving, what would be the reasons, if any, for your reluctance to do so'?

The former question was answered by a four-point Likert scale (agree, agree somewhat, disagree somewhat, disagree), while the latter was a multiple choice question in which participants chose all the answers that applied from 15 items created by the authors (a psychiatrist and public health specialist: YA and AA).

Statistical analyses

Multiple logistic regression models were used to compare the older group (65+ years) and younger group (40–64 years), and the drivers and non-drivers, on their perceptions of driving, adjusting for potential confounding factors such as age group/driving status, gender, place of residence, education, annual household income, living arrangement, and employment status. The associations between the probability of each reason for feeling reluctance to stop driving and the age group were evaluated by calculating the crude odds ratios (ORs) and the ORs adjusted for potential confounding factors, including gender, place of residence, education, annual household income, living arrangement, and employment status using the logistic regression models. All calculations were performed using SAS version 9.1.3 for Windows (SAS Institute Inc., Cary, NC).

Results

Table 1 shows the characteristics of the respondents ($n = 1010$) by age group and driving status. Most of the older drivers were men; further, the older age group had fewer years of education and lower annual household incomes than the younger age group. The younger drivers were more likely to be employed and lived in households with two or more generations present. The younger participants also tended to live in urban areas. Most of the drivers in both age groups frequently drove.

Regarding how the participants perceived 'driving', the largest number of older drivers agreed that 'driving is a "right" which we all deserve' (Table 2). Perceptions of driving did not significantly differ between the age groups. However, we found that the drivers tended to regard 'driving' as a deserved right compared with the non-drivers after controlling for potential confounders.

As shown in Table 3, 'It would be difficult for me to go out' (65.8% of the total) was the most common reason given for reluctance to stop driving among the frequent drivers, followed by 'It would be difficult for my family members to go out' (43.0%), 'Loss of something I enjoy' (29.2%), and 'A driver's license is

