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ORIGINAL ARTICLE

Mental representations of daily activities throughout the course of dementia

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Abstract

Background: Since dementia is a result of cognitive rather than physical impairment, cognitive aspects are important for care planning. This mixed-model study aims to understand how the loss of cognitive functioning affects mental representations of daily activities.

Methods: Mental representations were assessed via the script generation task of daily activities (grocery shopping, dentist appointment, doing laundry, leaving the house, car accident) and a qualitative semi-structured interview from 25 people (age (mean: 67.64; SD: 23.625), gender (f: 14 (56%); m: 17 (68%)). Cognitive status was assessed via the Montreal Cognitive Assessment.

Results: Mental representations of daily activities loose content and get inaccurate throughout the disease (i.e. number of actions, abstractions, unemotional content) with poorer cognitive status. People with mild dementia report the most strategies and extend their mental representation by including strategies to circumvent experienced problems. Overall, mental representations of daily activities seem to be largely intact throughout the course of dementia (i.e. sequencing, personalisations, intrusions, examples, emotional content).

Conclusion: This study outlines that even though the content of mental representations decreases with dementia, the mental representations themselves remain in good order. Performance of daily activities throughout dementia may be hampered by the loss of content of the generated actions.

Key words: *activities of daily living, cognitive functioning, mixed-method design, script generation.*

INTRODUCTION

When getting older, not only our body changes but also our memory. Activities of daily living that were easy to manage in the past now become a challenge[1–3] and require appropriate support to guarantee a life that is normal and worth living, especially in terms of age-related disorders such as dementia. Humans store the actions of a daily activity in form of a mental representation in long term memory once they are experienced.[4–6] Mental representations of daily activities are often stored in scripts that comprise successional action sequences of how the daily activity is normally executed.[7, 8] These action plans get disrupted by dementia[9–11] which also might reflect the inability of performing daily activities.[11, 12]

The script generation task provides information about one's ability to produce complex, successional action plans derived from mental representations of daily activities, where participants are asked to enumerate out loud a list of actions they generally perform for achieving a daily activity and to place these actions in the correct chronological order.[7, 13, 14] Each generated action of a script can be, for instance, classified according to the position in the action sequence, how central an action is regarding the script goal, the distinctiveness of a generated action and also how frequent the action is among other participants.[11, 12] These are interesting characteristics that can be considered when examining how mental representations of daily activities change throughout the course of dementia.

There are two underlying theories how script actions are stored. According to the Shallice model,[15] script actions are hierarchically organised and comprise two distinct processes that can be activated depending on the nature of the script. Whereas the Supervisory Attentional System relies on the activation of the frontal lobe when dealing with non-routine, novel scripts where conscious control is needed, the Contention Scheduling supports routine scripts that are already stored in semantic memory and can therefore be executed automatically, by its activation of the basal ganglia.[15–19]

In contrast to Shallice's model,[15] Grafman *et al*. (1991) referred script knowledge to managerial knowledge units that consist of chronological sequences with a hierarchical action organisation including a start and end action as well as a representation of the execution time each action will need.[20] Instead of distinguishing the Supervisory Attentional System from the Contention Scheduling, Grafman *et al*. (1991) assumed that generating routine and non-routine scripts rely on the same structure and that in both cases the frontal lobe, especially the prefrontal part is activated.

Since the script generation task relies heavily on the frontal lobe[21] as studies with frontal lobe patients[22] as well as patients with a frontal lobe dysfunction like in Parkinson's disease[23] can evidence, it is likely that mental representations of daily activities of demented patients get disrupted too as dementia pathology disrupts the connectivity of the frontal lobes in the brain.[24, 25]

Only three script generation studies were conducted with demented participants, investigating the impact of the disease on verbalised script actions. While all three studies agree that demented participants generate fewer actions than do controls,[9–11] generating more sequencing errors[10, 11] and intrusions[11] can only partly be supported. Since previous studies made only script generation comparisons between demented patients and healthy controls, we wanted to get a better insight into how the generated actions of a script get lost and affected with increasing cognitive impairment.

The aim of this study was to understand how the loss of cognitive functioning affects mental representations of daily activities throughout the course of dementia. A mixed-model study was conducted to study specifically how the content of the mental representations differ between stages of dementia.

METHODS

Study design

A total of 25 individuals were recruited by handing out flyers in pharmacies, nursing homes, adult education centres, and fitness centres that offer sports for seniors. We included individuals who were German, 60 years or older, and fulfilled one of the two inclusion group characteristics: individuals were either diagnosed with dementia (group characteristic 1) or had trouble with/ worries about their memory (group characteristic 2). Further, we excluded all individuals who had a history of mental disorders and severe brain injury.

At the beginning of the interview, participants filled out an informed consent form. Afterwards, personal data were obtained like year of birth, gender, profession, educational background, mother tongue, diagnosed medical diseases, use of vision aids, and hearing devices as well as possible motoric restrictions of each participant to control for biases that could influence the results of this study. Table 1 represents the characteristics of the participants. Further, tests of quantitative measures like memory functioning, mental representations of daily activities were performed as well as qualitative aspects of recognised daily activity problems and their thereupon developed strategies to circumvent those difficulties (described in more detail in the following section) were assessed. After the semi-structured interview participants received a payment of 20 € for their study participation.

The study was conducted in coherence with the Declaration of Helsinki and was approved by the ethics committee of the University of Kaiserslautern (reference number mh/mk 09072018 Nr. 5).

Table 1 Characteristics of the study participants

Participant characteristics	Frequency (*n*, %)/ (mean, SD)
Age (years)	67.64; 23.625
Education (<12 years/ ≥12 years)	8 (32%) / 17 (68%)
Gender (female/male)	14 (56%) / 11 (44%)
Vision aids (yes/no)	22 (88%) / 3 (12%)
Hearing devices (yes/no)	7 (28%) / 18 (72%)
Motor restrictions (yes/no)	5 (20%) / 20 (80%)

Quantitative measurements

Two different kinds of tests were conducted to get a better insight into the participant's mental representations of daily activities and the cognitive status. The used materials are listed chronologically according to the order at the assessment.

Montreal Cognitive Assessment

The cognitive status of the participants was assessed via the Montreal Cognitive Assessment (MoCa) test. The MoCa was developed by Nasreddine *et al*. (2005) as a brief screening tool for cognitive impairment and is a short clinical test that evaluates several cognitive domains of an individual by means of 30 questions. Examined domains are short-term memory recall, visuospatial abilities, multiple aspects of executive functions, attention, concentration, working memory, language and orientation to time and place. Participants were classified according to their achieved score on the MoCa test. Normal ageing elderly reach a MoCa score between 26 to 30.[26] Further, we set cut-offs for scores between 16 to 25 to classify participants with a mild dementia and participants below a score of 16 as having severe dementia. According to that, out of the sample size of 25 participants, six (24%) participants can be classified as healthy, seven (28%) as mild demented and 12 (48%) as severe demented.

Script generation task

The script generation task was developed to assess mental representations of daily activities.[27] Participants were asked to enumerate out loud, step by step and in chronological order how they perform five scripts of daily life activities.[11, 22, 28] The assessed scripts comprised grocery shopping (script 1), having a dentist appointment (script 2), doing the laundry (script 3), leaving the house (script 4), and having a car accident (script 5).[29, 30]

We analysed the script generation task based on Godbout and Doyon (1995, 2000). The total number of mentioned actions for the five scripts were calculated as well as the mean total number of generated actions for each script. In addition, for each script, generated action sequences were established by including all actions that were mentioned by 20% of all participants regardless of their cognitive status. Further, we classified the actions that did not fit in the action sequences according to the following elements:[13, 31]

1 intrusions (INT): actions that were normally not part of the script like opinions or jokesIntrusions can be subdivided into:
   a -relevant intrusions (INTrel): generated actions that belong to the script.
   b irrelevant intrusions (INTirr): generated actions that were not related to the script.For both types of intrusions, we classified if the type of intrusion was situational (i.e. giving an example; INTrelSit / INTirrSit) or emotional (i.e. expressing anger or joy; INTrelEm / INTirrEm)
2 personalisations (PER): type of intrusion that was personalised or episodic
3 sequencing errors (SEQ): actions that were mentioned in an incorrect sequence place

Qualitative measurements

The generated actions for each script of the script generation task were also analysed qualitatively. In addition, participants were asked, in a semi-structured interview, open-end questions about their daily activities (with a special focus on the activities in the scripts) including problems and developed strategies that allow the participant to talk in more detail on those issues.[32] The semi-structured interview followed the approach of the Grounded Theory,[33] in which the focus of the questions lay on incidents, events, and happenings in a person's life that might provide information on the research question.[34] If the participant mentioned problems in the interview before, the experimenter will start with questions concerning these problems and events that happened around this issue. If the participant was hesitant in providing information, the experimenter either proceeded with open-ended questions on the scenarios already used in the script generation task or asked for more information on the characteristics of the mental representations (attributes, locations, related actions, related categories).

Data analysis

Data analysis comprised three different parts. First, statistically relevant differences among the three different classified cognitive status groups, healthy, mild and severe demented participants, on the collected script generation data were estimated via the non-

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parametric Kruskal-Wallis test[35] in combination with the Dunn's test[36] for pairwise comparisons.

The second part comprises the qualitative data analysis including the script generation task and open-end questions concerning daily activities. The qualitative analysis was based on the Grounded Theory approach from Glaser and Strauss (1967) using the qualitative data analysis software nVivo. Qualitative data analysis was carried out by one coder. First, digital text files for each participant were created either by transcription of the audiotaped interviews or by digitalising experimenters´ notes. Then, the created files were loaded into the nVivo software. According to the Grounded Theory,[33] we first performed an ''open'' coding technique followed by an ''axial'' and a ''selective'' coding technique. Every text file was coded by assigning concepts and ideas emerging from the collected data and the literature review via an iterative line by line reading in the ''open'' coding approach where descriptive conceptual labels were summarised to a code.[37] Constant comparisons among text files were used to validate as well as refine an established code or to expand the coding scheme. Developed codes were grouped to a greater extent into conceptual categories through the elaboration of properties, dimensions, and/or subcategories. With the ''axial'' coding technique, we related those established categories and properties to each other to identify intervening conditions, strategies, and consequences. This process was completed by the ''selective'' coding technique where the categories were further condensed and integrated into a category network through the elaboration of a core category.[32, 33, 38]

In the third part, we turned the qualitative analysis of the script generation data, strategies and problems into quantitative data by counting the number of each mentioned strategy (Nb_STRAT), problems (Nb_PROB) and useful tools (Nb_TOOL) as well as categorising the generated actions of each script according to the three dimensions (1) Level of Abstraction (Abstract actions (Abstr) vs. Personalised / Example actions (PerExa), (2) Level of Emotion (unemotional actions (UnEm) vs. emotional actions (Em)) and (3) Ordering (if there is no interest in generating order actions (noINTord) and if order words are generated (ORDac) like after/before…). These qualitatively derived formalised script generation scores were statistically analysed via the non-parametric Kruskal-Wallis test[35] in combination with the Dunn's test[36] for pairwise comparisons. We also conducted a sensitivity analysis by calculating the ratio of the new scores to the total number of actions generated in the script generation task across all cognitive status groups.

All statistical analyses were conducted using STATA Version 15.0 and used $P < 0.05$ as the significance level (two-tailed).

RESULTS

Quantitative results

The results of the script generation data are demonstrated in Table 2 and show that script generation for script 1 was significantly associated with the cognitive status. Dunn's test revealed there is a strong evidence that severe demented participants generate significantly fewer actions than healthy controls do. In contrast to this, there was no evidence of a difference in script generation between the other pairs (severe demented compared to mild demented and mild demented compared to healthy participants). Further, script generation for scripts 3 and 4 were also significantly associated with cognitive status, where severe demented participants produced significantly fewer actions than healthy and mild demented participants do. In contrast, no overall significant decline was found for generating the actions for script 2 and script 5.

None of the associations between cognitive status and the classified actions for the five scripts according to the type of intrusion (INT, INTrel/INTirr, INTrelSit/INTirrSit, INTrelEm/INTirrEm), personalisation (PER) and sequencing errors (SEQ) reached significance.

General established action sequences by at least one-fifth of the participants for the three significant action generations of the scripts 1, 3 and 4 are reported in the Table 3. As Table 3 indicates and in contrast to other actions, the actions 'go to the store' and 'pick products from shelf' for script 1 seem to be relatively stable throughout the course of dementia, since these actions were mentioned by 50% or more severe demented participants. With severe dementia, checking out, paying, and bagging the items are most likely to be lost. Regarding the script generation for script 3, the action 'press the start button' was not mentioned by severe demented participants and

Table 2 Script generation results including the mean and SD of generated script actions and actions classified as intrusions, personalisations and sequencing errors for each script mentioned by the cognitive status group

		Mean (SD)				Kruskal-Wallis test			Dunn's test		
Script	Score	Total	Healthy	Mild	Severe	*P*	df	Chi	*P* (H:M)	*P* (H:S)	*P* (M:S)
Script 1	AC	8.48 (5.96)	12.67 (4.89)	10.29 (6.45)	5.33 (4.64)	0.024	2	7.445	0.152	0.004	0.057
	INT	2.32 (3.1)	2.17 (2.86)	2.29 (2.87)	2.41 (3.55)	0.975	2	0.050	0.421	0.417	0.494
	INTrel	1.88 (2.93)	2.17 (2.86)	2.14 (2.54)	1.58 (3.37)	0.656	2	0.844	0.379	0.292	0.174
	INTrelSit	1.80 (2.93)	2.17 (2.86)	1.86 (1.95)	1.58 (3.37)	0.663	2	0.823	0.394	0.2837	0.180
	INTrelEm	0.08 (0.40)	0.00 (0.00)	0.29 (0.76)	0.00 (0.00)	0.862	2	0.297	0.100	0.500	0.067
	INTirr	0.44 (0.82)	0.00 (0.00)	0.14 (0.38)	0.83 (1.03)	0.160	2	3.669	0.313	0.014	0.041
	INTirrSit	0.20 (0.50)	0.00 (0.00)	0.14 (0.38)	0.33 (0.65)	0.686	2	0.755	0.256	0.089	0.258
	INTirrEm	0.24 (0.72)	0.00 (0.00)	0.00 (0.00)	0.50 (1.00)	0.570	2	1.125	0.500	0.066	0.569
	PER	2.08 (3.05)	1.67 (2.25)	1.86 (3.08)	2.42 (3.55)	0.820	2	0.396	0.419	0.352	0.262
	SEQ	0.20 (0.41)	0.00 (0.00)	0.29 (0.49)	0.25 (0.45)	0.629	2	0.927	0.104	0.110	0.427
Script 2	AC	4.64 (3.85)	6.33 (4.13)	5.57 (4.35)	3.25 (3.17)	0.215	2	3.076	0.353	0.054	0.107
	INT	1.32 (1.93)	1.17 (1.60)	1.43 (2.57)	1.33 (1.83)	0.950	2	0.103	0.451	0.428	0.368
	INTrel	1.12 (1.76)	1.17 (1.60)	1.43 (2.57)	0.92 (1.38)	0.985	2	0.030	0.427	0.447	0.470
	INTrelSit	0.84 (1.62)	1.00 (1.55)	1.14 (2.61)	0.58 (0.90)	0.849	2	0.328	0.257	0.330	0.382
	INTrelEm	0.28 (0.61)	0.17 (0.41)	0.29 (0.76)	0.33 (0.65)	0.930	2	0.145	0.488	0.325	0.329
	INTirr	0.20 (0.82)	0.00 (0.00)	0.00 (0.00)	0.42 (1.16)	0.779	2	0.500	0.500	0.115	0.103
	INTirrSit	0.20 (0.82)	0.00 (0.00)	0.00 (0.00)	0.42 (1.16)	0.779	2	0.500	0.500	0.115	0.103
	INTirrEm	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	1.000	2	0.000			
	PER	1.16 (1.86)	0.67 (0.82)	1.29 (2.63)	1.33 (1.83)	0.759	2	0.551	0.403	0.320	0.217
	SEQ	0.04 (0.20)	0.16 (0.41)	0.00 (0.00)	0.00 (0.00)	0.833	2	0.365	0.067	0.048	0.500
Script 3	AC	3.56 (3.70)	6.67 (5.16)	4.43 (2.44)	1.50 (2.02)	0.039	2	6.515	0.364	0.012	0.024
	INT	0.44 (0.77)	0.50 (0.84)	0.57 (0.98)	0.33 (0.65)	0.930	2	0.145	0.490	0.344	0.347
	INTrel	0.44 (0.77)	0.50 (0.84)	0.57 (0.98)	0.33 (0.65)	0.930	2	0.145	0.490	0.344	0.347
	INTrelSit	0.44 (0.77)	0.50 (0.84)	0.57 (0.98)	0.33 (0.65)	0.930	2	0.145	0.4890	0.344	0.347
	INTrelEm	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	1.000	2	0.000			
	INTirr	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	1.000	2	0.000			
	INTirrSit	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	1.000	2	0.000			
	INTirrEm	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	1.000	2	0.000			
	PER	0.40 (0.71)	0.50 (0.84)	0.43 (0.79)	0.33 (0.65)	0.946	2	0.111	0.425	0.339	0.414
	SEQ	0.12 (0.33)	0.00 (0.00)	0.14 (0.38)	0.17 (0.39)	0.846	2	0.335	0.219	0.158	0.440
Script 4	AC	2.68 (2.79)	5.67 (1.97)	3.71 (2.81)	0.58 (0.79)	0.001	2	13.62	0.140	0.000	0.007
	INT	0.28 (0.68)	0.33 (0.52)	0.43 (1.13)	0.17 (0.39)	0.849	2	0.328	0.249	0.218	0.488
	INTrel	0.28 (0.68)	0.33 (0.52)	0.43 (1.13)	0.17 (0.39)	0.849	2	0.328	0.249	0.218	0.488
	INTrelSit	0.28 (0.68)	0.33 (0.52)	0.43 (1.13)	0.17 (0.39)	0.849	2	0.328	0.249	0.218	0.488
	INTrelEm	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	1.000	2	0.000			
	INTirr	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	1.000	2	0.000			
	INTirrSit	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	1.000	2	0.000			
	INTirrEm	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	1.000	2	0.000			
	PER	0.20 (0.65)	0.00 (0.00)	0.43 (1.13)	0.17 (0.39)	0.849	2	0.328	0.202	0.168	0.486
	SEQ	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	1.000	2	0.000			
Script 5	AC	3.72 (3.18)	6.17 (3.43)	2.71 (2.87)	3.08 (2.81)	0.155	2	3.736	0.031	0.052	0.319
	INT	1.12 (1.76)	0.67 (0.82)	0.29 (0.49)	1.83 (2.29)	0.285	2	2.513	0.237	0.205	0.044
	INTrel	0.60 (0.87)	0.67 (0.82)	0.14 (0.38)	0.83 (1.03)	0.330	2	2.220	0.105	0.433	0.050
	INTrelSit	0.60 (0.87)	0.67 (0.82)	0.14 (0.38)	0.83 (1.03)	0.330	2	2.220	0.105	0.433	0.050
	INTrelEm	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	1.000	2	0.000			
	INTirr	0.52 (1.33)	0.00 (0.00)	0.14 (0.38)	1.00 (1.81)	0.301	2	2.398	0.296	0.027	0.081
	INTIrrSit	0.52 (1.33)	0.00 (0.00)	0.14 (0.38)	1.00 (1.81)	0.301	2	2.398	0.296	0.027	0.081
	INTirrEm	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	1.000	2	0.000			
	PER	1.04 (1.79)	0.50 (0.84)	0.29 (0.49)	1.75 (2.34)	0.415	2	1.758	0.396	0.153	0.083
	SEQ	0.04 (0.20)	0.17 (0.41)	0.00 (0.00)	0.00 (0.00)	0.833	2	0.365	0.067	0.048	0.500

P (H:M), *p*-value of the Dunn's test when comparing healthy to mild demented participants; *P* (H:S), *P*-value of the Dunn's test when comparing healthy to severe demented participants; *P* (M:S), *P*-value of the Dunn's test when comparing mild demented to severe demented participants; Script 1, grocery shopping; Script 2, dentist appointment; Script 3, doing the laundry; Script 4, leaving the house; Script 5, having a car accident; AC, actions generated; INT, intrusions; INTrel, relevant intrusions; INTrelSit, relevant intrusions situation specific; INTrelEm, relevant intrusions emotional specific; INTirr, irrelevant intrusions; INTirrSit, irrelevant intrusions sitiational specific; INTirrEm, irrelevant intrusions emotional specific; PER, personalisations; SEQ, sequencing error.

Table 3 Generated common actions for scripts 1, 3 and 4 throughout the disease, rounded percentage to two decimal places where given for every action mentioned by the classified cognitive status group

Script content	Healthy (%)	Mild (%)	Severe (%)
Script 1			
Write a shopping list	100.00	57.14	25.00
Take a bag	66.67	28.57	33.33
Go to the store	100.00	85.71	50.00
Pick products from the shelf	100.00	71.42	58.33
Proceed to checkout	100.00	57.14	8.33
Pay	100.00	57.14	16.67
Bagging	66.67	0.00	16.67
Go home	100.00	57.14	33.33
Script 3			
Separate clothes	66.67	71.43	8.33
Load the machine	66.67	57.14	8.33
Add detergent	50.00	42.86	8.33
Choose program	66.67	28.57	16.67
Press the start button	50.00	28.57	0.00
Hang out the laundry	16.67	41.86	16.67
Script 4			
Get dressed	83.33	42.86	0.00
Take the keys	50.00	28.57	0.00
Check if all windows and doors are closed	16.67	42.86	0.00
Leave the house	83.33	14.29	16.67
Lock the door	66.67	42.86	16.67

Script 1, grocery shopping; Script 3, doing the laundry; Script 4, leaving the house.

decrease with the progress of the disease. In contrast, the action 'hang out the laundry' was mentioned equally often by healthy and severe demented participants, whereby the action was mentioned more by mild demented participants. The actions 'get dressed', 'take the keys' and 'check if all windows and doors are closed' for script 4 are completely absent in the severe demented cognitive status group. Opposed to this mild demented participants check more for closed windows and doors than healthy participants do.

Qualitative results

Qualitative analysis first comprised open coding leading to properties, dimensions and subcategories including diary and shopping list usage, storing things in always the same place, sorting things according to a particular schema, awareness of problems leading to strategy development, daily activities conducted on their own vs. daily activities overtaken by others, digression, concentration deficits, memories, fears and worries as well as gratefulness. Subsequently axial coding was conducted, in which we identified the following strategies, consequences and conditions: orderliness, making notes, conversations, stress, noise, severe problems, some problems, no problems. The categories network that was established in this process emphasises the variance in the desire for order, naming of examples vs. abstract actions, generation of emotional content, experience of disturbing daily life factors, development of strategies, and the usage of problem solving skills.

Mixed results

Scores were calculated for the categories obtained in the qualitative analysis: Nb_STRAT, Nb_PROB, Nb_TOOL, Abstr, PerExa, UnEm, Em, noINTord, ORDac. Results are shown in Table 4. They confirm that Nb_STRAT and Nb_PROB vary significantly across cognitive status groups. People with severe dementia named significantly fewer strategies and problems than healthy and mild demented participants do. Whereby a steady decrease in NB_PROB can be observed along the disease, the Nb_STRAT is higher for mild demented than for healthy participants. Albeit the Nb_TOOL is not significantly affected by cognitive status it should be mentioned that wherby tool usage is completely absent for severe demented participants, mild demented participants rely more on tool usage compared to healthy participants. There were significant main effects between Abstr and cognitive status of script 1, script

Table 4 Quantified mixed-method results including the mean and SD of generated strategies, problems and tools as well as script actions classified according to their level of abstraction, level of emotion and sequences for each script mentioned by the cognitive status group

Script	Score	Mean (SD) Total	Healthy	Mild	Severe	Kruskal-Wallis test *P*	df	Chi	Dunn's test *P* (H:M)	*P* (H:S)	*P* (M:S)
Script 1	Nb_STRAT	0.60 (0,87)	1.00 (1.10)	1.14 (0.90)	0.08 (0.29)	0.025	2	7.357	0.354	0.013	0.003
	Nb_PROB	0.48 (0.59)	1.00 (0.63)	0.71 (0.49)	0.08 (0.29)	0.011	2	8.955	0.256	0.001	0.007
	Nb_TOOL	0.44 (0.82)	0.50 (0.55)	1.14 (1.21)	0.00 (0.00)	0.063	2	5.531	0.240	0.029	0.002
	Abstr	6.28 (5.16)	10.33 (3.50)	8.57 (5.35)	2.92 (3.50)	0.006	2	10.15	0.2301	0.002	0.0123
	PerExa	2.24 (2.99)	2.33 (1.86)	1.86 (3.08)	2.42 (3.55)	0.594	2	1.041	0.148	0.296	0.255
	UnEm	8.12 (6.04)	12.67 (4.89)	10.00 (5.86)	4.75 (4.90)	0.014	2	8.583	0.172	0.003	0.033
	Em	0.32 (0.80)	0.00 (0.00)	0.29 (0.76)	0.50 (1.00)	0.694	2	0.729	0.247	0.092	0.274
	noINTord	0.16 (0.37)	0.00 (0.00)	0.14 (0.38)	0.25 (0.45)	0.694	2	0.729	0.246	0.091	0.274
	ORDac	0.16 (0.37)	0.17 (0.41)	0.43 (0.53)	0.00 (0.00)	0.310	2	2.343	0.104	0.187	0.008
Script 2	Abstr	3.36 (3.93)	5.17 (4.22)	4.29 (4.68)	1.92 (3.00)	0.142	2	3.909	0.332	0.0324	0.076
	PerExa	1.28 (1.95)	1.17 (1.60)	1.29 (2.63)	1.33 (1.83)	0.788	2	0.476	0.323	0.4221	0.228
	UnEm	4.32 (3.97)	6.17 (4.36)	5.29 (4.61)	2.83 (3.04)	0.237	2	2.879	0.320	0.0553	0.129
	Em	0.28 (0.61)	0.17 (0.41)	0.29 (0.76)	0.33 (0.65)	0.931	2	0.145	0.488	0.3247	0.329
	noINTord	0.28 (0.46)	0.17 (0.41)	0.14 (0.38)	0.42 (0.51)	0.536	2	1.249	0.463	0.1376	0.105
	ORDac	0.20 (0.41)	0.17 (0.41)	0.29 (0.49)	0.17 (0.39)	0.902	2	0.206	0.300	0.500	0.271
Script 3	S3_Abstr	3.20 (3.70)	6.33 (5.24)	4.00 (2.16)	1.17 (2.12)	0.036	2	6.642	0.367	0.010	0.019
	S3_PerExa	0.40 (0.71)	0.5 (0.84)	0.43 (0.79)	0.33 (0.65)	0.946	2	0.111	0.425	0.339	0.414
	UnEm	3.44 (3.62)	6.33 (5.24)	4.29 (2.29)	1.50 (2.02)	0.068	2	5.391	0.412	0.022	0.031
	Em	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	1.000	2	0.000			
	noINTord	0.16 (0.37)	0.17 (0.41)	0.00 (0.00)	0.25 (0.62)	0.671	2	0.798	0.212	0.328	0.08
	ORDac	0.28 (0.54)	0.00 (0.00)	0.71 (0.76)	0.17 (0.39)	0.166	2	3.592	0.008	0.233	0.021
Script 4	Abstr	2.40 (2.75)	5.33 (1.97)	3.29 (2.98)	0.42 (0.67)	0.001	2	13.386	0.143	0.000	0.007
	PerExa	0.28 (0.68)	0.33 (0.52)	0.43 (1.13)	0.17 (0.39)	0.849	2	0.328	0.249	0.218	0.488
	UnEm	2.68 (2.79)	5.67 (1.97)	3.71 (2.81)	0.58 (0.79)	0.001	2	13.620	0.140	0.000	0.007
	Em	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	1.000	2	0.000			
	noINTord	0.08 (0.28)	0.00 (0.00)	0.14 (0.38)	0.08 (0.29)	0.909	2	0.191	0.177	0.274	0.326
	ORDac	0.12 (0.33)	0.17 (0.41)	0.14 (0.38)	0.08 (0.29)	0.954	2	0.095	0.449	0.308	0.353
Script 5	Abstr	2.68 (3.25)	5.67 (3.83)	2.43 (2.76)	1.33 (2.31)	0.062	2	5.570	0.051	0.006	0.233
	PerExa	1.08 (1.78)	0.50 (0.84)	0.43 (0.53)	1.75 (2.34)	0.535	2	1.250	0.465	0.149	0.161
	UnEm	3.72 (3.18)	6.17 (3.43)	2.71 (2.87)	3.08 (2.81)	0.155	2	3.736	0.031	0.052	0.319
	Em	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	1.000	2	0.000			
	noINTord	0.24 (0.44)	0.17 (0.41)	0.00 (0.00)	0.42 (0.51)	0.311	2	2.337	0.246	0.126	0.022
	ORDac	0.04 (0.20)	0.00 (0.00)	0.14 (0.38)	0.00 (0.00)	0.862	2	0.297	0.010	0.500	0.067

P (H:M), *p*-value of the Dunn's test when comparing healthy to mild demented participants; *P* (H:S), *P*-value of the Dunn's test when comparing healthy to severe demented participants; *P* (M:S), *P*-value of the Dunn's test when comparing mild demented to severe demented participants; Script 1, grocery shopping; Script 2, dentist appointment; Script 3, doing the laundry; Script 4, leaving the house; Script 5, having a car accident; NbSTRAT, number of mentioned strategies; NbPROB, number of mentioned problems; NbTOOL, number of mentioned tools; Abstr, abstract actions; PerExa, personalised / example actions; UnEm, unemotional actions; Em, emotional actions; noINTord, no interest in generating order action; ORDac, generation of order actions.

Table 5 Ratios of the quantified mixed-method results including the mean and SD of generated strategies, problems and tools as well as script actions classified according to their level of abstraction, level of emotion and sequences for each script mentioned by the cognitive status group

		Mean (SD)				Kruskal-Wallis test			Dunn's test		
Script	Score	Total	Healthy	Mild	Severe	*P*	df	Chi	*P* (H:M)	*P* (H:S)	*P* (M:S)
Script 1	NbSTRAT_ratio	0.03 (0.06)	0.02 (0.03)	0.08 (0.09)	0.01 (0.03)	0.038	2	6.536	0.202	0.043	0.003
	NbPROB_ratio	0.02 (0.02)	0.03 (0.02)	0.03 (0.02)	0.00 (0.01)	0.023	2	7.573	0.428	0.006	0.007
	NbTOOL_ratio	0.03 (0.10)	0.01 (0.01)	0.11 (0.18)	0.00 (0.00)	0.059	2	5.670	0.198	0.036	0.002
	Abstr_ratio	0.67 (0.38)	0.84 (0.11)	0.81 (0.38)	0.50 (0.41)	0.169	2	3.556	0.277	0.126	0.030
	PerExa_ratio	0.33 (0.37)	0.16 (0.11)	0.21 (0.37)	0.50 (0.41)	0.211	2	3.116	0.326	0.126	0.043
	UnEm_ratio	0.91 (0.23)	1.00 (0.00)	0.99 (0.03)	0.82 (0.32)	0.400	2	1.831	0.305	0.037	0.010
	Em_ratio	0.08 (0.23)	0.00 (0.00)	0.01 (0.03)	0.17 (0.32)	0.621	2	0.952	0.279	0.072	0.195
	noINTord_ratio	0.07 (0.16)	0.00 (0.00)	0.04 (0.09)	0.12 (0.21)	0.621	2	0.952	0.279	0.072	0.195
	ORDac_ratio	0.02 (0.06)	0.01 (0.03)	0.07 (0.09)	0.00 (0.00)	0.302	2	2.395	0.088	0.216	0.009
Script 2	Abstr_ratio	0.59 (0.45)	0.73 (0.39)	0.74 (0.40)	0.41 (0.47)	0.245	2	2.814	0.371	0.103	0.051
	PerExa_ratio	0.41 (0.45)	0.27 (0.39)	0.26 (0.40)	0.59 (0.47)	0.245	2	2.814	0.371	0.103	0.051
	UnEm_ratio	0.87 (0.27)	0.92 (0.20)	0.89 (0.27)	0.82 (0.32)	0.731	2	0.628	0.477	0.193	0.211
	Em_ratio	0.13 (0.27)	0.08 (0.20)	0.11 (0.27)	0.17 (0.32)	0.898	2	0.215	0.476	0.289	0.313
	noINTord_ratio	0.21 (0.36)	0.08 (0.20)	0.06 (0.14)	0.37 (0.46)	0.332	2	2.206	0.468	0.074	0.062
	ORDac_ratio	0.03 (0.07)	0.01 (0.03)	0.04 (0.07)	0.04 (0.08)	0.831	2	0.370	0.207	0.365	0.285
Script 3	Abstr_ratio	0.75 (0.42)	0.78 (0.44)	0.92 (0.13)	0.57 (0.53)	0.793	2	0.463	0.388	0.330	0.220
	PerExa_ratio	0.26 (0.42)	0.24 (0.43)	0.08 (0.13)	0.43 (0.53)	0.793	2	0.463	0.388	0.330	0.220
	UnEm_ratio	0.93 (0.24)	0.78 (0.44)	0.98 (0.06)	1.00 (0.00)	0.515	2	1.326	0.159	0.038	0.219
	Em_ratio	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	1.000	2	0.000			
	noINTord_ratio	0.19 (0.39)	0.20 (0.45)	0.00 (0.00)	0.36 (0.48)	0.443	2	1.627	0.209	0.203	0.040
	ORDac_ratio	0.09 (0.14)	0.00 (0.00)	0.20 (0.17)	0.07 (0.13)	0.142	2	3.904	0.011	0.184	0.059
Script 4	Abstr_ratio	0.85 (0.30)	0.94 (0.09)	0.88 (0.31)	0.70 (0.45)	0.765	2	0.536	0.375	0.276	0.1842
	PerExa_ratio	0.15 (0.30)	0.06 (0.09)	0.13 (0.31)	0.30 (0.45)	0.765	2	0.536	0.375	0.276	0.1842
	UnEm_ratio	1.00 (0.00)	1.00 (0.00)	1.00 (0.00)	1.00 (0.00)	1.000	2	0.000			
	Em_ratio	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	1.000	2	0.000			
	noINTord_ratio	0.09 (0.26)	0 0.00(0.00)	0.08 (0.20)	0.20 (0.45)	0.824	2	0.387	0.207	0.147	
	ORDac_ratio	0.05 (0.13)	0.02 (0.06)	0.04 (0.10)	0.10 (0.22)	0.976	2	0.048	0.466	0.375	
Script 5	Abstr_ratio	0.62 (0.44)	0.81 (0.40)	0.83 (0.24)	0.37 (0.45)	0.173	2	3.510	0.429	0.034	0.078
	PerExa_ratio	0.39 (0.44)	0.19 (0.40)	0.21 (0.21)	0.63 (0.45)	0.172	2	3.523	0.264	0.027	0.150
	UnEm_ratio	1.00 (0.00)	1.00 (0.00)	1.00 (0.00)	1.00 (0.00)	1.000	2	0.000			
	Em_ratio	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	1.000	2	0.000			
	noINTord_ratio	0.12 (0.19)	0.08 (0.20)	0.00 (0.00)	0.21 (0.20)	0.209	2	3.133	0.262	0.071	0.025
	ORDac_ratio	0.01 (0.05)	0.00 (0.00)	0.05 (0.10)	0.00 (0.00)	0.759	2	0.553	0.050	0.500	0.042

P (H:M), *p*-value of the Dunn's test when comparing healthy to mild demented participants; *P* (H:S), *P*-value of the Dunn's test when comparing healthy to severe demented participants; *P* (M:S), *P*-value of the Dunn's test when comparing mild demented to severe demented participants; Script 1, grocery shopping; Script 2, dentist appointment; Script 3, doing the laundry; Script 4, leaving the house; Script 5, having a car accident; NbSTRAT, number of mentioned strategies; NbPROB, number of mentioned problems; NbTOOL, number of mentioned tools; Abstr, abstract actions; PerExa, personalised / example actions; UnEm, unemotional actions; Em, emotional actions; noINTord, no interest in generating order actions; ORDac, generation of order actions.

3 and script 4, where severe demented participants generated significantly less Abstr than healthy and mild demented participants do. In concordance with this, also the generation of UnEm actions differ significantly throughout the disease where severe demented participants produce fewer UnEm actions than healthy and mild demented participants do for scripts 1, 3, and 4. None of the other analysed dimensions reached an overall significance.

Sensitivity analysis

As represented in Table 5 the NB_STRAT_ratio and NB_PROB_ratio are higher for healthy and mild demented participants when comparing to severe demented participants.

DISCUSSION

The aim of the study was to investigate mental representations of daily activities throughout the course of dementia. A mixed-model study was conducted to study the content of the mental representations in more detail. The qualitative part of the study identified a desire for order, the naming of example vs. abstract actions, the generation of emotional action content, the development of strategies and

the usage of problem solving skills as relevant components of mental representations. We calculated scores for each of these dimensions and included them in the quantitative analysis. Results suggest that the number of actions generated for scripts 1, 3 and 4 significantly decline with dementia stage, in particular the number of Abstr and UnEm content decreased. This decline occurs steadily with the progress of the disease. Since the generation of Abstr and UnEm actions significantly decrease for scripts 1, 3 and 4, where actions significantly decline throughout the course of dementia, these dimensions might describe better how script actions get affected along the disease by generating not precise successional action plans that are common for every human but more individualised actions that the participants associate with the script. It should be noted that sensitivity analysis revealed that the Abstr and UnEm generation depend on the cognitive status of the participant and not on the number of actions generated. No significant action generation differences were found for script 2 and script 5, where only a steady decrease can be found for script 2 along the cognitive status groups. Therefore, our data partly confirm the findings from previous dementia script generation studies that demented patients produce significantly fewer actions than healthy participants do.[9–11]

Overall, mental scripts seem to remain largely intact in dementia patients, as we could not find significant differences in INT generation[10] as well as SEQ, PER, Em content, and giving PerExa. When taking the INT discriminations into account, if healthy participants generate INT, they are always relevant. Opposed to this, INTirr are only generated by mild and severe demented participants and increase along the disease. Participants generated no INTirr for scripts 3 and 4. Only in script 1 INTirrEm were found, where severe demented participants generate more INTirrEm than INTirrSit. Evidence is inconclusive for INT, PER and SEQ. Further, it could be that the observed loss and variation in content might reflect the inability of performing daily activities in the severe stages of dementia.[11, 12]

Despite the fact that scripts 1, 3 and 4 significantly lose content throughout the course of dementia, many actions are still mentioned in the severe dementia stages. People with dementia are least likely to remember the actions checking out, paying, and bagging items in the grocery store and getting dressed, taking the keys, and checking for open windows when leaving the house. Knowing that these are the most vulnerable actions, further research should develop means to help people with dementia in those aspects of daily life. The transition from healthy over mild to severe demented participants does not always go steadily down for the generated actions. First, it seems to be dependent on the type of script (i.e. type of household activity), and, second, it seems to be dependent on the action with some actions being a more stable mental representation even in later dementia stages than others. Since the script generation task investigated semantic knowledge[15–19, 21] it could be that the loss of script content either reflect an impairment of semantic memory by dementia pathologies or a reduced ability to access the verbal representation of a script action albeit the conceptual representation is still available.[39–41]

The qualitative analysis enriched the quantitative analysis with additional scores. Results suggest that the perceived problems and number of abstractions and unemotional content of mental representations decrease steadily with dementia. No overall steady decline can be observed for strategy development and tool usage. Dementia patients in mild stages report more strategy development and tool usage than healthy controls and seem therefore able to extend their mental representation of daily activities by incorporating a strategy into their established action sequence when noticing a problem with the activity under question. For example, they mention checking for closed windows and doors when leaving the house more frequently than healthy participants do. In concordance with this, only healthy and mild demented participants report problems with daily activities, hence a certain cognitive status is needed to be able to name problems. The perception of a problem requires the interpretation of the situation in a broader context and this ability seems to be impaired in dementia patients, probably because their mental representation of daily activities for the context have lost content since the safety check for closed windows and doors is completely absent for severe demented patients. Therefore, strategies are extensions to existing mental representations with the purpose of preventing problems to maintain a good functioning in daily life that could not only minimise the help someone needs but also enhance the

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self-esteem of a dementia patient while reducing nursing fees and caregiver burden.

However, this study has some limitations. We acknowledge that we only investigated a small sample size in which the cognitive status groups did not comprise the same amount of participants. This could have influenced the results of our study for the assessed SEQ and inappropriate action generation and our developed dimensions in the respective cognitive status group since they were too small to reach significance given the variance that we observed in our sample. It could be that our developed dimensions are also sensitive when investigating a small sample size since Abstr and UnEm reached significance. Therefore, in future it is more important to investigate a larger sample size for each cognitive status group to receive a more precise and valid view of how the action generation of a script gets affected throughout the course of dementia and to validate our established dimensions. Another aspect to consider is that this study investigated semantic knowledge of mental representations of daily activities. It might also be that mental representations of daily activities are also stored in episodic memory and a person with dementia might be able to perform the action if given the right cue without being able to describe it verbally. Further studies are needed to investigate episodic mental representations of daily activities. Including a diagnostic neurological assessment with imaging data in the study could be quite enlightening to see if different types of dementia affect different mental representations or not. It could also be that participants experience specific problems depending on their type of dementia and that all types of dementia share some problems or helpful strategies while other problems or strategies are type specific. Apparently, this would help to estimate the optimal care for a dementia patient.

Despite the fact that mental representations seem to be largely intact throughout the course of dementia, the generated content as well as Abstr and UnEm decreases. Therefore, it is important to develop helpful strategies and tools for dementia patients that fill missing actions of a script to enhance or stabilise the autonomy level, while reducing caregiver burden, nursing and medical care costs as well as holding the quality of life as long as possible for a longer independent life worth living.

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ETHICAL STANDARDS

The authors assert that all procedures contributing to this work comply with the ethical standards of the relevant national and institutional committees on human experimentation and with the Helsinki Declaration of 1975, as revised in 2008.

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