Journal of the International Neuropsychological Society (2013), **19**, 162–172.

doi:10.1017/S1355617712001105

The Impact of Semantic Dementia on Everyday Actions: Evidence from an Ecological Study

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(Received September 8, 2011; Final Revision August 7, 2012; Accepted August 8, 2012; First Published Online November 19, 2012)

Abstract

In theory, semantic memory may trigger and support the execution of everyday activities. This study explored this question by comparing three patients with semantic dementia to 40 normal controls performing different everyday activities. Participants were tested in their home using the Instrumental Activities of Daily Living Profile, an ecological measure of everyday functioning. Participants were informed that they had unknowingly invited two guests for lunch and should prepare accordingly. With these instructions, they dress to go outdoors, go to the grocery store, shop for food, prepare a hot meal, have the meal with the guests, and clean up after the meal. Performance was analyzed on the basis of four operations related to problem solving: formulate a goal, plan, execute, and verify attainment of the goal. Results indicate that compared to normal controls, two patients had significant difficulties and needed assistance with all operations of problem-solving, particularly while preparing a meal and cleaning up after the meal. One patient showed no difficulties despite severe semantic deficits. These results suggest that semantic deficits alone cannot explain the difficulties observed, but may contribute to some aspects of everyday actions such as those involved in everyday problem-solving. (*JINS*, 2013, *19*, 162–172)

Keywords: Semantic memory disorders, Semantic dementia, Activities of daily living, Problem-solving, Frontal lobe

INTRODUCTION

Semantic memory, the long-term memory system containing knowledge about the world (e.g., words, objects, and people) has been the subject of numerous studies. However, the way in which semantic memory allows us to interact with our environment and have goal-directed behaviors is not clearly understood (Bier & Macoir, 2009; Bier, Macoir, Hudon, Bottari, & Joubert, 2009; Binder & Desai, 2011).

Cognitive models of everyday actions may shed light on some of the relationships between semantic memory and everyday activities. Currently, the two most often cited theories are Grafman's model on scripts (Grafman, 1995, 2002) and Cooper and Shallice's contention scheduling model on schemas (Cooper, 2002, 2007; Cooper, Schwartz, Yule, & Shallice, 2005; Cooper & Shallice, 2000, 2006).

Scripts are high-level everyday activities (Cooper & Shallice, 2000), such as going to a restaurant or planning a trip, comprising a sequence of events (Grafman, 2002; Schank & Abelson, 1977). For example, "driving to the doctor's office," "reading while waiting in the waiting room" and "paying the consulting fee" constitute events that may represent the activity "going to a doctor's appointment" (Grafman, 2002). Simpler, more routine everyday actions, like making a sandwich or coffee, are referred to as "schemas" (Botvinick & Plaut, 2004; Cooper & Shallice, 2000; Humphreys & Forde, 1998). In the model by Cooper and Shallice (2000), schemas are represented as an ordered set of actions and sub-goals, like "getting coffee" or "adding milk." The schemas are activated or inhibited by the perception of objects in the environment or by the availability of the person's resources (e.g., language, number of hands).

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The schema in turn activates appropriate representation of objects or the resources needed for the execution of an action and inhibits other irrelevant schemas.

These models do not explicitly address the issue of the relationship between semantic memory and everyday actions. According to Sirigu et al. (1995), knowledge about scripts may be stored in the posterior association cortices. The nature of this knowledge is not clearly specified but may correspond to the actions that are central to—or distinctive of—a particular script (Sirigu et al., 1995). However, results to date suggest that patients with focal lesions of the left temporal cortex have no impairment on the semantic dimension of script representations (Armus, Brookshire, & Nicholas, 1989; Godbout & Doyon, 1995; Lojek-Osiejuk, 1996; Sirigu et al., 1995). Another hypothesis is that script content and organization, such as the temporal ordering of the sub-actions of a script, are represented in the prefrontal cortex (Grafman, 2002; Krueger et al., 2009). In the contention scheduling model, the representation of semantic memory is limited to basic (implicit) knowledge about object use, and deficits in object recognition may not have an impact on the triggering of schemas (Cooper, 2007).

Evidence regarding the impact of semantic memory in everyday actions is sparse, but some studies involving patients with semantic dementia (SemD) suggest that semantic memory may play a role in everyday actions. SemD is a clinical variant of frontotemporal lobar degeneration characterized by a progressive loss of semantic memory (Neary et al., 1998). Patients generally present with bilateral atrophy of the anterior temporal lobes (i.e., the temporal poles), usually more predominant in the left hemisphere (Hodges, Patterson, Oxbury, & Funnel, 1992). As the disease progresses, atrophy affects the temporal regions bilaterally, as well as the ventromedial frontal cortex and the left anterior insular region (Brambati et al., 2009). Clinical observations (Funnell, 2001) and some case studies (Buxbaum, Schwartz, & Carew, 1997; Lauro-Grotto, Piccini, & Shallice, 1997; Negri, Lunardelli, Reverberi, Gigli, & Rumiati, 2007; Riddoch, Humphreys, Heslop, & Castermans, 2002) suggest that object use is preserved in SemD. However, other studies have shown that loss of knowledge in SemD leads to loss of the ability to use objects (Bozeat, Lambon-Ralph, Patterson, & Hodges, 2002; Coccia, Bartolini, Luzzi, Provinciali, & Lambon-Ralph, 2004; Hamanaka et al., 1996; Hodges, Bozeat, Lambon-Ralph, Patterson, & Spatt, 2000; Hodges, Spatt, & Patterson, 1999).

Finally, other indications come from group studies conducted with patients with SemD. Mioshi et al. (Mioshi & Hodges, 2009; Mioshi et al., 2007) showed that patients with SemD present with deficits in everyday activities when measured with an informant-based questionnaire. Few of these patients showed deficits in basic core survival activities (such as eating and grooming), but the majority of them showed deficits in activities with a high level of complexity, reflecting the person's ability to live independently in the community. Activities reported as being the most difficult to carry out were using the phone, managing finances and preparing meals (Mioshi et al., 2007).

In summary, the role of semantic memory in everyday activities is not clearly understood. The purpose of this study was to explore the impact of semantic memory deficits on everyday activities in three patients suffering from SemD using a real-world performance-based measure of independence.

METHODS

Participants

Three patients with SemD participated in this study. Their demographic characteristics are presented in Table 1, and results of neuropsychological tests are presented in Table 2.

Neuropsychological Testing

The following tests were used to document the neuropsychological profile of the participants with SemD (note: some data were not available for all patients): The Rey Figure (Rey, 1960; Fastenau, Denburg & Hufford, 1999); The Delayed Matching to Sample 48 (DMS48) (Barbeau et al., 2004), in which the subject must memorize incidentally 48 pictures of drawing objects and then recognize them in immediate and delayed forced-choice recognition tasks; The Birmingham Object Recognition Battery (BORB) (Riddoch & Humphreys, 1993). In the length match test, the subject must decide if two lines presented in a pair have the same length. In the object decision tasks, the subjects must decide if line drawings correspond or not to real or unreal objects; The Stroop, the Trail Making Test A and B, and the Tower of London (Spreen & Strauss, 1998). Note that E.C. had a different Stroop version, which was the one used in the Delis-Kaplan Executive Function System (D-KEFS) (Delis, Kaplan, & Kramer, 2001); The Brixton tests (Burgess & Shallice, 1997), in which the subject must determine the position of a blue circle in an array of 10 cicles, according to series of rules that changes

Table 1. General characteristics of the participants

Characteristics	M.G.	C.S.	E.C.	Normal controls (mean ± *SD*)
Age	69	74	68	74.4 ± 6.0
Years of schooling	12	18	13	13.8 ± 4.5
Years since diagnosis of disease	2	5	1	—
MMSE	25	28	27	29.5 ± .80
DRS	—	133	—	139 ± 4.0

Note. Mini-Mental State Examination (MMSE) (Folstein, Folstein, & McHugh, 1975); Dementia Rating Scale (DRS) (Mattis, 1976).

Table 2. Neuropsychological assessment of the patients with SemD

Neuropsychological testing	M.G.	C.S.	E.C.	Norms
Copy of the Rey figure	31	34	36	31.76 ± 3.63
Delayed recall of the Rey figure	10	17.5	16	15.29 ± 5.57
DMS48—immediate recognition % (norms in %)	87.5* (98 ± 2)	97.9 (96 ± 5)	NT	
DMS48—delayed recognition % (norms in %)	87.5* (99 ± 2)	97.9 (97 ± 4)	NT	
BORB—length match task	28	27	NT	29.6 ± 1.6
BORB—Object decision A Hard	16*	19*	15*	27 ± 2.2
BORB—Object decision B Easy	25*	27*	17*	30.5 ± 1.4
Stroop Naming – colors (norms)	54 sec (44.04 ± 7.67)	28 sec (44 ± 4.67)	37 sec (D-KEFS; scale score 8)	
Stroop Reading—words (norms)	83 sec* (54.58 ± 11.8)	55 sec (59.36 ± 8.7)	23 sec (D-KEFS; scale score 11)	
Stroop Inhibition (norms)	121 sec (95.68 ± 16.26)	104 sec (109.46 ± 24.25)	102 sec* (D-KEFS; scale score 4)	
Trail Making Test Part A	38 sec	20 sec	50 sec	49 ± 18
Trail Making Test Part B	94 sec	39 sec	101 sec	118 ± 51
Digit span—forward	5	8	5	7 ± 2
Digit span—backward	4	7	5	6 ± 2
D-KEFS Tower Test—total achievement score (scale score)	NT	16 (11)	NT	13–14 (10)
Tower of London—total time	NT	NT	132.34	154.17 ± 11.7
Tower of London – total number of movements	NT	NT	52.7	50.6 ± 3.6
Brixton test (scaled score)	7	7	NT	10
Total letter fluency (norms)	23* (48.5 ± 11.1)	32 (42 ± 13.5)	16* (49.4 ± 11.5)	
Total semantic category fluency (norms)	31* (51.9 ± 12.1)	33* (40.6 ± 8.1)	4* (50.7 ± 10.1)	
Repetition of words /15 (norms)	15	15	15	14.96 ± .21
Repetition of non-words /10 (norms)	10	10	10	9.91 ± .29
Picture naming test (Test; norms)	56* (DO-80; 77.4 ± 1.4)	8* (Boston 15 items; 12.9 ± 1.9)	16* (DO-80; 77.4 ± 11.4)	
PPTT (norms)	40* (49.44 ± 1.9)	38* (48.41 ± 2.28)	34* (49.86 ± 2.21)	

Note. Delayed matching to sample 48 items (DMS48) (Barbeau et al., 2004); Birmingham Object Recognition Battery (BORB) (Riddoch & Humphreys, 1993); Delis-Kaplan Executive Function System (D-KEFS) (Delis et al., 2001); Test de Dénomination orale d'images - DO 80 (Deloche & Hannequin, 1997); Pyramids and Palm Trees Test (PPTT) (Callahan et al., 2010; Howard & Patterson, 1992).
NT = not tested; * = impaired score based on age-stratified norms.

without warning; Digit span—WAIS III (Weschler, 1987); Letter and semantic fluency (Joanette et al., 1995); Repetition of words and non-words (Macoir, Gauthier, & Jean, 2005); The *Test de Dénomination orale d'images* - DO 80 (Deloche & Hannequin, 1997), which is a picture naming test using 80 line drawings of concepts pertaning to different categories; Pyramids and Palm Trees Test (PPTT) (Callahan et al., 2010; Howard & Patterson, 1992).

Patient M.G.

M.G. is a 69-year-old right-handed woman with a grade 12 education, who had retired 3 years earlier from a job as an assistant accountant. She was presented to us in May 2010 with a 2-year history of cognitive decline mainly characterized by word-finding problems and difficulties in recognizing well-known people. With respect to memory, the patient was well oriented in time and space. The patient's performance was within the normal range for tasks exploring motor control and executive functions. Visual-perceptual abilities also appeared to be well preserved, except for object decision tasks. Visual recognition memory was slightly impaired. Speech output was fluent, well-articulated and grammatically correct but presented many signs of word-finding difficulties. M.G. was severely impaired in tasks exploring semantic memory and in confrontation naming.

An MRI carried out in November 2009 revealed substantial cortical atrophy limited to the anterior portion of the temporal lobes, slightly more marked on the left side.

M.G. lived with her husband. With respect to everyday activities, she was still carrying out household chores, gardening and shopping, and still driving her car. She did not cook much but said that it was mainly due to a loss of interest.

Patient C.S.

C.S. is a 74-year-old right-handed man with 18 years of education. He is a retired civil engineer. In 2004, he was

https://doi.org/10.1017/S1355617712001105 Published online by Cambridge University Press

referred to a geriatrician because of memory problems as well as word-finding and reading difficulties that began approximately 1 year before the medical consultation. He was well oriented in time and space, and his performance was normal on tests exploring executive functions, working memory, and non-verbal episodic memory. He also performed normally on perceptual tasks. C.S.'s performance was substantially affected on tests requiring semantic processing. With regard to language, speech output was fluent, well-articulated and grammatically correct but he presented many word-finding difficulties.

A brain positron emission tomography was conducted in April 2009. The reconstructed images showed hypometabolism in the anterior portion of the temporal lobes, more prevalent on the left side.

C.S. lived with his wife. Regarding everyday activities, C.S. reported in 2004 that he needed assistance to find a phone number in the directory, to prepare a meal, and to make shopping lists. In 2008, his wife reported that C.S. also needed help with paying bills. Finally, he gradually engaged in less and less conversations and avoided social situations because he was increasingly embarrassed by his cognitive difficulties. When he was seen in 2009, C.S. was still driving. He was relatively passive at home but walked about 2 hours a day and spent several hours each day playing Sudoku.

Patient E.C.

The third patient, E.C., is a 68-year-old right-handed woman with 13 years of formal education. She is a retired elementary school teacher. In 2009, she was referred to a memory clinic because of word-finding difficulties. Her complete neuropsychological profile is presented elsewhere (Bier et al., 2011). To summarize, E.C. showed severe deficits on tests requiring semantic processing and verbal comprehension but generally performed normally on tests exploring other cognitive domains. The anatomical MRI done in 2010 revealed bilateral atrophy of the anterior temporal lobes, predominating in the left hemisphere. At the time of testing, she was doing her household chores, managing her money and budget alone, and was still driving. However, she no longer prepared meals.

Control Participants

Forty normal control participants (25 women and 15 men) were also included in this study (see Table 1). They were matched for age and level of education with the three patients, as well as for their level of experience in preparing a hot meal. This was determined based on the frequency with which they carried out this activity ("I do not prepare meals," "I prepare meals occasionally," or "I prepare meals regularly"), as measured with the Instrumental Activities of Daily Living Profile – Interview (Bottari, Dassa, Rainville, & Dutil, 2010b). Exclusion criteria for control participants included dementia, memory complaints, history of head injury and depression.

The project was accepted by the Ethical Review Boards of the patients' institutions, or the researchers affiliated research centers, and all participants (patients and controls) gave their written informed consent to participate in the study.

Material and Procedures

The Instrumental Activities of Daily Living Profile (IADL Profile) (Bottari, Dassa, Rainville, & Dutil, 2009a, 2009b, 2010a; Bottari, et al., 2010b) was used to assess all participants. This tool was recently developed as a performance-based ecological measure of independence in everyday activities. So far, the measure has been validated with individuals with traumatic brain injury and its psychometric properties have been established (Bottari et al., 2009a, 2009b, 2010a, 2010b; Bottari, Gosselin, Guillemette, Lamoureux, & Ptito, 2011). This test is administered in the person's home and community environment and provides a measure of: (1) the person's level of independence in everyday activities carried out in a real-world environment, and (2) where breakdown in task performance occurs particularly in relation to problem solving (executive functions). The test, which has been described in detail elsewhere (Bottari, et al., 2009a, 2009b, 2010a, 2010b), consists of eight everyday tasks, six of which are combined to form a complex series of inter-related tasks aimed at preparing a meal for unexpected guests: dressing to go outdoors, going to the grocery store, shopping for food, preparing a hot meal, having a meal with guests, and cleaning up after the meal. The participant is first asked to prepare a hot meal for unexpected "guests" and is given $20 to cover expenses. With these instructions, it is expected that the participant will formulate an overarching goal related to preparing to receive his guests for a meal and the sub goals of the six inter-related tasks. The two other tasks are single complex tasks consisting of obtaining the bus schedule for a complete day between Montreal and Toronto, and preparing a budget. All activities are administered using a non-structured approach, that is, instructions and assistance are kept to a minimum.

Scoring takes into consideration four operations related to problem solving for each task: ability to formulate the goal, plan, execute the task, and verify attainment of the goal. For each operation, the person's level of independence is scored on an ordinal scale ranging from dependent (score of 0) to independent without difficulty (score of 4). A score of 0 indicates that the person is unable to perform the operation within a reasonable amount of time or in an acceptable manner, despite help. Scores of 1 and 2 are assigned based on the assistance required by the person: a need for both verbal and physical assistance (score of 1) or a need for either verbal or physical assistance (score of 2). The latter is the score that is used to represent the assistance required for individuals with SemD as they only have cognitive deficits and no physical deficits requiring specific physical assistance (e.g., balance deficits). Thus, a score of 1 was never used in our study. A score of 3 is assigned when the individual is capable of performing all aspects of the operation alone, but

https://doi.org/10.1017/S1355617712001105 Published online by Cambridge University Press

with difficulty (e.g., time taken to complete the tasks, quality of execution such as burned food). Finally, the individual is totally independent (score of 4) when all components of the operation are performed without difficulty.

For the purpose of this study, only results pertaining to the six tasks related to meal preparation are presented. The participants were videotaped and two independent evaluators rated their performance. Discrepancies were discussed to reach a consensus.

Statistical Analyses

The performances of the patients with SemD were first described on the basis of each of the four operations and for each of the tasks related to the goal of preparing a hot meal for guests. In a factorial validity study, Bottari et al. (2009b) reported four task-based correlated factors related to this overarching goal: (F1) going to the grocery store and shopping for food (grocery shopping), (F2) having a meal with guests and cleaning up, (F3) putting on outdoor clothing, and (F4) preparing a hot meal for guests. Each factor score represents the average score of a differing number of operation scores. They have excellent reliability (Bottari et al., 2010b) and were thus used in this study.

The number of times assistance was required as well as safety issues were documented. The performance of the three participants with SemD was compared to the performance of the controls by means of modified *t* tests, which estimate whether an individual score is significantly different from the score of a small control group (Crawford & Howell, 1998).

RESULTS

A description of each patient's performance is given in Appendix 1. A more complete description of E.C.'s performance can also be found in Bier et al. (2011).

Results are presented in Figures 1 and 2. All normal controls were independent (score of 4) or independent with difficulty (score of 3) on all tasks. Since there was no difference between male and female, performance was not compared based on gender (Mann-Whitney *U* tests, all *ps* > .21; except for the operation "planning" of the tasks "having the meal/cleaning up after the meal" that was almost significant with $p = .068$). Compared with normal controls, M.G. had no specific difficulties in any task (all *p* values-*ps* > .29). E.C. and C.S. could put on outdoor clothing normally. However, E.C. ($t = -1.25$; $p = .11$) and C.S. ($t = -1.08$; $p = .14$) tended to have more difficulties than controls with grocery shopping but the differences were not significant. Preparing a hot meal was the most difficult activity for both of them (C.S.$-t = -2.46$; $p = .009$; E.C.$-t = -3.18$; $p = .001$). Finally, C.S. ($t = -3.98$; $p < .001$) and E.C. ($t = -2.34$; $p = .012$) showed more difficulties than the normal participants with having the meal/cleaning up after the meal.

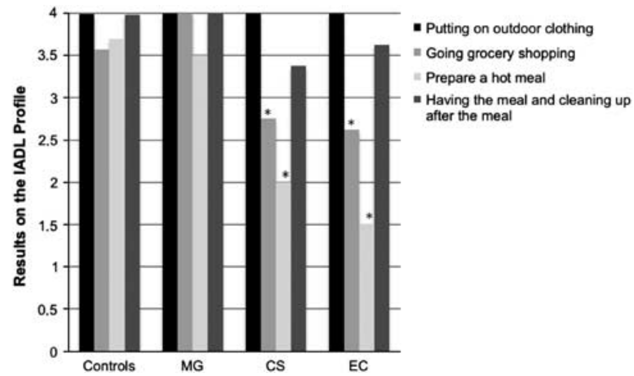

Fig. 1. Results of patients with semantic dementia (SemD) and normal controls on the Instrumental Activities of Daily Living Profile (IADL Profile). *Significant differences between the patients with SemD and normal controls.

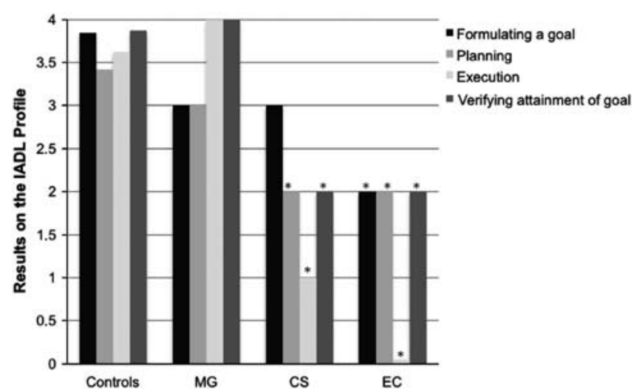

Fig. 2. Scores of patients with semantic dementia (SemD) and normal controls on each of the four operations of the task "preparing a hot meal." *Significant differences between the patients with SemD and normal controls.

Preparing a hot meal was further analyzed since E.C. and C.S. had substantial difficulties in this task. E.C. had difficulties with all operations related to problem solving (formulating goal: $t = -2.61$; $p = .006$; planning: $t = -1.88$; $p = .034$; execution: $t = -5.12$; $p < .001$; verifying: $t = -4.04$; $p < .001$). C.S. had difficulties with planning ($t = -1.88$; $p = .034$), execution ($t = -3.71$; $p < .001$) and verifying attainment of the goal ($t = -4.04$; $p < .001$). Data were also analyzed in relation to the number of times patients asked for assistance, the number of times assistance was requested and given to participants, as well as safety issues. E.C. frequently requested assistance (17 times) while C.S. and M.G. never asked for it. Normal controls almost never asked for help (.05 times; E.C. vs control $t = 75.76$; $p < .001$). With respect to the number of cues given by the experimenter, E.C. (36 cues; $t = 87.71$; $p < .001$) and C.S. (3 cues; $t = 7.03$; $p < .001$) also differed significantly from the normal controls (.13 cues). Significant safety issues were noted in the observed behaviors of E.C. and C.S. (6 and 1 safety issues, respectively) while none were observed in the normal controls. For example, E.C. forgot to turn off the stove burners twice and C.S. was going to put the cooked ground beef in the same bowl used to mix the uncooked meat.

DISCUSSION

The purpose of this study was to explore the impact of semantic memory deficits on everyday activities. Three patients with SemD and 40 normal controls were evaluated in their homes using an observation tool called the IADL Profile (Bottari et al., 2010b). Among the three patients, E.C. was the most impaired. She showed marked difficulties in almost all tasks pertaining to preparing a hot meal for guests, and had difficulties in all operations related to problem solving. C.S. was less impaired but showed difficulties when shopping and preparing a hot meal and in most operations. M.G. had no marked impairment. None of the problematic behaviors reported in the patients with SemD was observed in the normal controls.

The first observation that can be drawn from these data is that SemD has an impact on everyday activities. This result is in line with what is reported by caregivers (Kashibayashi et al., 2010; Mioshi & Hodges, 2009; Mioshi et al., 2007). These patients show impairments in complex everyday activities and these deficits seem to increase with the progression of the disease. Routine activities such as personal hygiene and food selection were also reported to be impaired in some patients (Kashibayashi et al., 2010; Mioshi & Hodges, 2009; Mioshi et al., 2007; Rosen et al., 2006; Shinagawa, Ikeda, Fukuhara, & Tanabe, 2006; Snowden et al., 2001).

The second observation emerging from our results is that SemD has an impact more specifically on the ability to *solve problems* related to complex everyday tasks. In accordance with our results, caregivers of patients with SemD also reported difficulties in everyday problem solving (Mioshi et al., 2007). All three patients had problems with selecting the meal to prepare (planning). They had only one idea of a possible menu (all three patients) and needed help to find one (C.S. and E.C.). Also, regarding execution, all patients had difficulties in recognizing food items in the grocery store (M.G. and C.S.) or during cooking (E.C.). These results are not surprising considering the difficulties of SemD patients with identifying real objects (Bozeat et al., 2002; Coccia et al., 2004; Hodges et al., 1992, 2000).

Apart from these common difficulties, the three patients showed different patterns of results. C.S. and E.C. showed substantial difficulties. C.S. differed from E.C. regarding the unsanitary aspects of his food preparation and cleaning dishes. Although a loss of knowledge about germs may have contributed to his behavior, it may also reflect a loss of concern or difficulty understanding the negative aspects related to his behaviors. Orbitofrontal cortex degeneration appears during the course of SemD (Brambati et al., 2009; Desgranges et al., 2007; Rosen et al., 2002), and this region of the frontal lobe is associated with the emotions related to social behaviors and decision-making (Bechara, Damasio, & Damasio, 2000). C.S.'s performance and lack of insight may be interpreted as reflecting orbitofrontal cortex degeneration. Imaging data did not reveal any such evidence in either of our patients, but it may be that the imaging data failed to capture some amount of pathology. Neuropsychological tests measuring various aspects of social cognition related to the orbitofrontal cortex, such as the Iowa Gabling Task (Bechara, Damasio, Damasio, & Anderson, 1994), may help address this question in more detail in future ecological studies with SemD patients. E.C. showed more insight about her performance than C.S. and was even frustrated about her difficulties. Two of her mistakes (she forgot to turn off the stove twice) may be explained by episodic memory problems. In fact, some studies have reported alterations of the hippocampal region in SemD (Desgranges et al., 2007; Rosen et al., 2002). Nevertheless, most of E.C.'s mistakes seemed to be related to lost knowledge about food and cooking, but a possible contribution of orbitofrontal cortex degeneration cannot be totally ruled out. As for M.G., she globally had no marked difficulties in the IADL Profile, although she showed semantic memory deficits similar to those of C.S. In light of this discrepancy, it may be that the difference between C.S. and M.G. rely on the presence (C.S.) or absence (M.G.) of orbitofrontal cortex degeneration.

These heterogeneous results from three SemD patients thus suggest that semantic deficits alone cannot explain the difficulties observed in the IADL Profile. However, E.C.'s performance, although probably not uniquely related to semantic memory deficits (e.g., orbitofrontal cortex degeneration, episodic memory deficits), provides interesting information about the role of semantic knowledge in everyday tasks, which is the main objective of this study. In E.C., semantic memory and complex everyday activities appear to interact *via* object recognition and use. They also appear to interact *via* problem-solving. This latter interaction may be explained by the vast mapping of connections existing between the frontal lobes and the posterior cortices. For example, such connections have been established in studies exploring the associations between language and action (Martin, Wiggs, Ungerleider, & Haxby, 2000), showing that the semantic representation of an object involves information about its shape, color and size, but also about the sensory-motor features associated with its use. Consequently, the activation of this concept in a language task, such as in a word comprehension task, or in carrying out an action, recruits a large cortical network involving frontal, parietal and temporal areas (Rizzolatti, Fogassi, & Gallese, 2001). Models emerging from the study of apraxia (Buxbaum & Kalenine, 2010) or semantic processing (Binder & Desai, 2011) have also pointed out the close relationship between knowledge and action and the involvement of large cerebral networks.

Of interest, Binder and Desai (2011) recently proposed a neuroanatomical model of semantic processing in which the ventral and lateral temporal cortex and the inferior parietal cortex form two important convergence zones for storing the abstract content of semantic knowledge. More precisely, and in line with everyday tasks, the inferior parietal cortex stores representations of "event" concepts. These concepts refer to the representations of everyday activities (e.g., a birthday party) in which entities (people, objects) interact in space and time (the beginning of the party, eating the birthday cake, opening gifts). This complex configuration helps define our representation of an event and distinguish it from others. According to Binder and Desai's model, a third important region, the prefrontal cortex, controls top-down activation and selection of the content of semantic memory stored in the posterior cortices. The content is selected regarding its relevance to the problem at hand and to allow for creative problem solving.

In accordance with Binder and Desai's view regarding the interaction between knowledge and problem solving, Barsalou (2003) specifies that these two cognitive domains are closely related *via* two processes: simulation and goal-derived categories. With simulation, the subject can reactivate multi-modal representations of past experiences (Barsalou, 2008) and make an informed decision in accordance with it. Let us take Barsalou's example of a person who wants to change a light bulb. After simulating the action needed to change the bulb—that is, standing on something to reach the ceiling—the person concludes that he/she needs a large object to stand on. The person may have the idea of standing on an object having specific attributes, such as being tall and stable, and search in the environment to select an object that meets these criteria. When mapping is done between the selected goal and the environment, a new goal-oriented category (e.g., things one can stand on to change a light bulb) is created. Since the primary goal of such categories is to optimize a plan, reasoning is done on the ideal attributes that the exemplar of the new category should have (e.g., solid, high, and stable). Goal-oriented categories also direct the execution of the plan by taking into account the environment in which the action takes place. The role of conceptual knowledge in planning, according to Barsalou, is thus very important when the action takes place in a new context or when the action itself is new.

These models are of particular interest when considering E.C.'s performance in everyday tasks. Her profound loss of knowledge about objects and actions had a great impact on her ability to use objects purposefully. However, her general cooking abilities, which included cutting, rinsing, mixing and so on (simple gestures), were well preserved overall, as well as the general milestones of the activities (the beginning, the middle, and the end). But most importantly, we observed that her profound semantic memory deficit had a great impact on her ability to plan actions and reach a goal.

How can the above-mentioned difficulties (and models) be put in relation with models of scripts and schemas? E.C.'s difficulties were apparent during complex tasks requiring problem solving (scripts). As such, routine activities (schemas) were not really evaluated. In regard to script models, Grafman and colleagues (Grafman, 2002; Krueger et al., 2009) focused on the role of the frontal lobes in storing and activating complex structures comprising series of events (scripts). E.C.'s performance on the IADL Profile and on semantic memory testing suggests that posterior cortices responsible for semantic processing may also play an important role in scripts.

Our results do not allow us to confront the models of script and semantic processing but future research may allow a deeper understanding of these views and how they relate to each other. Future studies may shed light on the similarities and distinctions between semantic knowledge and scripts regarding their structure and content. In fact, classical taxonomic categories and scripts share very comparable properties (Barsalou & Sewell, 1985; Galambos, 1986; Galambos & Rips, 1982; Grafman et al., 1991). Their content differs—classical taxonomic categories contain objects while scripts contain actions—but the structure is similar. Also, future studies should try to better identify the brain regions involved in script processing. More specifically, an attempt should be made at reconciling the role of the inferior parietal lobe, a convergence zone concerned with knowledge of actions and events as posited by current theories on semantic processing (Binder & Desai, 2011), and the role of frontal lobes in storing and retrieving complex actions and events, such as posited by current theories on scripts (Grafman, 2002). Studies on conceptual combination and simulation (Barsalou, 2003) in semantic memory and their contribution to problem solving may also contribute to a better understanding of the role of conceptual knowledge in everyday life.

This study was a first attempt to explore the complex relationship between cognition and everyday actions by observing three SemD patients carrying out activities in their home and community. The role of semantic memory in everyday action should be further explored with studies conducted with larger groups of patients presenting isolated semantic memory deficits and with various degrees of severity. The relationship between the patients' behavior in everyday actions and the precise localization of brain lesions should also be established. Finally, future studies should comprise a diversity of simple and complex everyday activities to allow a deeper understanding of the theoretical models on schemas and scripts.

ACKNOWLEDGMENTS

The first two authors were supported by a postdoctoral fellowship award from the Canadian Institutes of Health Research during the time of the study. The third and fourth authors are supported by a salary award from the *Fonds de recherche Québec – Santé*. The authors wish to thank E.C., C.S., M.G. and the controls for their participation in this study, as well as all the evaluators who participated in data collection (Chantal Messier, Émilie Beauchemin, Maryline Pellerin, Marisol Petit, and Ariane Lacasse). The authors report no conflict of interest.

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Appendix 1

The chart shows brief qualitative descriptions of the behaviors of the patients with SemD on the IADL Profile. The information in italics identifies the relevant operation.

Patients with SemD	Transcript (chronology of the tasks as performed by the participant)
M.G.	
Preparing a hot meal / *formulating goal and planning*	M.G. quickly suggested preparing spaghetti, considering the timeframe of the evaluation.
Shopping for groceries / putting on outdoor clothing	The evaluator had to insist that she use the $20 to buy some items because she did not want to spend any money (*formulating a goal*). After being convinced by the examiner, she agreed to go grocery shopping. She said that she needed to buy salad to go with the spaghetti (*planning*). M.G. was dressed appropriately to go outside. Grocery shopping went well, but she had to ask a clerk where to find salad and was directed to the counter with prepared pasta salads (*execution*). She did not recognize the salad she was looking for (said that this was not salad) and asked another clerk where to find a prepared salad with lettuce. She also bought cakes and soft drinks.
Preparing a hot meal / *execution and verifying*	M.G. had no specific difficulties (*execution*). Although she did not make any mistakes, some semantic issues were observed during the task. When looking at the salad she had bought, she did not recognize the kind of salad (a Caesar salad mix), mistakenly took grated cheese for pasta, and did not suggest a salad dressing to go with it. At the end of the evaluation, when asked what other menu she could have prepared, she said she does not cook much anymore and could not think of any possible menu other than spaghetti.
Having the meal / cleaning up after the meal	For herself, she preferred preparing a sandwich, explaining that she was not used to eating spaghetti for lunch. After the meal, she cleared the table appropriately.
C.S.	
Preparing a hot meal / *formulating goal and planning*	C.S. first wanted to buy burgers at a nearby restaurant (*formulating a goal*). He said he was uncomfortable cooking a hot meal and would have preferred to prepare a simpler meal (eggs with toast) (*planning*). With the help of the evaluator, he finally suggested cooking ground beef but had no idea what to cook with it. With help, he finally decided to prepare potatoes and a salad (*planning*).
Shopping for groceries / putting on outdoor clothing	When it was time to go shopping, C.S. was properly dressed and independently chose where to go grocery shopping. He also drove to the grocery store. When shopping, instead of looking for tomatoes in the fruit and vegetables section, he searched for them in the aisles (*execution*). He completed the task without buying all the items on his list (salad, potatoes), and bought additional items (cheese) (*verifying*).
Preparing a hot meal / *execution and verifying*	Meal preparation took a very long time since he prepared only one thing at a time and with no specific plan. Interventions were required: C.S. was going to use nearly rotten lettuce; he washed his hands using only water after handling uncooked ground beef; he was going to pick up slices of bread with his dirty hands after handling uncooked ground beef and put cooked ground beef in the same bowl used to prepare the uncooked meat. He also used a huge amount of margarine to cook the beef. C.S. was not aware of the mistakes he made during the process, specifically related to handling the ground beef (*verifying*). At the end of the evaluation, he said that everything had gone well (*verifying*). When asked if he could have thought of another menu, C.S. said he had no other ideas.

(Continued)

Continued

Patients with SemD	Transcript (chronology of the tasks as performed by the participant)
Having the meal / cleaning up after the meal	C.S. was fully independent in having a meal with guests and actively participated in the conversation. After the meal, he cleared the table and put the dishes in the dishwasher (*execution*). When the dishes did not fit in the dishwasher any more, he just wiped them with a towel and put them back in the cupboard (including the bowl used to mix the uncooked ground beef) (*execution*). He used the same cloth to dry his hands, wash the cat's bowl and wipe the counter. Also, he did not use soap to clean the counter (*execution*). C.S. never realized or corrected his mistakes (*verifying*).
E.C.	
Preparing a hot meal / *formulating goal and planning*	E.C. said that she had already prepared a meal before the evaluators' visit (*formulating a goal*). Following the experimenter's encouragement, she said that she did not know what to prepare and would have to look in a cookbook (*planning*). She opened and closed her cookbook a couple of times, saying there were a lot of things she did not do any more. The experimenter asked her if she had chosen which recipe to prepare and after a long hesitation, she opened her cookbook again and finally found the recipe she had been looking for (*planning*).
Shopping for groceries / putting on outdoor clothing	Despite the continued assistance of the examiner to help her initiate the tasks, she took time to act and only did so once she had finally understood that she really had to do these tasks. She then proceeded to prepare her shopping list with a lot of verbal assistance from the evaluator as she was unable to recognize many ingredients in the recipe (*execution*). E.C. selected appropriate clothes to go grocery shopping. She chose to buy groceries at the closest grocery store and drove her car without difficulty. While grocery shopping, she asked the clerks for help many times (*execution*). She ended the task even though her shopping cart did not match her grocery list (*verify*).
Preparing a hot meal / *execution and verifying*	A complete description of the execution part can be found in Bier et al. (2011). E.C. made several mistakes related to difficulties in recognizing ingredients and utensils (e.g. she used parsley stems instead of leaves; she used a 1/4 cup of garlic instead of a 1/4 teaspoon; she wanted to used plastic bowls to cook her pie in the oven). She omitted the zucchini and asked for help many times (e.g. what is a beaten egg? What is draining?). She had difficulty following the appropriate sequence of actions listed in the recipe. At one point, the evaluator had to tell her exactly which step she had to do. Many safety issues were also observed for which assistance was provided (e.g. she forgot to turn off the stove burners twice, she walked around the kitchen with a a knife in her hand). However, she knew how to cut and prepare all the vegetables correctly even when she had not recognized them at first. In the end, she said that she was not satisfied with her performance.
Having the meal / cleaning up after the meal	When the meal was ready, she took the warm plates out of the oven and sat at the table. She appeared to be waiting for the evaluator to tell her what to do next (*formulating a goal*). When the evaluator reminded her about the instructions to have the meal with the guests, she said that she was ready, that everything was in the freezer. In fact, she thought the evaluators would not want to eat the meal she had just prepared. She finally managed to serve the guests (*execution*) but for herself prepared a portion of the frozen meal. She did not initiate conversation while having the meal with her guests but was able to participate. Cleaning up after the meal was accomplished without any difficulties.