Journal of the International Neuropsychological Society (2000), **6**, 265–270.

Conceptual apraxia in probable Alzheimer's disease as demonstrated by the Florida Action Recall Test

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(Received October 21, 1997; Revised November 11, 1998; Accepted November 25, 1998)

Abstract

Patients with probable Alzheimer's disease (AD) often have difficulties associated with semantic knowledge. Therefore, conceptual apraxia, a defect of action semantics and mechanical knowledge, may be an early sign of this disease. The Florida Action Recall Test (FLART), developed to assess conceptual apraxia, consists of 45 line drawings of objects or scenes. The subject must imagine the proper tool to apply to each pictured object or scene and then pantomime its use. Twelve participants with Alzheimer's disease (NINCDS–ADRDA criteria) and 21 age- and education-matched controls were tested. Nine Alzheimer's disease participants scored below a 2-standard-deviation cutoff on conceptual accuracy, and the three who scored above the cutoff were beyond a 2-standard-deviation cutoff on completion time. The FLART appears to be a sensitive measure of conceptual apraxia in the early stages of Alzheimer's disease. (*JINS*, 2000, *6*, 265–270.)

Keywords: Apraxia, Conceptual apraxia, Ideational apraxia, Alzheimer's disease, Semantic

INTRODUCTION

Limb apraxia, hereafter referred to as apraxia, is a loss of ability to perform skilled purposive movements that cannot be attributed to elemental sensory or motor deficits (Heilman & Rothi, 1993). Liepmann (1905/1980) posited that voluntary motor actions were initiated by the idea of an action and the translation of that concept into kinesthetic motor programs. Current models of praxis knowledge posit two major components: productive and conceptual (Roy & Square, 1985). The productive component includes the spatial and temporal codes needed for the performance of skilled purposive motor actions, and the impairment of this component leads to ideomotor apraxia (Rothi et al., 1991). Ideomotor apraxia leads to errors of spatial or temporal coding. Ideational apraxia refers to deficits in sequential organization of actions (e.g. prepare a letter for mailing, light a candle from a matchbook; Poeck 1983). The conceptual domain involves associative and mechanical knowledge about tools (i.e., manipulable objects) and actions. The associative realm involves the relationships between tools and their actions (e.g., knife–cut) and between tools and the objects they act upon (e.g., knife–bread). The mechanical realm involves understanding the advantage that tools afford in completing certain tasks. Deficits in the mechanical realm include the inability to solve mechanical problems or construct novel tools. Impairments related to the praxis conceptual system lead to conceptual apraxia (Ochipa et al., 1992; Rothi et al., 1991).

Conceptual apraxia is most commonly associated with left hemisphere injury (Heilman et al., 1997). Lesion studies in humans support the hypotheses that the productive and conceptual components of the praxis system may be anatomically distinct. The productive component includes praxicons or gesture movement representations that may be stored in the supramarginal or angular gyrus of the inferior parietal lobe (Heilman & Rothi, 1993; Rothi et al., 1985), innerva-

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https://doi.org/10.1017/S1355617700633015 Published online by Cambridge University Press

tory patterns, and kinesthetic images critical for the translation of gesture representations into skilled purposive movements stored in the premotor cortex (Rapscak et al., 1989; Watson et al., 1986). The conceptual component is felt to be widely distributed in the left hemisphere but associative or mechanical realms are not anatomically distinct (Heilman et al., 1997).

Both ideomotor (production; Rapscak et al., 1989) and conceptual apraxia may occur in Alzheimer's disease (Benke, 1993; Ochipa et al., 1992). As the earliest pathological changes in Alzheimer's disease preferentially affect the temporal and parietal lobes (Albert, 1984; Friedland et al., 1985), conceptual apraxia may be one of the earliest clinical signs of dementia in Alzheimer's disease. Studies of disease progression and prognosis in Alzheimer's disease have shown that patients who develop apraxia early in the disease decline more rapidly than those who do not (Yesavage et al., 1993). Also, apraxia in Alzheimer's disease may be more predictive of early death than aphasia or amnesia (Burns et al., 1991). These findings suggest that accurate and early identification of conceptual apraxia in Alzheimer's disease may help to identify an important subset of patients who could most benefit from both neuroprotective and symptomatic therapies as they emerge.

Conceptual apraxia may be difficult to diagnose in its early stages when ideomotor praxis is normal. While tests have been developed to assess conceptual praxis, these instruments are cumbersome and require protracted testing (Ochipa et al., 1992). We wanted to develop a test of conceptual praxis that could be easily administered in the clinic or at the bedside in a reasonably short period of time. We constructed a new clinical test designed to measure conceptual praxis: the Florida Action Recall Test (FLART; Schwartz et al., 1996). We wanted to learn if the FLART was a sensitive measure of conceptual apraxia. In this test, participants view an item that can be acted upon by a tool and must produce an appropriate gesture depicting use of the tool on the object. In this paradigm, the conceptual component involves selecting an appropriate instrument and action for each object. We administered the FLART to a series of patients with probable Alzheimer's disease and to age- and education-matched normal control participants.

METHODS

Research Participants

We tested 12 patients (7 male, 5 female) from our Memory Disorders Clinic with a clinical diagnosis of probable Alzheimer's disease according to NINCDS–ADRDA criteria (McKhann et al., 1984). Their mean age was 73.67 years (range = 55–84, $SD = 7.8$) and mean educational level was 11.83 years (range = 5–16, $SD = 3.90$). The patients' mean score on the Mini-Mental Status Exam (MMSE; Folstein et al., 1975) was 19.75 (range = 12–24, $SD = 3.6$), indicating mild to moderate cognitive impairment.

Our control group consisted of 21 volunteers (5 male, 16 female) with no history of neurological disease, psychiatric disorder, head trauma, learning disability, or alcohol or drug abuse. Their mean age was 71.95 years (range = 60–87, $SD = 6.53$) and mean educational level was 12.48 years (range = 10–18, $SD = 1.57$). Based on a traditional inventory (Raczkowski et al., 1974), we tested 18 right-handed and 3 left-handed controls. On the MMSE, the control group mean was 28.52 (range = 24–30, $SD = 1.66$). There were no significant differences between controls and Alzheimer's disease patients in regard to age ($t = 0.68$, $p = .503$) or education ($t = 0.68$, $p = .502$).

Experimental Task

The FLART consists of 45 black-and-white line drawings of objects placed in scenes implying an action (Figure 1). For example, a drawing of a cooked turkey required a carving action (as if they were holding a knife). A drawing of an unshaven face required a shaving action (as if they were holding a razor). Each participant was instructed to imagine what tool was needed to act upon each object or scene and then to pantomime the action associated with that tool in relation to the drawing. The tool was not shown in the drawing. The participant was not asked to name the draw-

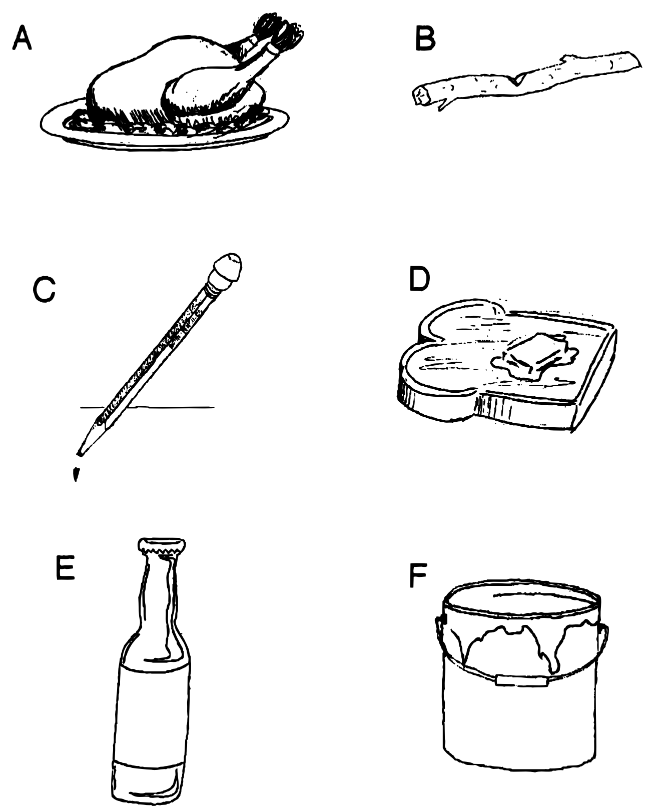

Fig. 1. Sample items from the Florida Action Recall Test (FLART). Target gesture (tool): A. carving (knife), B. chopping (hatchet), C. sharpening (pencil sharpener), D. spreading (knife), E. opening (bottle opener), F. painting (paint brush).

https://doi.org/10.1017/S1355617700633015 Published online by Cambridge University Press

ing or the missing tool. A "tool" was defined as any item that can be held and could be used to act on a pictured object or scene in the proper manner. Tools included kitchen utensils, personal care items, household items, garage tools, sports equipment, and musical instruments. The dominant hand was used for pantomiming. No time limit was imposed.

The instructions emphasized that the action required was a pantomime of actual tool use and that using a hand to complete the action without the assistance of a tool (hand errors) was unacceptable (e.g., twisting the top off a bottle rather than pantomiming the use of a bottle opener). Control participants were reminded to pantomime tool use on only one occasion and thereafter all hand errors were scored as incorrect. Alzheimer's disease participants were reminded as necessary throughout the test to help them remain on task.

Scoring

Testing in all cases was completed in one session and each session was videotaped for scoring at a later time by three raters experienced in praxis scoring using methods developed in our laboratory (Rothi et al., 1988). Each response was scored by consensus. Two out of three raters were blinded as to the designation of each participant (AD or control). Our primary objective in this pilot study was to evaluate conceptual apraxia. Therefore, we only scored the concept conveyed by each pantomine. If a participant did not produce a gesture within approximately 1 min, then that item was scored as incorrect. All production errors were noted but were counted as a correct response as long as the concept was interpretable and deemed correct. For example, the "turkey" item was scored as correct if the participant produced a carving gesture despite production errors of amplitude (e.g., small movements), timing (e.g., slow, irregular movements), or external configuration (e.g., not maintaining a consistent plane). Each session was timed for length to completion as well as response time to individual items. In addition, 25% of the sessions were subsequently scored by two of the original raters independently. There was excellent reliability between these raters for both Alzheimer's disease participants (Kappa = .82) and normal controls (Kappa = .95). Intrarater reliability was also excellent for both Alzheimer's disease participants and normal controls combined (Kappa = .97).

We wanted to learn whether participants with conceptual apraxia would also demonstrate functional impairment. We posited that activities requiring a specific component of tool use would be more impaired than other activities of daily living. We administered an Instrumental Activities of Daily Living (IADL) questionnaire (Lawton & Brody, 1969) to the primary caregiver of each Alzheimer's disease participant.

RESULTS

Data on our Alzheimer's disease subjects is summarized in Table 1. Comparison data between Alzheimer's disease and the normal control groups are shown in Table 2. Based on Welch's t test (which does not assume equal *SD*s between groups), Alzheimer's disease patients scored significantly worse on conceptual accuracy ($t = 5.04$, $p = .0002$) and took significantly longer to complete the FLART ($t = 4.81$, $p = .0005$) than controls.

We used a score equal to 2 standard deviations beyond the control group mean as the lower limit of normal for both accuracy and time to complete the test. The normal cut-off score for accuracy was 32/45 (71%). The normal cut-off for time to completion was 12.23 min. For Alzheimer's disease patients, 9/12 (75%) demonstrated conceptual apraxia by scoring beyond the accuracy cut-off score. Of the 3 participants who scored within the normal range (32 or better), all were beyond the cut-off for time to complete the test.

Table 1. Test results for Alzheimer's participants

Participant	Sex	Age (years)	Handed	Education (years)	IADL	MMSE	FLART completion time (min)	FLART (no. correct)
1	M	71	R	12	2	21	22.59	39
2	M	81	R	12	4	24	13.57	36
3	M	77	R	16	2	20	36.35	35
4	M	77	R	11	0	19	15.05	28
5	M	79	R	16	2	23	15.51	28
6	F	79	L	8	8	23	15.59	28
7	M	55	R	15	4	20	27.50	27
8	F	69	R	14	8	23	10.24	26
9	F	73	L	14	7	17	43.41	26
10	F	84	R	5	1	12	19.43	22
11	F	66	R	5	2	20	18.54	17
12	M	73	R	12	4	15	39.40	10

Note. IADL = instrumental activities of daily living; MMSE = mini-mental status exam.

https://doi.org/10.1017/S1355617700633015 Published online by Cambridge University Press

Table 2. Comparison of test results for Alzheimer's disease patients and controls

Group	N	MMSE no. correct/30 M	MMSE no. correct/30 (SD)	FLART no. correct/45 M	FLART no. correct/45 (SD)	FLART % correct	FLART time (min) M	FLART time (min) (SD)
Alzheimer's disease	12	19.75	(3.6)	26.83	(8.02)	59.6	23.39	(11.05)
Controls	21	28.52	(1.66)	39.10	(3.42)	86.9	7.89	(2.17)

Taken together, all 12 Alzheimer's disease patients were beyond the normal cut-off in either total accuracy score or time to completion. As expected based on the choice of cut-off scores, all 21 control subjects were within normal range on both accuracy and time to completion (Figure 2).

Alzheimer's disease subjects and controls were significantly different on the MMSE (Welch's t test: $t = 7.97$, $p <$ .0001). For Alzheimer's disease subjects, there was a trend for MMSE and FLART scores to be correlated on both accuracy (Figure 3; $r = .5594$, $p = .0586$) and time to completion (Figure 4; $r = .5206$, $p = .0827$). The 3 Alzheimer's participants who scored in the normal range on the FLART had MMSE scores indicative of mild cognitive impairment. Each of these individuals was beyond the cut-off for time to completion.

Although the FLART is based on knowlege of tool use, most items would likely be described as gender-neutral (e.g., brushing teeth). Although female AD participants had a lower FLART score than male AD participants, female controls had a higher FLART score than male controls. There were no significant differences based on sex in either the Alzheimer's disease group [female $M = 22.4$ (7.27), male $M =$ 30.0 (7.39), $t = 1.7676$, $p = .1076$] or the control group [female $M = 39.25$ (3.66), male $M = 38.6$ (2.79), $t = 0.3629$, $p = .7207$].

Based on the results of the IADL questionnaire, we did not demonstrate a strong relationship between functional performance and conceptual apraxia. Female Alzheimer's disease participants had a mean score of 5.6 ($\pm$ 3.05) on an 8-point scale. Male Alzheimer's disease participants had a mean score of 2.3 ($\pm$ 1.38) on a 5-point scale. There was no correlation between IADL score and FLART score for either accuracy (Pearson correlation; $r = -.0614$, $p = .8497$) or time ($r = .0652$, $p = .8403$). An IADL questionnaire that focuses more specifically on learned skilled movements (e.g., ability to use a hammer or slice bread) may have provided a more accurate functional assessment. Although the number of participants in our study was small, there was a correlation between IADL and MMSE for female participants with Alzheimer's disease ($r = .9204$, $p = .0267$) but no correlation for male participants with Alzheimer's disease ($r =$ .5292, $p = .222$). The relationship between functional decline, overall cognitive decline, and sex may warrant further study.

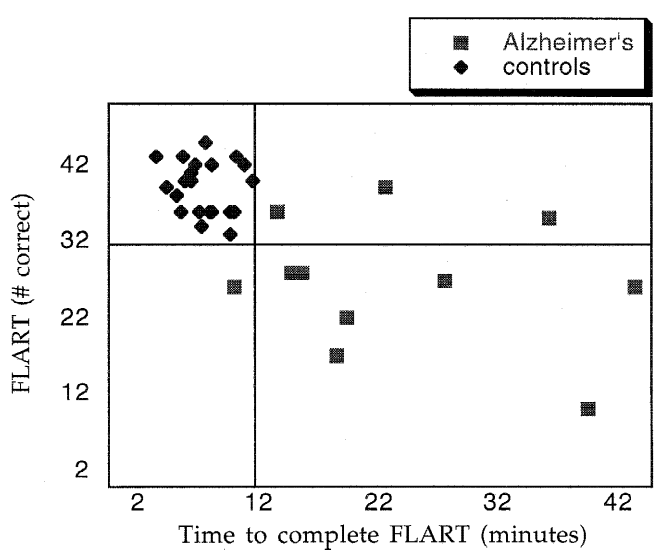

Fig. 2. Graph showing the number of correct items on the Florida Action Recall Test (FLART) *versus* time. Solid lines = cut-off score for normal performance (M of controls + 2 SD for time; $M - 2$ SD for no. correct). ■ = Alzheimer's disease; ♦ = controls.

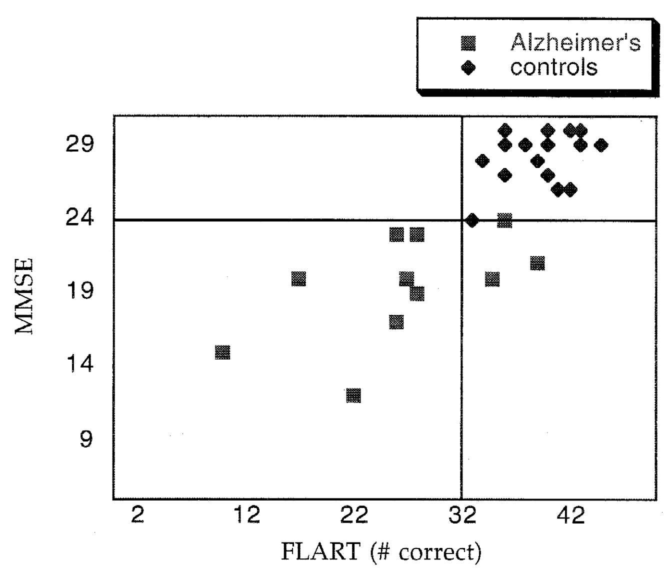

Fig. 3. Graph showing the number of correct items on the Florida Action Recall Test (FLART) *versus* MMSE score. Solid lines equal the normal cut-off. ■= Alzheimer's disease; ♦controls.

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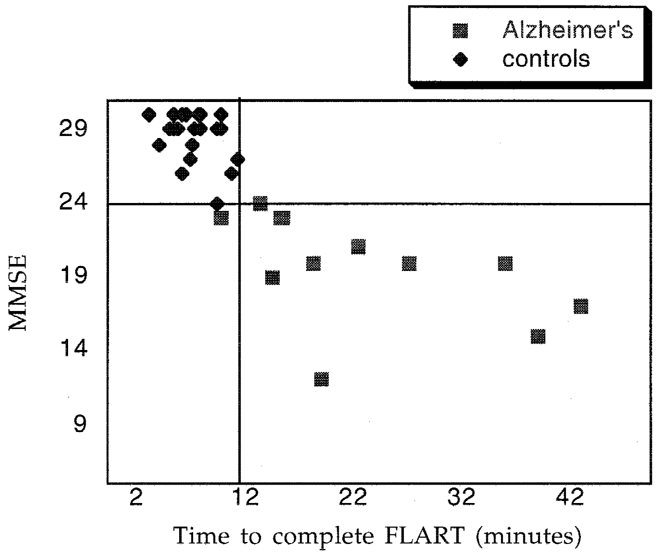

Fig. 4. Graph showing time to complete the Florida Action Recall Test (FLART) in minutes *versus* MMSE score. Solid lines equal the normal cut-off. ■= Alzheimer's disease; ◆controls.

DISCUSSION

Prior studies have demonstrated both ideomotor and conceptual apraxia in Alzheimer's disease (Benke, 1993; Ochipa et al., 1992; Rapscak et al., 1989). We developed a new test of conceptual praxis that can be easily administered in a short period of time. The FLART consists of a series of line drawings designed to examine both the conceptual and productive components of the praxis system. Our Alzheimer's disease participants scored significantly lower on the FLART than normal, matched controls and also averaged nearly 3 times as long to complete the test. All 12 Alzheimer's disease participants were beyond the normal cut-off score (2 *SD* beyond the mean of our control group) on either accuracy or time to complete the test. Based on these results, the FLART appears to be a useful test to identify conceptual apraxia in patients with Alzheimer's disease.

Although the Alzheimer's disease patients often made production errors, the present study was designed to evaluate conceptual apraxia and responses on the FLART and were scored for praxis content accuracy only. Ideomotor apraxia refers to a deficit in the production component of the praxis system that programs for motor action and the translation of those programs into skilled limb movements. Ideomotor apraxia results in errors of spatial or temporal coding (Rothi et al., 1988). The conceptual domain of praxis, which is also tested on the FLART, involves associative and mechanical knowledge about tools and actions. The associative realm involves tool–action and tool–object knowledge. The mechanical realm involves understanding the advantage that tools afford. Both the mechanical and associative realms may be stored as action semantic knowledge.

Patients with Alzheimer's disease often demonstrate semantic memory deficits (Huff et al., 1986; Martin & Fedio, 1983; Nebes, 1989). The conceptual memory system may be a centralized, multimodal system that encompasses both verbal and action semantic knowledge (Carramazza et al., 1990; Riddoch et al., 1988). Alternatively, the semantic system may be fractionated into discrete domains of conceptual knowledge with action semantics as a separate domain from verbal semantics (Raymer, 1992; Rothi et al., 1991; Shallice, 1988). As Alzheimer's disease often disrupts the ability to understand tool use, conceptual apraxia may relate to the loss of the representations for action knowledge or action semantics (Ochipa et al., 1992).

In addition to conceptual apraxia, 11 out of 12 Alzheimer's disease participants were beyond the normal cut-off time for test completion. These individuals invariably developed a verbal strategy that distracted from the production of the target gesture. They would describe the line drawings, describe how to act on the scenes, provide elaborate circumlocutory details about the scenes—all verbal strategies to try to engage a representation of the motor action that would then enable proper gesture production. This suggests that verbal semantic knowledge was available to at least some of our Alzheimer's disease participants whereas action semantic knowledge was not.

Evidence indicates that verbal semantics may degrade relatively early in Alzheimer's disease (Hodges & Patterson, 1995). However, Ochipa et al. reported conceptual apraxia in Alzheimer's patients without semantic language deficits (Ochipa et al., 1992). Although the precise relationship between verbal and action semantics is unknown, this dissociation suggests two functionally distinct semantic systems rather than one centralized, unimodal system. Also, the possibility remains for conceptual apraxia to precede either verbal semantic deficits or lexical retrieval deficits as may have been the case in some of our Alzheimer's disease participants. Follow-up studies will focus on distinguishing verbal and action semantic knowledge through the use of matching tasks, naming tasks, and gesture to verbal descriptions as related to the FLART.

An alternative explanation for decreased accuracy on the FLART would be that perceptual deficits associated with object recognition may be masquerading as a conceptual deficit. The elaborate verbal descriptions of the line drawings make this explanation less likely. However, we cannot rule out this possibility on the basis of our data. A picture-matching task where participants match each object or scene on the FLART to the correct tool picture may provide evidence to rule out a perceptual deficit.

Limb apraxia can be a significant problem for patients with neurological diseases other than Alzheimer's disease. Foundas et al. (1995) have recently shown that stroke patients with apraxia were significantly impaired in their mealtime eating behavior, suggesting that apraxia may hinder activities of daily living. This type of cognitive deficit may impair a patient's functioning in ways that may be difficult for caregivers to understand or interpret. The FLART may aid in early diagnosis of these problems in stroke patients as well as patients with Alzheimer's disease. Identification

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of specific cognitive deficits such as apraxia may facilitate the development of more focused rehabilitation strategies.

Just as Alzheimer's disease may lead to signs of conceptual apraxia, other degenerative disorders may similarly affect distinct components of the praxis system. For example, corticobasal ganglionic degeneration is associated with a progressive ideomotor limb apraxia (Riley et al., 1990). It may be possible to identify subgroups of corticobasal ganglionic degeneration patients with conceptual apraxia similar to our Alzheimer's disease patients. Further research is needed to fine-tune our understanding of apraxia through the analysis of both ideomotor and conceptual apraxia in degenerative diseases as well as patients with focal lesions.

ACKNOWLEDGMENTS

We thank Janet Wootten for editing the manuscript and Anne Hines for manuscript preparation. Supported by the Medical Research Service of the Department of Veterans Affairs and the State of Florida, Department of Elder Affairs.

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