CogWatch – Cognitive Rehabilitation of Apraxia and Action Disorganisation Syndrome

D4.2.1 Report on Healthcare Evaluation

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EXECUTIVE SUMMARY

This report describes procedures and reports results involved in evaluating the CogWatch First prototype (P1.1) for making one of four different types of a cup of tea (black, black with sugar, white, white with sugar). It covers work undertaken in T4.2 Healthcare evaluation [HW, UOB, TUM, TSA] (M15-36).

Section 1 comprises the introduction to the report and outlines the objectives of the experimental testing with patients and gathering of views of end user representatives, namely stroke survivors, carers and health professionals.

Sections 2 and 3 detail testing of CogWatch system P1.1 with 5 stroke patients at UOB and 8 at TUM. The system was rated as helpful by all patients even though it was only able to deliver correct cues in approximately half of cases. A number of practical issues in running the system in the simulated kitchen environment in the lab were identified.

Section 4 details procedures carried out by HW in conjunction with TSA for investigating the views of end users via focus groups and questionnaires. Opinions were canvassed from users including stroke survivors, carers and healthcare professionals regarding the CogWatch system, specific tools, risks associated with the system, and likely impact on care and treatment costs. Overall, the CogWatch system was perceived as useful in principle but dependent on training as to whether it would have an impact in practice. Information was obtained concerning the prevalence of difficulties making a hot drink in the context of other ADL limitations, and on the costs associated with current therapy practice for use in an exploratory cost analysis.

Section 5 summarises the conclusions of the healthcare evaluation in terms of experimental results and user experience, and the views of end users. Implications for the further development of CogWatch are addressed in terms of patient validation, technical specification, system devices and investigating cost benefits.

It is concluded that the first prototype CogWatch affords a practicable approach to providing continual multimodal cueing for an everyday activity of daily living, making a hot drink. CogWatch is perceived as being of value by potential users including healthcare professional, carers and stroke survivors. A number of practical points for improvement of the first prototype are suggested including making the cues more salient and the need to tailor cueing to the individual. Limitations of the system in operating outside the lab, for example in the home environment, are noted.

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REVISION HISTORY

Revision no.	Date of Issue	Author(s)	Brief Description of Change
V1	06/08/2013	Alan Wing (UOB)	Initial draft
V2	08/08/2013	Amy Arnold (UOB)	Initial draft
V3	14/08/2013	Danni Sims (UOB)	Editing testing information & formatting
V4	19/08/2013	Alan Wing (UOB)	Editing & comments for change
V5	30/08/2013	Alexa Hazell, Andrew Worthington (HW)	Data analysis and adding HW data Redrafting, editing and collating
V6	02/09/2013	Eva Fringi, Danni Sims, Alan Wing (UOB)	Minor textual changes, editing and formatting
V7	18/10/2013	Alan Wing	Final paras added to executive summary and conclusion
final	12/11/2013	Alexa Hazell, Alan Wing, Rosanna Laverick	Response to reviewers; formatting.

LIST OF ABBREVIATIONS AND DEFINITIONS

Abbreviation	Abbreviation in full
UOB	University of Birmingham
TUM	Technische Universität München
STKM	Städtisches Klinikum München
BUIC	Birmingham University Imaging Centre
HW	Headwise
TSA	The Stroke Association
ADL	Activities of daily living
BCoS	Birmingham Cognitive Screen

1. INTRODUCTION

This report is based on T4.2 which is concerned with the usability, effectiveness and practicality of the CogWatch system as experienced by end-users including patients, healthcare professionals, community workers and family members. Issues that are addressed include; (a) How well the technology is received by patients, their families and carers. (b) Reductions in care needs associated with provision of CogWatch (c) Utilisation of information provided by CogWatch by healthcare professionals.

In a quantitative evaluation the effectiveness of the system in reducing errors, and supporting fluent execution of activities of daily living (ADL) was assessed in labs with spatial arrangement similar to patients' kitchens developed at both UOB and TUM.

Qualitative investigations (focus groups and interviews) were undertaken with end users to address the following questions:

(a) How well the technology is received by service users, their families and carers as well as health professional's

(b) The effectiveness of the CogWatch system in terms of preventing injuries, including any risks

(c) Perceived and anticipated reductions in care needs associated with provision of CogWatch

(d) Utilisation of information provided by CogWatch by healthcare professionals

This data was supplemented by quantitative methods (questionnaires and surveys) which provided additional information concerning acceptability, market appeal and cost-effectiveness, and preliminary cost analysis was undertaken comparing potential costs of therapy using CogWatch with current practice.

2. UOB BEHAVOURAL TESTING

2.1 Overview

Behavioural testing at UOB comprised a brief CogWatch training session of 6 tea making trials during which the CogWatch system was operating and two pre- and post-training trials with the system turned off to determine any (short-term) changes as a result of the CogWatch training trials. Following the tea making, patient participants completed questionnaires in order to document their opinions of the CogWatch system.

2.2 Methods

2.2.1 Participants

Participants comprised 5 chronic stroke patients aged between 64 and 78 years recruited from the UOB patient panel. Demographic details are provided in Table 1.

Table 1: Participant demographic details

Patient ID	Age in years	M/F	CVA	Duration since CVA (months)	Dominant Hand
CWUBP001	78	M	Right	74	Right
CWUBP017	64	F	Bilateral	180	Right
CWUBP018	66	F	Right	48	Left
CWUBP024	81	M	Left	54	Right
CWUBP026	75	M	Right	60	Right

2.2.1.1 Screening

Prior to using the CogWatch system patients underwent screening tests (see scores in tables 2 and 3). Tests included: a) Barthel and Neadl – to measure independence functioning in ADL; b) Complex tea making task – to make 2 cups of tea (lemon tea with sugar and normal tea with milk and sweetener); c) Filing task – to staple 2 pieces of paper, hole-punch and add to ring-binder; d) Birmingham Cognitive Screen, BCoS (2013) see table 3 and http://www.bcos.bham.ac.uk) measuring memory, language, attention, and praxis.

In terms of Barthel and NEADL screening tasks, P026 was most affected, whereas in terms of BCOS, P024 was generally most affected, except P026 was worst on gesture imitation and P017 was worst on complex figure copying.

Table 2: Screening Task Scores

Patient ID	Filing task		Barthel	Neadl	Complex tea task	
	Duration (s)	Score (/10)	Score (/100)	Score (/63)	Duration (s)	Score (/24)
CWUBP001	53	8	55	18	339	22
CWUBP017	95.5	10	100	45	No data	No data
CWUBP018	64	10	75	40	154	24
CWUBP024	202	0	90	53	263	14
CWUBP026	No data	No data	35	9	No data	No data

Table 3: BCoS praxis profile scores. Cut off scores appropriate to age group are shown in parentheses

Patient ID	Multi-Step Object Use – (/12)	Gesture Production – (/12)	Gesture Recognition – (/6)	Meaningless Gesture Imitation – (/12)	Complex Figure Copy – (/47)
CWUBP001	12 (10)	12 (9)	4 (4)	10 (9)	45 (37)
CWUBP017	12 (11)	10 (10)	6 (5)	12 (9)	11 (42)
CWUBP018	12 (10)	11 (9)	5 (5)	8 (9)	35 (41)
CWUBP024	2 (10)	7 (9)	3 (4)	8 (9)	30 (37)
CWUBP026	12 (10)	12 (9)	5 (4)	2 (9)	No Data

2.2.2 Apparatus

All objects needed for making a cup of tea (plus the addition of a coffee jar) were set out on the table top as shown in Figure 1 (also see description in D4.1.1). Participant actions on all trials were videoed and later transcribed using ELAN software.

The testing table was located in a specialised test kitchen in which was placed the CogWatch system P1.1 comprising two PCs, one with the clinician screen (used by the experimenter) and one with the patient interface screen (used by the participant). The patient screen was positioned at the right hand far corner of the testing table relative to the participant. The patient screen was a touch screen interface. Participants interacted with the screen by selecting the tea type to be made (see Figure 2), and by pressing Start, Finish, and Help as appropriate. The clinician screen (see Figure 3) allowed the experimenter to input patient information, view a record of completed actions, errors, cues, a countdown timer, and the reliability of the sensors on the objects. Patients wore a MetaWatch, providing vibration alerts as required.

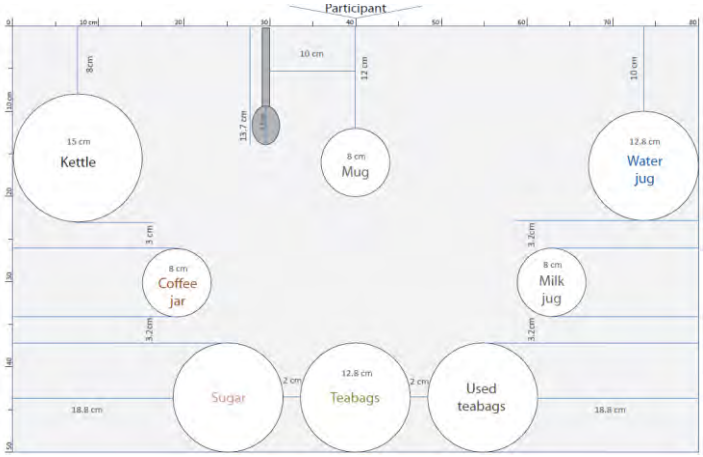

Figure 1: Prototype P1.1 Layout

Figure 2: P1.1 Patient Interface Screen

Figure 3: P1.1 Clinician Interface Screen

Two questionnaires were designed, one by UOB one by UPM, to allow participant to provide their views on their experience of using the CogWatch system. The UOB questions ranged over items concerning how the patients felt when interacting with the screen, the helpfulness of instruction, the ease of use and the overall impression (see Appendix A). The questionnaire designed by UPM was administered first, followed by the questionnaire designed by UOB. Details of the questionnaire designed by UOB are described below while the UPM questionnaire is detailed in D4.1.1.

2.2.3 Procedure

After providing informed consent patients were seated at the table and were given verbal and written instructions for the task; this material included three questions about the participant's usual tea making (see appendix B). Patients were instructed to make a different tea type to their preferred tea type. The tea type made in the task differed by one element to their preferred tea type. For example, if a patient's preferred tea was black tea, they would be asked to make either black tea with sugar, or tea with milk.

Patients were then familiarised with the operation of the kettle, after which tea making trials were delivered as follows:

1. **Trials 1 & 2:** *pre-training trials* in which the system was disabled and no cues were provided. Following the pre-test trials they were provided with verbal instructions regarding use of the patient screen including: i) Selection of the required tea type from 4 images; ii) Use of the Start, Finish and Help buttons; iii) Information regarding the types of cues provided by the system.
2. **Trials 3, 4, 5, 6, 7, 8:** *training trials* in which the CogWatch system provided cues in response to errors; comprising auditory warning, vibration from the watch, and visual indication (still images and videos) of the correct action.
3. **Trials 9 & 10:** *post-training trials* carried out under the same condition as the pre-test trials.

For UOB patients, at the end of the session each participant completed a patient evaluation questionnaire (Appendix A) with the assistance of the experimenter. There were two types of items requiring participants to respond either with Yes/No or on a scale of 1-5 in order to evaluate the patient's opinion and experience of the CogWatch system in 5 areas: presentation (layout of the screen), usability (ease), instructions, the watch, overall.

2.3 Results

Results are presented as a series of case studies. Each case study includes a summary of performance on pre & post training trials and trials trained on the CogWatch system (number of completed trials, number and position (trial number) of errors, and tester comments).

2.3.1 Case Studies

2.3.1.1 Patient: CWUBP001

Patient P001's preferred tea type was **Tea with Milk**. Throughout the 10 trials the patient was asked to make **Tea with Sugar only**. A summary of pre and post training performance can be seen in table 4. A summary of performance using the CogWatch system can be seen in table 5.

Table 4: Summary of performance over pre & post training trials (P001)

ID: CWUBP001	**Pre & post training performance**
Number of trials completed	4/4
Number and position (trial number) of **patient errors**	0
Testing comments	No errors in pre and post training trials

Table 5: Summary of performance over training trials (P001)

ID: CWUBP001	**CogWatch system training performance**
Number of trials completed	6/6
Number and position (trial number) of **patient errors**	2 (trials 4 & 5)
Number of **system errors**	2
Testing comments	i) CogWatch successfully cued trial 4 error ii) Trial 5 – patient began making tea before selecting tea type on touch screen iii): Addition error: used teabag placed on unused teabags – error not yet recognised by system

	iv) Trials 1-5, patient experienced difficulty operating the kettle.

2.3.1.2 Patient: CWUBP017

Patient P017's preferred tea type was **Sugar and Milk**. Throughout the 10 trials the patient was asked to make **Tea with Milk**. A summary of pre and post training performance can be seen in table 6. A summary of performance using the CogWatch system can be seen in table 7.

Table 6: Summary of performance over pre & post training trials (P017)

ID: CWUBP017	**Pre & post training performance**
Number of trials completed	4/4
Number and position (trial number) of **patient errors**	0
Testing comments	No errors made in pre and post training trials

Table 7: Summary of performance over training trials (P017)

ID: CWUBP017	**CogWatch system training performance**
Number of trials completed	6/6
Number and position (trial number) of **patient errors**	0
Number of **system errors**	7
Testing comments	i) Some difficulty using tea type selection and Start/Finish buttons ii) Difficulty operating kettle iii) System prompted task steps when no cue needed, and omitted feedback at the end of a trial.

2.3.1.3 Patient: CWUBP018

Patient P018's preferred tea type was **Tea with Milk**. Throughout the 10 trials the patient was asked to make **Black Tea with Sugar**. A summary of pre and post training performance can be seen in table 8. A summary of performance using the CogWatch system can be seen in table 9.

Table 8: Summary of performance over pre & post training trials (P018)

ID: CWUBP018	**Pre & post training performance**
Number of trials completed	4/4
Number and position (trial number) of **patient errors**	1 (trial 2)
Testing comments	i) Self-correction made in trial 1. Patient almost added milk (see preferred tea type) ii) Addition error: cup contents stirred before water added to cup (error not yet recognised by system) ii) boiled water spilled from kettle

Table 9: Summary of performance over training trials (P018)

ID: CWUBP018	**CogWatch system training performance**
Number of trials completed	6/6
Number and position (trial number) of **patient errors**	2 (trials 3 & 8)
Number of **system errors**	0
Testing comments	i) Patient forgot to press the Finish button in trial 3 ii) System correctly cued fatal error in trial 8

2.3.1.4 Patient: CWUBP024

Patient P024's preferred tea type was **Tea with Milk**. Throughout the 10 trials the patient was asked to make **Black Tea with Sugar**. A summary of pre and post training performance can be seen in table 10. A summary of performance using the CogWatch system can be seen in table 11.

Table 10: Summary of performance over pre & post training trials (P024)

ID: CWUBP024	**Pre & post training performance**
Number of trials completed	1 (post-test)/4
Number and position (trial number) of **patient errors**	1 (trial 9)

Testing comments	i) Pre test trials 1&2 were not performed ii) Second post test (trial 10) was not performed iii) Video recording of patient screen failed iv) Toying error made

Table 11: Summary of performance over training trials (P024)

ID: CWUBP024	**CogWatch system training performance**
Number of trials completed	6/6
Number and position (trial number) of **patient errors**	9 (trials 3, 4, 5, 6 & 8)
Number of **system errors**	Video recording of the patient screen failed – therefore the reliability of the CogWatch system was dependent on real time observation
Testing comments	i) 6 omission errors were made. 4 of these were corrected when prompted by the system ii) 2 omission errors went uncorrected, despite prompting from the system iii) The patient twice reverted to his preferred tea type, by adding milk iv) The patient frequently omitted to press the Finish button v) The patient repeatedly toyed with objects – but on each occasion this was less than 30 seconds and therefore not corrected by the system.

2.3.1.5 Patient: CWUBP026

The system failed and would crash immediately prior to starting it up when testing Patient P026 and no data could be recorded.

2.3.2 Completion Times

Trial completion times across patients were measured. Times were measured from start to end of each trial (total completion time). The time taken from when the kettle finished boiling to completion was also measured, to allow action times to be accurately measured without interference from variable kettle boiling times. Completion times were shorter following training on the CogWatch system. There was more variability on pre-training trials (see figure 4).

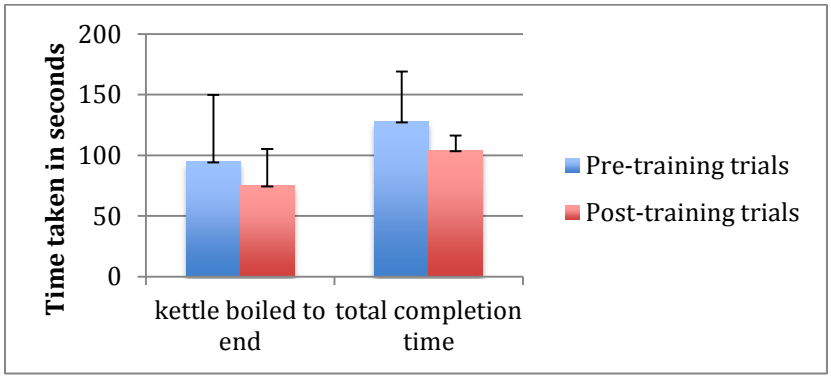

Figure 4: Tea making completion times across participants - before and after training with the CogWatch system

Completion times for CogWatch training trials showed that task completion times remained relatively stable over the six training trials. Completion times were less variable during the later stages of training (see Figure 5).

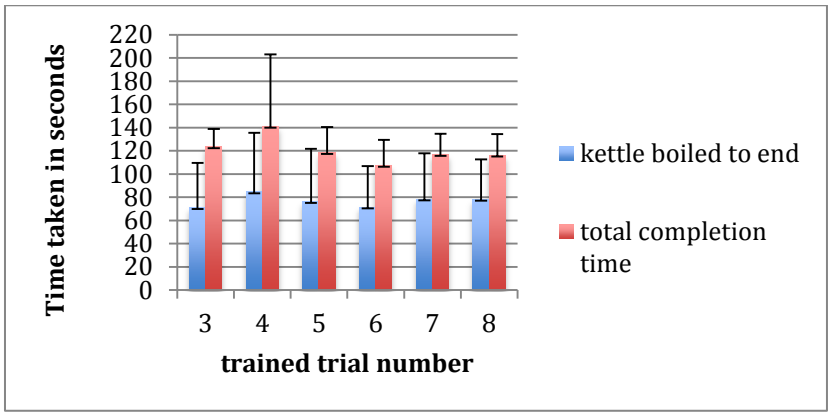

Figure 5: Tea making completion times across participants during training with the CogWatch system

2.3.3 Error Summary

A summary of patient and system errors is shown in Figure 6. 15 patient errors were identified by the CogWatch system, 6 of which were cued successfully. 9 system errors were identified in real time by the experimenter. When working with patients the experimenter was fully occupied with entering system information at the clinician interface and monitoring the patient. When system errors occurred the experimenter was partly dependent on the log file to describe the error. Sometimes the log file reporting appeared to be incomplete or in error and so a further small number of system errors could not be reported. In general, unnecessary cueing of (sometimes incorrect) task steps constituted the largest proportion of system errors. Failure of the patient to correctly interact with the system was also frequently observed (see Usability Errors in Figure 6).

Errors successfully cued by CogWatch system	Errors unrecognized by CogWatch system	System error types	Usability Errors
All omission errors (5) (except failure to select screen options)	Addition errors * Addition errors: Adding an extra component action that is not required during the sequence, and is outside the range of actions produced by control participants (e.g., pouring water from the cup into the sugar bowl, or adding two teabags in one cup)	Unnecessary and incorrect cueing of task steps.	System currently unable to address patient failure to select tea type.
Fatal error (1)	Self-corrections	Counter reset problems (subsequently identified as due to multiple installations of different versions of the system	Failure to press Start/Finish
	Toying <30 seconds		

Figure 6: Summary of patient and system performance.

2.3.4 Questionnaire Evaluation

4 out of 5 participants completed the UOB questionnaire (see Appendix A). The questionnaire comprised of two scoring types i.e. scores rated on a scale of 1 – 5 and yes/no responses. Each patient rated all elements of the system.

Each section of the questionnaire as described above (section 2.1.3) relates to the evaluation of specific areas of the system. The average score across all patients was taken for each section of the questionnaire. Table 12 below shows the average scores for the questions rated on a scale of 1-5 (with SD in parentheses). Table 13 shows the frequency of favourable (to the system) responses.

Table 12: Overall average scores for questions rated 1-5 for each section of the questionnaire completed by 4 of the 5 patients.

Area	Average Score across all patients/ total (Standard Deviation)
Presentation	4.5 (0.58)
Usability	4.5 (0.58)
Instructions	4.75 (0.5)
Watch	4.67 (0.58)
Overall Impression	3.75 (1.89)
Average overall score	4.42 (0.96)

Table 13: Overall average scores for questions rated yes/no (favourable answer=1/unfavourable answer=2) for each section of the questionnaire.

Area	Frequency of Favourability Score
Presentation	4/4
Usability	3/4
Instructions	4/4
Watch	2/2 (the other 2 participants did not interact with the watch)
Overall Impression	4/4
Average overall score	17/18

The questionnaire data shows that overall the patients rated the presentation of the system (such as the font size and picture size) and the instructions of system (such as the helpfulness of the instruction), as very good. For example, all patients rated the presentation highly with all agreeing that the 3 buttons (‘help’, ‘repeat’, ‘finish’) were helpful and the meaning of each button was clear. The usability of the system was also rated positively by most patients; however one patient felt the screen was difficult to press but suggested this may be due to long nails.

The watch was rated as comfortable by all participants and many found the vibration helpful when it worked. Feedback from patients regarding the watch also found that the ability to adjust the strength of the vibration of the watch would be a positive addition to the system.

Overall, the questionnaire showed that all patients had a positive experience of the system and all felt the system helped them with making a cup of tea and would try the system in their own home.

3. TUM BEHAVIOURAL TESTING

3.1 Overview

TUM encountered some difficulties with conducting initial validation trials on P1.1 with stroke patients due to difficulty with installation of P1.1. The problem with UPM assistance, was diagnosed as due to software incompatibility on the ASUS EEE unit at TUM and was resolved by complete reinstallation of the system.

3.2 Methods

3.2.1 Participants

So far eight patients have been tested with the P1.1 version gamma, coded in the TUM database as S22, S27, S61, S62, S70, S71, S74 and S75.

S22: 70 years old female, with first CVA on the 05.12.2011, causing LBD. The bleeding was located in the basal ganglia region. Hemiplegia was present during screening along with diagnosis of Broca's aphasia.

S27: 54 years old male, with first CVA on the 10.08.2012, causing LBD. The ischemic stroke was located in the anterior cerebral artery. No neglect or hemiplegia was present.

S71: 56 year old female, with first CVA 26.08.2013, causing LBD. The ischemic stroke was located in the middle cereberal artery. Right side neglect and right side plegia present.

S70: 54 year old male, with first CVA 14.09.2013, causing LBD. The ischemic stroke was located in the middle and posterior circulation infarct. Right side plegia present.

S75: 43 year old male, with first CVA 12.06.2013, causing RBD. The ischemic stroke was located in the posterior cereberal artery. Left side plegia present.

S74: 67 year old female, with first CVA 25.08.2013, causing LBD. The ischemic stroke was located in the posteriori cerebral artery infarct (subacute). NO neglect or plegia present at the time of testing.

S61: 58 year old female, with first CVA 24.03.2013, causing RBD. The stroke was caused by subaranchoid, middle cereberal artery bleeding. Left side plegia and neglect plegia.

S62: 69 year old female, with first CVA 10.08.2013, causing LBD. The ischemic stroke affected middle, tempoparietal and posterior circulation infarct. Right side neglect and plegia present.

Validation on the sample of three elderly subjects

Three subjects were tested: 2 males, 1 female (M=66.8, SD=3.5).

3.2.1.1 Screening

The screening results for patients S22, S27, S61 and S62 are given in Table 14. The data for the other 4 patients has not yet been processed.

Patient S22 at the time of the screening had used left hand for the task execution (right-handedness prior to CVA). In the screening patient committed errors in both trials of complex tea making. Overall two types of errors were identified, 1 anticipation error – turned on the kettle before putting water in, and 2 quality errors – not putting enough water to the kettle to fill 2 cups. The document filing task was completed without errors.

Patient S27 at the time of screening did not exhibit difficulties with motor execution, however was diagnosed with Transcortical Motor Aphasia causing the communication to be limited. In the screening processes he omitted 2 trials of complex tea making. Overall the patient committed 7 errors: 5 ingredient omissions, 1 substitution error and 1 sequence omission. The document filing task was completed without errors.

Patient S61 at the time of screening demonstrated difficulties with performance of the tasks, failing in the tea making task and document filing task, due to perplexity

Patient S62 at the time of screening demonstrated severe motor execution problems, severe aphasia and problems with understanding of the task. In the document filing task the patient demonstrated problems with the use of puncher.

Table 14: Summary of BCoS scores for 4 of the 8 patients with data processed to date

Patient ID	Multi-Step Object Use – (/12)	Gesture Production – (/12)	Gesture Recognition – (/6)	Meaningless Gesture Imitation – (/12)	Complex Figure Copy – (/47)
S22	12 (10)	11 (9)	5 (4)	9 (9)	30 (37)
S27	12 (10)	11 (9)	5 (4)	6 (9)	36 (37)
S61	6 (10)	10 (9)	5 (4)	5 (9)	0 (37)
S62	5 (10)	4 (9)	4 (4)	5 (9)	17 (37)

3.2.2 Apparatus

The apparatus used in the CogWatch lab at the TUM site was identical to the one described in section 2.1 of this report (CogWatch kitchen lab at UoB site).

3.2.3 Procedure

After providing informed consent patient was seated at the table and given verbal instruction for the task. Participant was given time to familiarize themselves with the apparatus and ask questions.

The participant was informed he would be asked make two cups of tea. One of the preferred type, the other one for a friend (usually black tea with milk and sugar, or black tea with milk). The preferred type was the first trial, the forced choice one the second one.

At the end of the session participants completed the questionnaire with assistance of experimenter.

3.3 Results

Results are presented as a series of case studies describing each participant's interaction with the CogWatch system. Results are first presented for the three healthy elderly participants and then for the patients.

Case studies

In working with the CogWatch system, the healthy elderly group (Tables 15-17), P6 made no errors, while P7 forgot to stir and P8 forgot to press the finish button,

Table 15: Summary of interaction with the CogWatch System (Participant - P6)

ID: P6	**CogWatch system training performance**
Number of trials completed	2/2 Black Tea and Tea with Milk and Sugar
Number, total execution time and position (trial number) of **patient errors**	0, Trial 1 (TT: 2m11s) and 2 (TT:01m23s)
Number of **system errors**	1
Testing comments	i) Patient did not exhibit any problems with task performance. ii) The system needed to be restarted once iii) The system successfully saved the Log files and the sensor data

Table 16: Summary of interaction with the CogWatch System (Participant - P7)

ID: P7	**CogWatch system training performance**
Number of trials completed	2/2 Black Tea with Milk and Tea with Sugar
Number, total execution time and position (trial number) of **patient**	1, Trial 1 (TT: 1m20s) and 2 (TT:03m21s) – forget to stir

errors	
Number of **system errors**	1
Testing comments	i) Participant reacted to the cue A7 E05- and followed the cue instructing to stir the tea. ii) The system needed to be restarted once iii) The system successfully saved the Log files and the sensor data

Table 17: Summary of interaction with the CogWatch System (Participant - P8)

ID: P8	**CogWatch system training performance**
Number of trials completed	2/2 Black Tea and Tea with Milk and Sugar
Number, total execution time and position (trial number) of **patient errors**	1, Trial 1 (TT: 1m59s) and 2 (TT:02m16s) – forget to press the finish button
Number of **system errors**	0
Testing comments	i) Participant reacted to the cue A11-C01- and followed the cue instructing to press the Finish button iii) The system successfully saved the Log files and the sensor data

The patients' performance with the CogWatch system is summarized in Tables 18 through 25.

Table 18: Summary of interaction with the CogWatch System (Patient - S22)

ID: S22	**CogWatch system training performance**
Number of trials completed	2/2 Black Tea with Sugar and Tea with Milk and Sugar
Number, total execution time and position (trial number) of **patient errors**	0, Trial 1 (TT: 2m01s) and 2 (TT:02m15s)

Number of **system errors**	1
Testing comments	i) Patient did not exhibit any problems with task performance. During the lab testing patient was primarily still using the left (non-dominant hand). The use of the prototype was smooth, however the research assistant had to prompt pressing the Finish button for the second time after the final message. The total execution time was similar to the values observed in the healthy elderly controls. ii) The system needed to be restarted 3 times between trials to connect properly between the VTE and CPI units. iii) system successfully saved the Log files and the sensor data

Table 19: Summary of interaction with the CogWatch System (Patient - S27)

ID: S27	**CogWatch system training performance**
Number of trials completed	2/2 Trial Black Tea and Tea with Milk and Sugar
Number and position (trial number) of **patient errors**	Trial 1 (TT: 03m29s) and 2 (TT:01m52s)
Number of **system errors**	5
Testing comments	i) Patient persisted on repeating the error: putting the tea bag inside the kettle (wrong object selection). Although the system was prompting to put the teabag in the mug, patient ignored those cues and communicated to the interface and researchers present in the lab that it is a wrong instruction. ii) Patient did not press the finish button at the end, although he was prompted to by the researcher iii) Clinician had a difficulty using the interface when typing in the details of the error not listed and following the action sequences produced by patient. iv) Patient committed the same mistake twice, although each time the VTE was prompting to put the tea bag in the mug.

	v) System was restarted 2 times to connect between VTE and CPI units. vi) system successfully saved the Log files and the sensor data

Table 20: Summary of interaction with the CogWatch System (Patient - S61)

ID: S61	**CogWatch system training performance**
Number of trials completed	2/2 Black Tea with Milk and Sugar
Number and position (trial number) of **patient errors**	Trial 1 (TT: 05m20s) and 2 (TT:03m20s)
Number of system errors	0
Testing comments	i) Patient spontaneously pressed the HELP button at the beginning of the T1 and pressed the button at each step. Most successful interaction with the system in the sample. In between the cues was waiting for the system to prompt further. ii) Guided with prototype through T2. iii) Unable to perform the task on her own. iv) system successfully saved the Log files and the sensor data

Table 21: Summary of interaction with the CogWatch System (Patient - S62)

ID: S62	**CogWatch system training performance**

Number of trials completed	2/2 Black Tea with Milk and Sugar
Number and position (trial number) of **patient errors**	Trial 1 (TT: 01m20s) and 2 (TT:02m45s)
Number of system errors	1 (problems with timer, needed one reset)
Testing comments	i) Fatal error in T1, cold water in the cup with teabag. ii) T2 Problems with opening the kettle lid. To little water put in the kettle – misestimation error. T2 successfully completed. iii) system successfully saved the Log files and the sensor data

Table 22: Summary of interaction with the CogWatch System (Patient - S70)

ID: S70	**CogWatch system training performance**
Number of trials completed	2/2 black tea / black tea with milk and sugar
Number and position (trial number) of **patient errors**	Trial 1 (TT: 01m59s) and 2 (TT:03m13s)
Number of system errors	0
Testing comments	i) Difficulties with operation of the kettle - patient turned on the kettle when trying to open it. Closed and open the lid. ii) Patient prompted to put a tea bag in the cup. iii) Patient was toying with glass bowl, kettle, cup, tea box and spoon. iv) Patient adding milk to “tea with sugar”. v) system successfully saved the Log files and the sensor data

Table 23: Summary of interaction with the CogWatch System (Patient - S71)

ID: S71	**CogWatch system training performance**
Number of trials completed	2/2 Trial Black Tea with Milk and Sugar / Black Tea with Milk
Number and position (trial number) of **patient errors**	Trial 1 (TT: 01m49s) and 2 (TT:02m58s)
Number of system errors	2 – need to reset system twice
Testing comments	i) In the first trial patient has shown perplexity at the stage of heating up the water and toying behavior with the spoon. Patient did not turn on the kettle, until prompted by the system. ii) Patient filled too less water into the cup. (no cue in the system to correct this behavior). Patient filled the remaining cup volume with cold water. iii) In the second trial patient did not turn on the kettle, but corrected this later iv) Toying behavior with milk, cup and tea box. v) system successfully saved the Log files and the sensor data

Table 24: Summary of interaction with the CogWatch System (Patient - S74)

ID: S74	**CogWatch system training performance**

Number of trials completed	2/2 Black Tea / Black Tea with Sugar and Milk
Number and position (trial number) of **patient errors**	Trial 1 (TT: 03m20s) and 2 (TT:03m22s)
Number of system errors	1 – repeated cue (remove teabag)
Testing comments	i) Patient did not fill the kettle with water. Successfully prompted by system in T1. ii) Patient did not remove tea bag in T1, successfully prompted. iii) In T2 patient switched on the kettle without water, successfully prompted. iv) system successfully saved the Log files and the sensor data

Table 25: Summary of interaction with the CogWatch System (Patient - S75)

ID: S75	**CogWatch system training performance**
Number of trials completed	2/2 Trial Black Tea with Sugar, #2 aborted
Number and position (trial number) of **patient errors**	Trial 1 (TT: 03m13s) and 2 (TT:03m30s)
Number of system errors	0
Testing comments	i) Patient toyed with cup, tea bags, spoon. ii) Did not fill the water into the kettle, successfully prompted in the first trial. iii) Patient did not stir until prompted in both instances. iv) In the second trial patient forgot to

	remove teabag, successfully prompted by the system. v) System successfully saved the Log files but the sensor data are missing.

3.3.1 Completion times

The average completion (total) times for the two tea making trials are shown in Figure 7. On the basis of this pilot evaluation it seems that, due to errors and perplexity behavior, the patients took somewhat longer to interact with the system than healthy elderly.

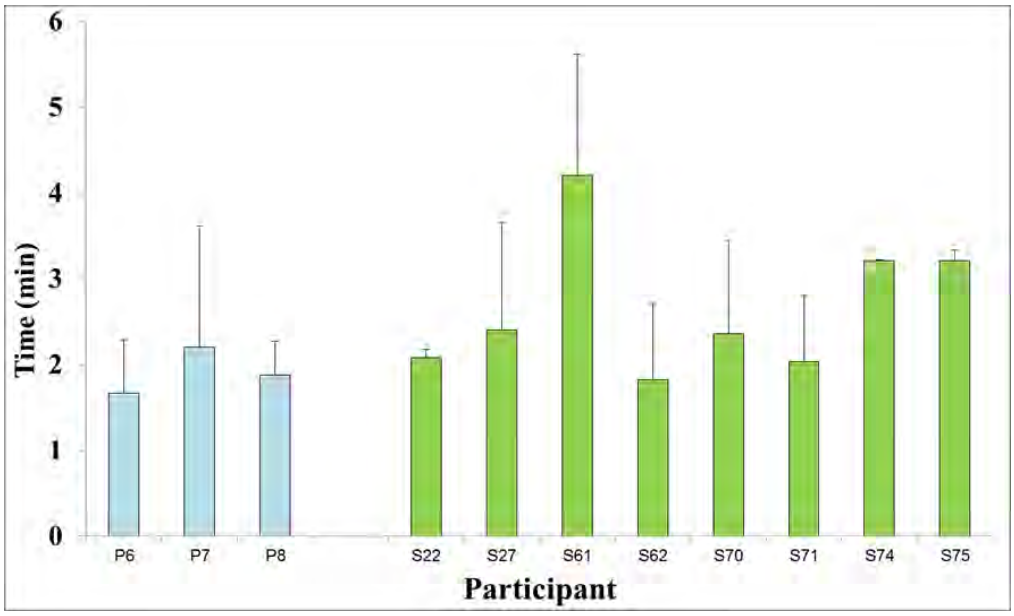

Figure 7: Comparison of the task completion time between healthy elderly and patients

3.3.2 System observations

TUM site at times experienced connectivity problems with the LAN connection and Bluetooth signal from the object sensors. In addition occasionally during the pilot testing the VTE interface would freeze, not respond or not display the selected cues. However, in a majority of the trials, the system worked smoothly and the sensor data was saved appropriately. In order to change the settings, the system needs to be connected to the network. In many cases, in the hospital setting there is no availability of internet connection, and this should be considered in the further development of the CogWatch system.

In two cases of healthy elderly participants the CogWatch system effectively prompted the next step in task execution. In six instances the system effectively prompted patients with the next sequence step. Therefore, the initial validation of the prototype shows a promising approach to incorporating Cogwatch in the neuro-rehabiliation routine, on a hospital ward.

Patients were overall content to interact with the system. Clinical data shows a need for further development of the system as many errors that occur are not listed in the current version of the Prototype (e.g. quality - misestimation errors, toying). Also, TUM validation has demonstrated that there is a need to change the character of the cues from alert signals towards prospective guidance. This way, many of the fatal errors could be avoided by participants and the trials could be continued. In one case the used cues were not effective in prompting the patient. Patients often waited for the system to prompt them with the next step. Therefore there seems to be a need to further develop different approaches to the cues implemented in P2. Patient S61 had by far the best interaction with the system, she had severe features of both apraxia and AADS, and she benefited short term from being guided by the system. S61 was not able to perform the task before or after, without the Prototype guidance. We did not observe short term benefits of using the system. Patients reverted to the mistakes committed earlier on before the Prototype trials in the one-off post intervention measurement. This needs further investigation during planned home-based intervention study.

4. HEADWISE EVALUATION

4.1 Introduction

The specific role of the Headwise led evaluation (carried out in collaboration with the Stroke Association) is to investigate the views of health professionals, adults with stroke and their carers regarding the usability, effectiveness and practicality of the CogWatch system as characterised by prototype 1 (P1) which is concerned with hot drink making. The P1 system had been developed following the input from D1.4.1 which looked at user, carer and health professional requirements at that stage. A number of methodologies were used to provide quantitative and qualitative information that could be used to inform the development of future prototypes.

The use of volunteer participants in the evaluation was approved by the University of Birmingham ethics committee.

4.2 Methods

4.2.1 Focus Groups

Focus groups are known to encourage a more thorough exploration of issues than is possible through questionnaires and to stimulate debate. An open-ended question format was developed to give participants free rein to raise issues relevant to the evaluation (appendix D and E). Analysis would be 'bottom-up' based on content analysis of transcribed material.

4.2.1.1 Participants

In total 45 health professionals participated in the focus groups, predominantly occupational therapists (75%) as illustrated.

Table 26: Health Professionals by occupation

Category	*No.*	*Approx %*
Occupational Therapist	34	75
Occupational Therapy Assistant	4	8
Occupational Therapy student	2	5
Physiotherapist	4	8
Psychologist	1	2

Mean number of years post qualification was 11.35 years (SDF: 8.83; range 1 - 38) with an average of 6.71 years of direct stroke experience. In addition, for purposes of cost analysis, information was obtained on their pay band on the current England & Wales NHS *Agenda for Change* payscale which covers salaries for non-medical healthcare workers on a scale of 1 to 9. There was a wide range of pay (bands 3 to 7) with a mean salary of £29,759.00 pa.

There were also 32 adult stroke survivors: 16 male and 16 female; with a mean age of 65.6 years (SD: 12.5; age range 43 – 93). All participants had suffered a stroke in the last six years (mean: 2.5 years; SD: 1.56).

In addition 15 carers also participated, all of whom were currently involved in caring for a relative who had experienced a stroke.

4.2.1.2 Procedures

Participants were given information sheets prior to agreeing to take part (appendix F and G), as well as giving informal written consent (appendix H and I). Participants were shown a video of the system in operation at UOB, and pictures of the tools, watch and sensors, with examples of visual, auditory and tactile prompts. Each group was led by two researchers to increase the validity of the collected responses. Both researchers took notes which were then transcribed for final analysis. Each focus group lasted for approximately 1hr 30 minutes.

4.2.2 Questionnaire Surveys

We developed the questionnaire format used successfully in an earlier deliverable D1.4.1 to obtain reliable information on end users' views and experiences.

After consultation with healthcare workers we also devised a form to collect data on therapist's current practice each day when involved in "hot drink preparation" with stroke patients.

4.2.2.1 Participants

All participants in the focus groups also completed the questionnaire, as did an additional 120 occupational therapists recruited through professional organisations.

4.2.2.2 Procedures

Questionnaires concerning P1 (appendix C) were first piloted with 13 health professionals (in five focus groups), 8 stroke survivors and 7 carers across (in four focus groups). As a result of the pilot some amendments were made to the health professional format:-

- Instructions were added in case someone else had to lead the focus groups in the absence of the researcher
- Additional questions relevant to this report were added regarding; what support they feel they may need to ensure confidence in using a system like CogWatch and thoughts around whether CogWatch could reduce carer burden.(appendix E)

For health professionals the revised questionnaire was also handed out for completion during the focus groups (appendix D) and a further version distributed amongst special interest groups across the UK (appendix K) and This was to gain information on current practice in stroke rehabilitation and on the potential cost benefits of the CogWatch system.

We also implemented the *hot drink preparation form* with one community rehabilitation team over a two week period (appendix L) to provide information about professional time spent in this activity over this period.

Service users and carers were also asked to complete questionnaires providing demographic background and information concerning their current situation and care needs (appendix M and N).

4.3 Results

SPSS 19 was used to analyse questionnaire data; qualitative information was analysed with ATLAS.ti using a grounded theory approach. The data was coded and grouped into common themes. The themes that emerged from the user and carer focus groups were compared to those that emerged from the health professionals' focus groups. There were some themes specific to a particular group but also themes that were present across all three groups. Comments were categorised by group (health professionals, carers and service users) and analysed on an item by item basis.

4.3.1 Views concerning prototype 1

4.3.1.1 Health Professionals' opinions

Health professionals welcomed the idea of this type of technology and saw its rehabilitative potential: "good idea"; "better in a hospital setting to encourage rehabilitation"; "useful to assess and monitor progress of patients".

Seven themes were generated from the professionals' opinions after seeing a demonstration of prototype:

1. ***Personalisation*** - the most commonly cited theme (5 statements) included comments about the need to be able to personalise the equipment. The terms used included 'adapt', 'personalise', 'individualise' and 'patient requirements'.

2. ***Independence*** - (4 statements) included concerns about the prototype's ability to increase independent living: "How much help would be available from health care professionals and family members?", "Could the person use it independently?", "How will risks be managed, for example hot water?"

3. ***Potential use*** - a theme emerged regarding its potential use (4 statements): "Is it intended to be a rehabilitation tool or to use for daily living?", "We would like to see it in hospital therapy kitchens".

4. ***Positive advance*** - most groups thought it was a good idea (3 statements) and had potential.

5. ***Technology concerns*** - a theme surfaced questioning the technology (8 statements): "Kinect technology is known to have issues with distance and lighting"; "It should be triggered automatically to start"; "What level of technical support will be available?

6. ***Cultural insensitivity*** – (4 statements) people commented on the lack of cultural awareness of the system: "It doesn't consider cultural differences, such as the Asian practice of using a saucepan to heat the water".

7. ***Ecological utility*** - some concerns were expressed about real world utility (2 statements): "How will it fit into a patient's kitchen?"; "Will the patient need to find room to put a TV screen in their kitchen?"

4.3.1.2 Carers' opinions

Three themes emerged from carers:

1. ***Positive advance*** - most carers thought it would be a good idea (2 statements)

2. ***Carer burden*** - the most commonly cited theme amongst carers was that it would reduce carer burden (5 statements): "If this can help my wife make a cup of tea I can go back to being her husband for some of the day"; "It will let me supervise rather than do the activity."

3. ***Technology concerns*** - (1 statement): "If the patient poured water into the milk jug rather than the cup, would the sensors pick this up in time?"

4.3.1.3 Stroke survivors' views

Two themes emerged from the service users regarding their initial thoughts:

1. ***Ecological utility*** - the most common theme was ecological validity (5 statements): "It should try and look more normal"; "How does the water get in the kettle? Is this monitored too?"; "Would I need a TV screen in my kitchen to use it? I don't have room" and "I like the touch screen idea, I find it difficult to use a keyboard."

2. **Technological compatibility** – stroke patients were also curious whether CogWatch could be integrated with existing technology (2 statements): "Can it be customised to be used with a kettle tipper?" and "Can I use my laptop for the prompts?"

4.3.2 Views concerning the CogWatch tools

4.3.2.1 Health Professionals' opinions

Five themes emerged regarding the CogWatch tools:

1. ***Practicality of using a watch*** – 6 statements expressed concerns about using a watch, including: "Most of my patients experience paralysis in one arm following stroke, so they would have difficulty even putting the watch on without assistance"; "Consider a fob rather than a watch" and "It is good you are using a normalised piece of equipment like a watch but if it vibrates mid-task it may disrupt the task and create risks especially if dealing with hot water."

2. ***Flexibility of sensors*** - (6 statements). The sensors generated excitement around their potential flexibility, such as "Can they be put on…. the fridge, milk cartons, patient's own crockery?"

3. ***Ecological utility in the home*** - some health professional questioned the ecological validity of the tools (5 statements): "Would it fit in people's homes?"; "How big is this

piece of equipment?" whereas others saw the potential of the sensors "It would be brilliant if the sensors could fit into existing crockery."

4. ***Suitability for hospital use*** - CogWatch was identified as a system professionals would like to use in the hospital setting (2 statements): "It would be useful in the hospital setting to prepare the patient for going home" and "At the moment the tools need facilitation from the therapist, yet it is a system that will allow for the reduction in therapeutic input during rehabilitation."

5. ***Technological compatibility*** - The final theme generated from the discussion on tools was the ability of CogWatch to utilise existing utensils and technology (3 statements): "Could the technology use patients' own IT equipment?" and "Definitely more user friendly if it can use items someone already has as well as more cost efficient."

4.3.2.2 Carers' opinions

Three themes emerged:

1. ***Benefits of using a watch*** - The most common theme was concerns using a watch (7 statements): "The audio may startle patients"; "They would need to have the watch on their good arm which may not be practical during the task" and "Unable to have visual prompts on the watch due to risk of moving the hand to look at it."

2. ***Concerns using a watch*** - However carers also felt there benefits in using a watch (2 statements): "Looks good" and "Normalised technology for the elderly as well as the young."

3. ***Ecological utility*** - one statement around ecological validity was raised "Fitting the screen into the kitchen may be too difficult."

4.3.2.3 Stroke survivors' views

Three themes emerged:

1. ***Normalisation*** - the view that watch is a good idea as it's practical and normalising.

2. ***Technological compatibility*** – the desire to be able to integrate it with existing equipment.

3. ***Ecological utility*** - the most common theme that emerged from service users was they welcomed the idea of using a watch (5 statements): "I like the idea of having something that looks normal."

4.3.3 Views concerning risks associated with CogWatch

We separated out statements specifically concerned with perceived hazards and risks, as we were particularly interested in safety risks and any potential of CogWatch to undermine rather than facilitate rehabilitation. Questions of this kind were raised by all categories of participant and in each focus group. These could be broken down into four principal themes:

1. ***Risks associated with using a watch*** - health professionals (9 statements) focussed on the concerns of using a watch: "Vibrations of the watch could cause someone to spill hot water." Stroke patients commented on the potential risks of a watch, although they liked the idea of it (3 statements): "A vibration could startle me."

2. ***Risks associated with multiple cues*** - Both health professionals (4 statements) and stroke patients (3 statements) mentioned issues regarding memory, attention and the fact that very often individuals can get distracted or forget what they are doing and leave the room "I often find when I am doing anything in the kitchen it only takes the phone to ring and I forget to go back, until I smell burning …."

3. ***Safety risks*** - Carers (7 statements) identified any task involving hot water would require supervision for stroke survivors "It would be better to think of tools to assist in activities that have a low risk, like tooth brushing. Health professionals identified possible safety issues, "Stroke patients have good and bad days and require supervision when using boiling water as it's a health and safety risk".

4. ***Risks to current rehabilitation practice*** - Some health professionals had concerns about replacing carers with technology (2 statements): "What if the patient becomes anxious, the computer can't respond to this?"

4.3.4 Views concerning reductions in care and cost

4.3.4.1 Carers' Opinions

There were few opinions expressed about costs, carers being more interested in care needs. Their views could be encapsulated within a single main theme that emerged from the discussions:

1. ***Reduction in carer burden*** - (5 statements): "It will allow me to supervise and get on with other jobs that need doing" and "It will reduce my amount of work".

Questionnaire responses provided additional information about carer burden. For this investigation we were particularly interested in how much time carers spent assisting stroke patients in different daily tasks, especially making a hot drink.

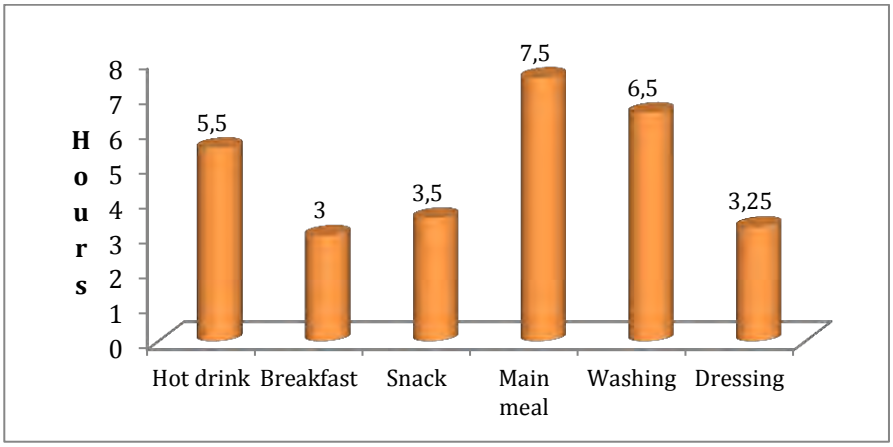

Figure 8: hours per week spent by carers on selected tasks

As shown in Figure 8 overall carer's reported spending 19.5 hours per week assisting with kitchen tasks compared to 9.75hrs in personal care tasks.

4.3.4.2 Stroke survivors' views

The majority of stroke patients had significantly increased care needs as a result of their stroke and importantly for our analysis this was predominantly delivered by a spouse or other unpaid carer (81% of all care). The figure 9 below shows the percentage of participants rating themselves as receiving no care, unpaid care or paid care after their stroke compared to premorbidly.

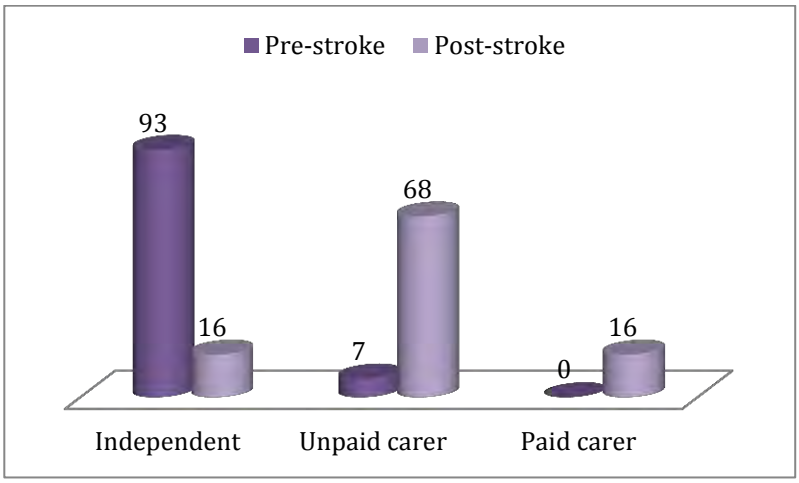

Figure 9: Type and amount of care pre- and post-stroke

Stroke survivors were asked to indicate the presence of barriers to independent living across five domains of function commonly affected by stroke figure 10. Predictably the most commonly identified impairments were physical, but at least 50% (allowing for poor insight in some cases) also reported language and cognitive problems restricting their independence.

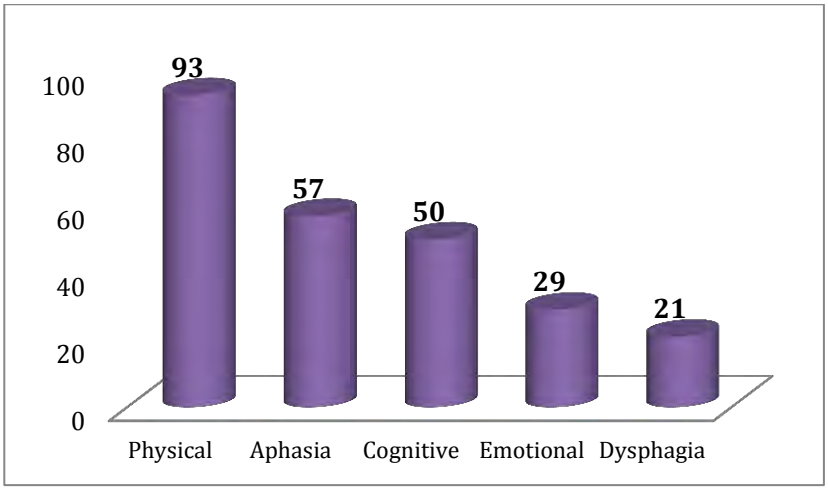

Figure 10: Percentage of patients reporting impairments in five domains

Stroke patients were also asked about whether they experienced difficulties with specific activities of daily living relevant to CogWatch figure 11. Over half indicated they had

problems with some aspect of making breakfast, a third experienced problems dressing, over a quarter making a hot drink and 1 in 7 had difficulty brushing their teeth. Overall 85% reported problems in kitchen-related tasks compared to 50% who rated themselves as being impaired with personal care tasks. Of note, 35% of stroke patients rated themselves as being impaired in both areas.

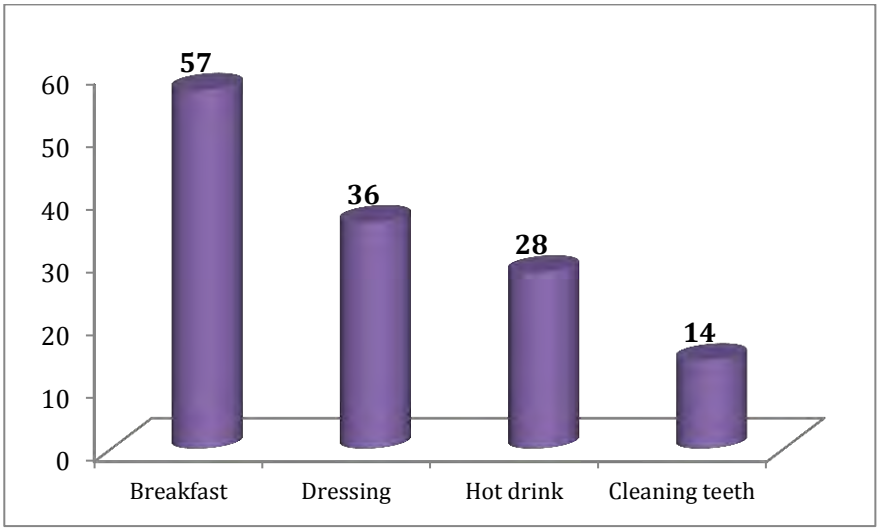

Figure 11: Percentage of stroke patients reporting daily living problems

4.3.4.3 Health Professionals' opinions

Five themes were generated:

1. ***No reduction in costs*** – the most common theme was a perception that there would be no reduction in cost (8 statements): "Initially CogWatch would require additional time for set up and training which would increase costs. It is difficult to see if these costs will reduce down the line"; "Most patients do not get OT support following discharge from hospital, at the most it's the intermediate care team for 6-12 weeks. Therefore any additional support whether it's technology or therapy will be an additional cost"; "CogWatch will not reduce costs as the activities covered are already included in the care package."

2. ***Reduced carer burden*** – (7 statements): "It may not reduce care needs but it will increase independence"; "The system could support existing care and take some of the load off current carers" and "It may reduce carer burden, but supervision will still be required."

3. ***Social isolation*** - social isolation was generated as a theme from the discussion on cost (2 statements): "It is important to remember patients rely on health professionals as a form of social interaction" and "It's good to have social contact."

4. ***Rehabilitative value*** - One group commented on the rehabilitative value of CogWatch: "Will help to establish a routine."

5. ***Ability to reduce costs*** - One statement highlighted the potential for CogWatch to reduce costs: "We do think it could reduce the need for paid care and would be cost effective if it were able to fit in with the technology the patient already has."

Data from 120 Occupational Therapists (OT) was analysed to establish how much time is devoted to certain tasks during their working week figure 12. The graph below shows the breakdown in hours per week across key tasks.

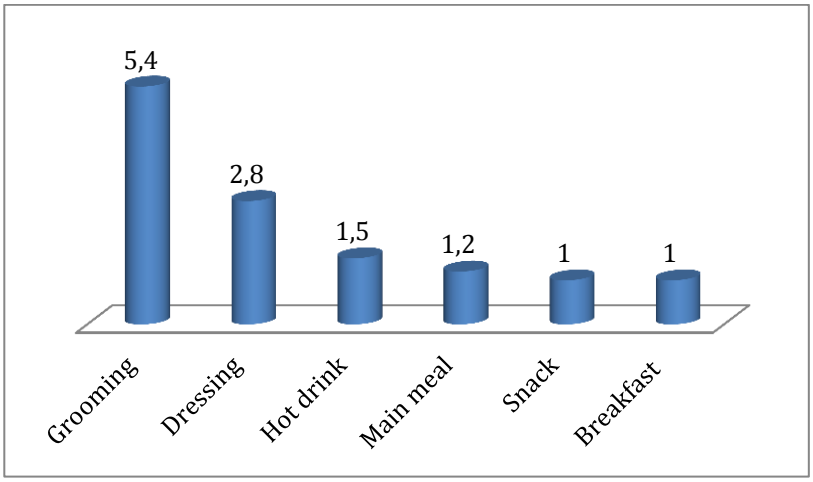

Figure 12: Hours per week spent by Occupational Therapists on ADL tasks

Time spent in non-patient contact activities otherwise known as indirect clinical contacts as this aspect of professional practice (as opposed to non-clinical activities) is where one might expect CogWatch to have an impact figure 13. The single most time-consuming task was writing up clinical notes, equivalent to one full day a week, with half a day a week on average being spent monitoring progress, attending meetings and travelling to see patients.

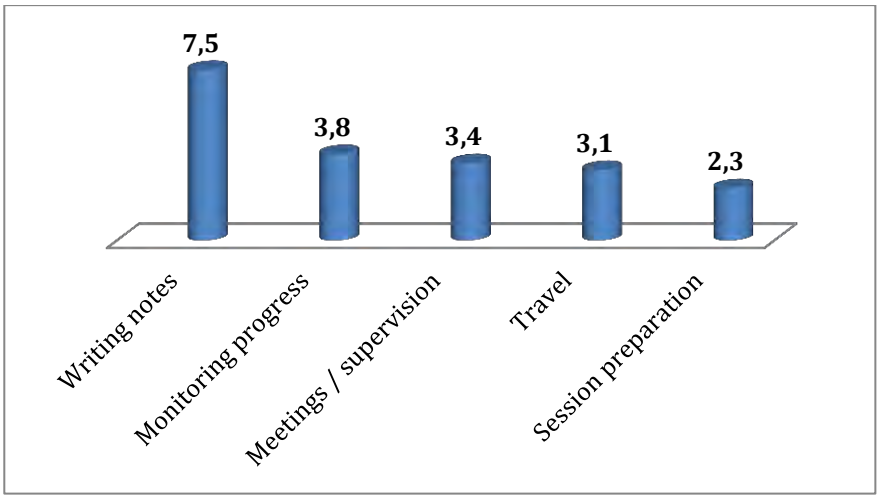

Figure 13: Time spent on indirect clinical activities.

4.3.5 Hot drink Preparation recording forms

One Occupational Therapy department agreed to complete these forms over a two week period. They provided data for 9 assessments of hot drink making for 5 female and 4 male stroke patients (mean age: 71). This provided useful supplementary information concerning professional practice 'on the ground.' Assessments were completed on average within 10 days of stroke onset. The mean time to complete the task was 7.5 minutes. Amongst therapists working in the community, as opposed to a hospital, they spend on average each day spend 45 minutes travelling to see patients.

Of the 9 patients assessed 3 were considered sufficiently unsafe or otherwise unable to make a drink adequately that they required further intervention from the community rehabilitation team. The types of errors made by these 3 patients were rated by their therapists and were typical of AADS, with sequencing errors, omission of sequence steps, ingredient omissions and perseveration being the most frequently reported problems. The most frequent kind of assistance provided was verbal cueing (in 40% of cases) with physical prompting needed in 10% of all interventions, for example to remove a teabag that had been placed in the kettle.

4.3.6 Cost analysis

A preliminary cost analysis was undertaken based on data from health professionals and taking into account information provided by stroke patients and their carers. At present this can only be an initial exploratory analysis of some key factors likely to influence the marketing and cost-effectiveness of CogWatch which will be investigated further as the system develops.

It was noted that while health professionals expressed reservations about likely cost benefits, there was a lot of interest amongst therapists in the system as depicted by P1. Our data show that Occupational Therapists spend one and a half hours a week on average assisting stroke patients to make a hot drink, about a third of whom need on-going rehabilitation in this regard. In the analysis outlined below the cost of making a hot drink is indicated in terms of direct and indirect time costs. For ease of calculation this is calculated as a cost per hour. Of course the process of making a hot drink takes much less time (<10 minutes according to our data) but in practice therapy sessions may include a range of information-gathering strategies relevant to the context of the intervention as well as general conversation that would not occur were the therapist not present to support hot drink making. Therefore at this preliminary stage we considered it reasonable to work on the basis of therapy sessions of one hour duration.

Indirect time costs were based on data collected for administrative time as a proportion of hours spent on hot drink making (which constitutes 11.5% of all ADLs) as opposed to other therapeutic activities. Thus session planning (2.3 hours a week), note writing (7.5 hours) and progress monitoring (3.8 hours) x 11.5% = 1.6 hours. We have taken into account the true labour cost to an employer, which in the UK includes a Class 1 National Insurance Contributions (NICs) of 13.8% on earnings above £7,755. This adds an additional £1.56 per hour, calculated as 13.8% x £22,004 (£29,759 average salary minus £7,755 allowance). This makes the labour cost per hour of occupational therapists in our sample **£16.82** (£29,759/52weeks/37.5hrs = £15.26 + £1.56)

Separate figures are provided with and without travel costs. This reflects scenarios where (i) CogWatch is in a hospital setting (no therapist travel costs) and (ii) is installed at home

(travel costs being based on the number of hours travelling reported by therapists as a proportion of time spent specifically in hot drink making).

In addition there is a cost associated with mileage, although this information was not collected at the time. However 1.5 hours' travel at approximately 30mph (*c.*50 km/h) represents 45 miles (*c.*75 km). From 1st July 2013 a new NHS reimbursement scheme was introduced by which staff would be paid £0.67 for the first 3,500 miles and £0.24 thereafter. We have arbitrarily taken a figure mid-way between these two rates of £0.45.

For ease of calculation annual costs are based on a 50 week year allowing for 2 weeks without therapy input.

Table 27: Therapy costs associated with hot drink making in hospital and at home.

	Calculation	Hourly cost	Annual cost (x 50)
OT hourly cost	£29,759 + NICs / 52 weeks / 37.5 hrs	£ 16.82	£ 841.00
Cost of making hot drink	1.5 hrs x £16.82 hrs	£ 25.23	£1,261.50
Associated indirect costs	13.6 hrs x 11.5% x £16.82	£ 26.31	£ 1,315.50
Subtotal *(in hospital)*	£25.23 + £26.31	**£ 51.54**	**£ 2,577.00**
Associated travel time	3.1 hrs x 11.5% x £16.82	£ 6.00	£300.00
Distance travelled	3.1 x 30 x 11.5 x £0.45	£ 4.81	£240.50
Total *(at home)*	£51.54 + £6.00 + £4.81	**£ 62.35**	**£ 3,117.50**

The assumptions on which these costs are based are considered reasonable and justifiable and the parameters can be easily adapted to local circumstances in calculating costs. It is therefore possible to incorporate our data from health professionals into a simple cost analysis by comparing the current costs of hot drink making with CogWatch costs. This will assist in identifying a marketable price point for the system. In the following analysis we have assumed variable costs for set up and installation and a fixed annual cost of £250 (from year 2 onwards) for maintenance. Of course some therapy oversight will still be necessary during the life of the CogWatch system and this is reflected in the sensitivity analysis below which shows variable savings according to 4 system costs (£500 – 2000) and 2 therapy inputs. For ease of calculation we have assumed therapy input will remain the same as long as CogWatch is in place but in practice it may well reduce. Similarly, if CogWatch is successful as a training device rather than a compensatory substitute it may well be possible to withdraw the system in time, further reducing long terms costs. Our financial estimates are therefore very conservative and actual cost savings may be greater than shown.

Our data indicates that 1.5 hours are spent per week in hot drink making, and 13.6 hours in indirect clinical work of which we have assumed 11.5% pertains to hot drinks on the grounds that hot drinks take up this proportion of ADL-related OT time (which equates to *c.*1.5 hours). Overall this indicates that 3 hours per week is related to hot drink making. In the table below we show costs on the basis of reductions in therapist time from the current 3

hours to 2 hours and 1 hour (@ £16.82/hour). In addition we have included the notional costs of travel time (£6.00) and distance mileage (£4.81) which brings the total cost per hour to £27.63.

By comparison the cost of standard treatment, as illustrated in the table above, is £62.35 per hour and £3117.50 per annum.

Thus considering the table below it can be seen that the cost of set up and installation would yield an initial profit if set at £1500 or below and if therapy input on hot drink making can be reduced from the current 3 hours to 1 hour. Of interest, the set-up cost has less impact on profit than does reducing therapy hours. Hence it is possible to double the set up cost (from £500 to £1000) yet make more profit as long as the system results in a greater reduction in therapy time. It is acknowledged that this is an exploratory analysis and certain assumptions have had to be made but as far as possible the conclusions are empirically driven.

Table 28: Cost comparisons of CogWatch and standard treatment

CogWatch cost	Therapy input	Standard treatment	Cost difference Year 1	Cost difference Year 2 +
£500	£55.26 x 50 = £2763	£3117.50	- £145.00	£ 104.50
	£27.63 x 50 = £1381.50	£3117.50	**£ 1236.00**	**£ 1486.00**
£1000	£55.26 x 50 = £2763	£3117.50	- £645.00	£104.50
	£27.63 x 50 = £1381.50	£3117.50	**£ 736.00**	**£1486.50**
£1500	£55.26 x 50 = £2763	£3117.50	- £1145.50	£104.50
	£27.63 x 50 = £1381.50	£3117.50	**£ 236.00**	**£1486.50**
£2000	£55.26 x 50 = £2763	£3117.50	- £1645.50	£104.50
	£27.63 x 50 = £1381.50	£3117.50	- £ 264.00	**£1486.50**

Finally, in order to appreciate the likely cost-outcomes of CogWatch it is important to recognise that most rehabilitation may not be being provided by health professionals but by informal carers in the course of their daily routines. Our investigations indicated that by far the majority of care for stroke survivors at home, including assistance with kitchen tasks, is provided informally by unpaid carers, usually a spouse or other family member. Carers reported spending on average three to four times more hours than occupational therapists in hot drink making. As this is unpaid work it does not figure in conventional cost-benefit comparisons and a broader analysis will be required. The age of carers in this regard may be important to consider in future investigations as carers of working age are likely to have

incurred greater financial losses as a result of their care responsibilities and consequently may benefit disproportionately by reductions in their hours spent caring.

5. CONCLUSIONS

Evaluation of CogWatch prototype 1 (P1.1) is well underway. This deliverable describes the process of testing the usability, effectiveness and practicality of the CogWatch system with end users: stroke patients, carers and health professionals. Experimental studies were undertaken at UOB and TUM; focus groups and surveys were conducted in the UK by HW in collaboration with TSA.

5.1 Results of patient testing

On pragmatic grounds a 'familiar kitchen set up' was created at UOB under the guidance and help of UPM and 5 stroke patients were tested. The system performance was unreliable meaning that testing session took longer due to the system occasionally crashing or not recording data. Due to this only 4 out of 5 of patients were completed for testing. This also meant that recording system errors was dependent on visual observation, rather than information from the log files.

At UOB one patient (P024) was cued to successfully finish a trial that would have otherwise been unsuccessful. Patient P018 was the only patient to make a fatal error (e.g., adding milk to black tea). Although the system ended the trial and gave the appropriate feedback the patient went on to complete the trial.

In general UOB patients made few errors, but showed a consistent decrease in task performance times from pre to post training trials, suggesting a learning effect. It was expected that completion times would increase during training trials, due to time taken to cue and respond to errors. However, this was not the case and performance times steadily decreased throughout the session.

All UOB patients had some difficulty interacting, or remembering to interact with the system and had to be prompted by the experimenter. However data from the questionnaire suggests that overall all patients rated the system as very helpful, clear to understand, very good presentation and easy to use.

TUM experienced difficulties carrying out validation trials due to practical and technical difficulties. Nonetheless eight patients were tested and three healthy controls. Of note one of the patients had an anterior cerebral artery bleed and was unable to modify their behaviour in response to cueing, both from the system and the researcher. P1 testing will continue as suitable patients become available.

5.2 Results of HW-TSA focus groups and questionnaires

5.2.1 Views concerning prototype 1 and tools

Healthcare professionals were broadly positive about the potential of CogWatch to promote independence, especially if the system were able to be personalised, sensors could be adapted to fit with other household tools and appliances, was compatible with existing devices and had adequate technical support (which may reflect concerns about usability and reliability). Practical difficulties of using a (wrist) watch were raised as many patients have hemiplegia. Many felt it would be a useful system in a hospital, perhaps in part

reflecting concerns over how well it could be integrated into a patients' home. Some reservations were expressed about insensitivity to cultural variables in hot drink making where different utensils are used.

Health professionals also expressed caution about the use of multiple cues: while recognising the need for flexible cueing options according to a patient's preference, there was potential for cues to startle and distract patients during task performance.

Stroke survivors reported significant problems carrying out tasks in the kitchen at home in 85% of cases due to physical, language and cognitive impairments. Specific difficulties making a hot drink were reported by 28% and 1 in 7 had difficulty brushing their teeth. They were very positive about CogWatch, being impressed by the potential for increasing independence and the reliance on adapting everyday devices, thus normalising therapy. They were keen that the system should make use of existing technology in the home as much as possible, such as their own laptops of mobile 'phones.

Carers were also positive about the potential for CogWatch to promote autonomy. They liked the 'normalisation' of the system but also expressed reservations about the appropriateness of using a wristwatch in all cases. Like, stroke survivors, they stressed the benefits of the system being compatible with existing technology in the patient's home.

5.2.2 Views concerning reductions in care and cost

Stroke survivors reported that over 80% of their care was undertaken informally, which means that consideration of cost outcomes must not be limited to impact on professional care and therapy.

Carers believed the system had potential to reduce care load for example by allowing them time to carry out other care-related tasks instead of having to supervise hot drink making. This could also result in an overall reduction in care hours.

While health professionals expressed reservations about likely cost benefits these were inconsistent and somewhat contrary (on the grounds that CogWatch would take up already limited staff resources, that input was already covered in standard care packages, or that there was already very little input). They thought it would increase independence even if did not reduce care needs. It was recognised that it could help to reduce carer burden.

There was some concern that reliance on technology could lead to increased social isolation as for some patients contact with a therapist at home was an important social outlet.

Therapists pend on average 1.5 hours a week addressing hot drink making directly, which time increases to double this time once administration is included, and longer still when travel is taken into account, with the result that helping someone make a hot drink is calculated as £51.54 in hospital (not including overheads) and £62.35 at home. A preliminary cost analysis suggested that an important factor in demonstrating cost-benefits of the system will be the extent to which it reduces direct and indirect therapy time. At a cost of £1500 of less this is more relevant than the initial cost of the system to its longer term cost-effectiveness.

5.2.3 Implications for CogWatch

5.2.3.1 Patient validation

Preliminary feedback from patients using P1.1 is encouraging, but further work is required on testing the system with stroke patients. Experience has shown that training reduces task completion times despite system cueing time and patients having to respond to errors. Patients had difficulty interacting with P1.1 and relied on the researcher; some patients fail to respond to cues altogether. Additional testing with such patients may be required to identify if problems can be predicted, for example if they are more common with anterior lesions, and cues modified accordingly, and to investigate whether this impervious tendency reduces over time with repeated exposure to cues.

5.2.3.2 Technical specification

At present the CogWatch system is unable to prompt the patient to start and finish trials. This development should be relatively easy to implement and reduce error frequency.

Patient testing has been delayed at TUM by technical compatibility issues. The longer term viability of current technical specific requires further consideration, especially as end users regard as very important the ability of the system to integrate with existing technology in the home. In this regard a minimum technical specification to establish compatibility is likely to be necessary when bringing the stem to market.

5.2.3.3 Feedback on system devices

Practical difficulties of using a (wrist) watch were raised as many patients have unilateral motor and/or sensory impairment affecting upper limbs which would make it difficult to strap on if placed on the intact limb and difficult to use if placed on a hemiplegic arm. Further consideration will need to be given to how the watch is attached, or to an alternative such as a fob watch, or a range of cueing devices that perform the same purpose according to the patient's physical abilities

Some reservations were expressed about insensitivity to cultural variables in hot drink making where different utensils are used. At present this is limited to alternate end goals (tea with and without milk, for example) rather than introducing new utensils although in principle with adaptive sensors this could be overcome.

It was recognised by carers and health professionals that multiple cues could startle and distract patients during task performance. In practice however this could be managed by moderating cue intensity and sensitisation with repeated exposure to cues during training.

There was some concern, principally from health professionals, that reliance on technology could lead to increased social isolation as for some patients contact with a therapist at home was an important social outlet. This is a common concern but recipients tend to report the opposite, that technology improves their self-confidence and independence and allows them more opportunity to integrate socially. By reducing on-task intervention from carers CogWatch is also likely to allow more time in normal social interaction with carers and family.

5.2.3.4 Cost benefits of CogWatch

Our preliminary exploration of the costs of standard treatment and the likely impact of CogWatch suggests that, while the clinical effectiveness of the system will be measured by its outcomes for the patient, any conventional analysis of its cost-effectiveness will largely be determined by how much it reduces therapy time.

There are two reasons however to consider that cost-benefits are likely to be greater than our initial analysis demonstrates:

(1) We have assumed therapy input will remain the same while CogWatch is running but in practice it may well reduce. In addition experimental data suggests that CogWatch can function as a training device which may result in its withdrawal over time which will reduce long terms costs further

(2) As over 80% of care is informal and unpaid a true cost-benefit comparison must not be limited to impact on professional care and therapy but involve a broader analysis for example by considering utility measures (cost utility analysis) and indirect financial benefits (such as impact on welfare benefits) and opportunity costs (carers giving up work). Consequently the age of carers may be important to consider in future investigations.

These issues will need to be considered more fully in subsequent evaluations of the next stage of CogWatch development.

5.3 Closing remarks

It is concluded that the first prototype CogWatch affords a practicable approach to providing continual multimodal cueing for an everyday activity of daily living, making a hot drink which is recognised as being of potential value by healthcare professional, carers and stroke survivors. A number of practical points for improvement of the first prototype were suggested including making the cues more salient and the need to tailor cueing to the individual.

In its current form, the first CogWatch prototype places strict limitations on the task environment. Thus, the tea making takes place on a standard table top template with specified positions for the utensils and tea making ingredients. There are no items “hidden” in kitchen cupboards, as would be the case in a normal home environment. The ability to systematically search for, locate and grasp target objects among visually similar (eg salt for sugar) or functionally similar (eg coffee for tea) distractors might well be affected by, for example, attention impairments after stroke. Such a context would require significant further development of the CogWatch system including more sensors, additional action recognition capabilities, elaborated task model and extended feedback tables. Nonetheless, all the elements that would require development have already been identified in the current CogWatch prototype and thus the key groundwork has been completed to allow a fundamentally new approach to continual, consistent and pervasive rehabilitation for cognitive impairment of action in AADS.

6.0 REFERENCES

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APPENDICES

Appendix A

CogWatch Prototype 1 – Patient Evaluation
Patient ID:
Date:

Please answer the following questions using the scales provided.

PRESENTATION

		COMMENTS
1. Was the layout of the screen clear?	1 2 3 4 5	•
2. Are the 3 buttons (‘help’, ‘repeat’, ‘finish’) clear?	Y / N	•

USABILITY

3. Did you have any difficulty pressing the buttons on the screen?	Y / N	•
4. Was it clear from the initial images which are the 4 tea type options?	1 2 3 4 5	•

INSTRUCTIONS

5. Were the written instructions during the task helpful, clear and easy to read?	1 2 3 4 5	•
6. Were the picture cues and videos large enough on the screen?	Y / N	•

WATCH

7. How comfortable did you feel wearing the watch? (1=very uncomfortable)	1 2 3 4 5	•
8. Was the vibration helpful?	Y / N	•

OVERALL IMPRESSION

9. Would you prefer to interact with the system using voice or touch? (i.e. when choosing your cup of tea, would you prefer to select the image on the screen or say aloud the tea?)	Y / N	•
10. How likely would you use the system in your home? (1 =not at all likely)	1 2 3 4 5	•

Appendix B

Instructions:

INSTRUCTIONS ONTHE EVALUATION OF PROTOTYPE 1 – TEA MAKING

TASK

- You will be asked to make 10 cups of tea.

  There will be an opportunity to take a break should you need it.

- Before we start, a few questions:

  1. How often do you have tea?

  a. every day **b.** 3-4 times a week **c.** 3-4 times a month **d.** Never

  2. If you usually have tea, how do you usually have it?

  a. black **b.** with sugar **c.** with milk **d.** with sugar and milk

  3. When you usually make tea, which hand do you use to manipulate the kettle?

  a. right **b.** left

  - Throughout this task you will asked to make 1 type of tea from the following:

    Black tea

    Tea with **sugar** only

    Tea with **milk** only

    Tea with both **sugar and milk**

  - Before each trial I will remind you of which type of tea you have to make.

  - You will need to interact with a touch screen monitor during some trials of the task. This screen will be positioned close to you so it is easy to reach, please let me know if this distance is uncomfortable.

- During this task, you may need assistance to stabilise the objects you are using. In these cases, you can ask me to help.
- All trials will be videoed using 2 cameras.
- Everything you need for the task is on the table in front of you.
- Do you have any questions?

Appendix C

Ideas of Questions to pilot for Health professional focus group

1. **Initial thoughts on prototype one**

- Would you use it with your clients? If yes, what would you hope to gain? If no, what are the barriers?
- What problems do you for see using the system? How could we address these problems?

2. **Thoughts around prompts – visual and auditory**

- What cues do you currently use to guide patients through ADL tasks?

3. **Thoughts around tools used** – sensors/ watch/ screen etc.

4. **What tasks do you think should be covered in the next prototype** (rank)

- Teeth brushing
- Grooming – brushing hair shaving
- Snack prep – sandwich or soup in microwave
- Any others

5. Thoughts on the system as a whole and any changes/ additions for prototype 2 to include around the prompts as well

Appendix D

Ideas of Questions for Health professional focus group (amended after pilot)

1. Initial thoughts on prototype one
- Would you use it with your clients? If yes, what would you hope to gain? If no, what are the barriers?
- What problems do you foresee in using the system? How could we address these problems?

2. Thoughts around prompts – visual and auditory
- What cues do you currently use to guide patients through ADL tasks?
- What factors do you consider when choosing what cues to use?

3. Thoughts around tools used – sensors/ watch/ screen etc.

4. What tasks do you think should be covered in the next prototype
- Teeth brushing
- Grooming – brushing hair shaving
- Snack prep – sandwich or soup in microwave
- Any others

5. Do you currently use any technology? If so what and what for?

6. Thoughts on the system as a whole and any changes/ additions for protype 2 to include around the prompts as well

7. How do you currently monitor progress with your patients? Including what types of prompts do you currently use in tasks of every day living

8. What feedback would you want the system to provide for you to monitor progress? –

9. What training/support do you feel you and your patients would need to use a piece of equipment like this?

10. Do you think this system could result in a reduction in care needs in a cost effective way? If not, why not?

Appendix E

Questions to use for service users/carers focus group

1. Initial thoughts on prototype one
- Thoughts around prompts – visual and auditory
- Are they easy to follow and understand?
- Can you see any potential difficulties with them? How could these be overcome?

2. Thoughts around tools used – sensors/ watch/ screen etc.
- Would they wear the watch? If not, why not?
- Can they see any potential problems with the tools? How could these be overcome?

3. What tasks of everyday activities do you think should be covered in the next prototype?
- Tooth brushing
- Grooming
- Snack preparation – toast

4. Thoughts on the system as a whole and any changes/ additions for protype 2 to include around the prompts as well
- Would they use this – reasons etc.
- What might the benefits be? What would put them off using it?

5. What support do you feel you would need to use a piece of equipment like this?

6. Do you think a system like this could reduce care needs? If not, why not?

Appendix F

CogWatch

Information sheet for Healthcare Professionals

Introduction

Stroke is recognised as the leading cause of disability. According to the World health organisation 15 million people worldwide suffer from a stroke each year (WHO 2004).

Following a stroke, people can experience a range of cognitive problems in addition to any difficulties in motor function. Cognitive problems strongly influence how well people functionally recover following stroke.

A recent study in the UK found that 68% of stroke patients showed characteristics of Apraxia and Action Disorganisation Syndrome (AADS) (BUCS 2007). AADS can result in an impairment of cognitive abilities to carry out activities of daily living (ADL) such as washing and dressing, preparing a meal or hot drink. Apraxia and Action Disorganisation Syndrome is defined as:-

- **Apraxia** A neurological disorder of learned purposive movement skill that is not explained by deficits of elementary motor or sensory systems (Rothi & Heilman 1997)
- ***Action Disorganisation Syndrome(ADS)***: Cognitive errors when performing multiple-steps tasks (Morady & Humphreys, 2009)

AADS patients whilst maintaining their motor skills, commit cognitive errors during every day goal orientated tasks which they used to perform automatically. Patients most typically **omit** steps of a task (e.g. make cereal without milk) or **sequence** the steps of the task incorrectly (add sugar before the cereal).

AADS has great impact on patients' individual independence, their families, and the national healthcare systems which have to provide continuous support and care. Thus, technological advances that address these personal and economic costs by enabling independent living of AADS patients would be of great value and must be developed.

Healthcare professionals recognise that **stroke care is typically short-term**; hospital based and often focuses on physical rather than cognitive rehabilitation. Regardless of their functional state, patients are often discharged on physical grounds with the assumption that cognitive rehabilitation, if needed, will continue at home. Yet current methods of treating AADS are hampered by a lack of recognition of the prevalence and impact of the condition amongst many practitioners, inadequate training for therapists, and limited evidence base for effective therapy.

Many people with AADS after stroke are left with life-long disability and suffer unnecessary social exclusion and mental health problems because of inadequate rehabilitation. Cost-effective care for stroke requires the promotion of maximal independence in the stroke patient with minimal hospital admissions, through provision of home-based (community) services.

To date this has involved relatively expensive care arrangements, with bolt-on therapy, that is often reactive in nature. Standard technologies have had little impact on therapy, and are often threatening to patients. Most rehabilitation is therefore still very 'low tech'. A more efficient system would put the patient and their family at the centre, utilise labour-saving technology, and provide sufficient data for healthcare professionals to monitor progress and intervene in proactive and timely fashion.

The purpose of the project

The CogWatch project will focus on neurological patients with symptoms of Apraxia and Action Disorganisation Syndrome. It is proposed as a Personal Healthcare System (PHS) that aims to:-

- Be personalised to suit the needs of individual patients
- Offer long-term, continuous and persistent cognitive rehabilitation to maximise treatment impact
- Be affordable and customisable to reduce unnecessary costs
- Be portable, wearable and ubiquitous to allow patients to continue rehabilitation and increase independence within familiar environments when carrying out activities of daily living.
- Be practical and adaptable for home installation

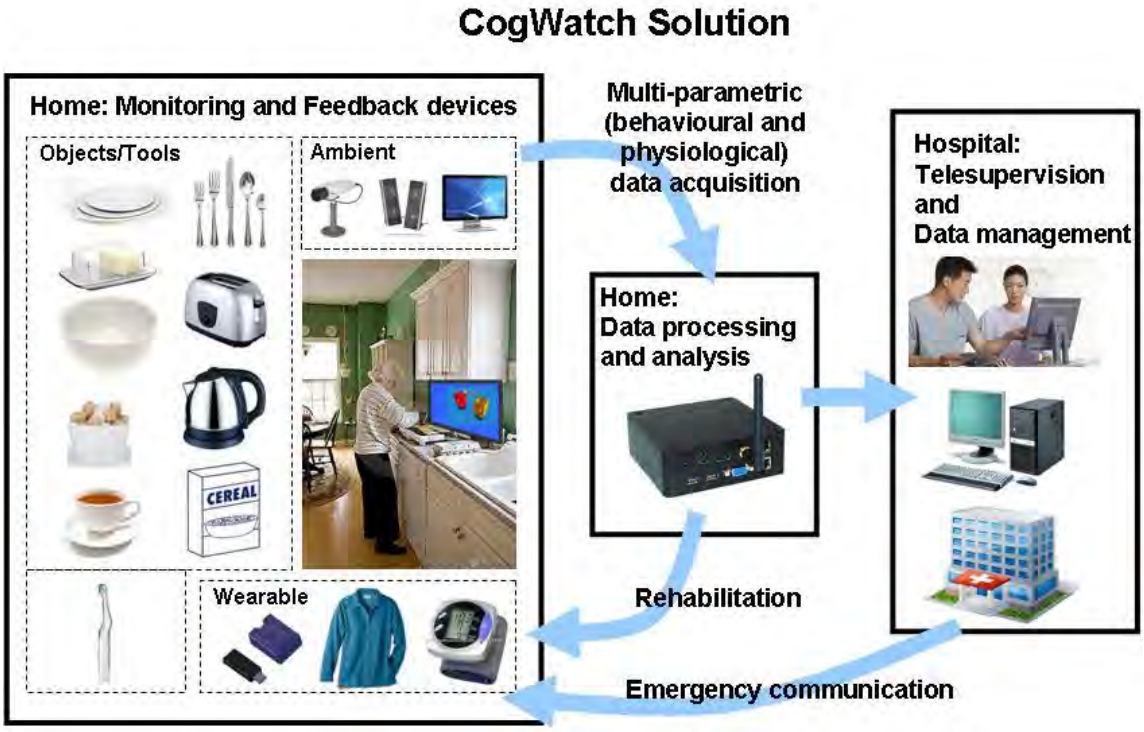
To develop a high- tech, personalised healthcare system for AADS patients, CogWatch has adopted a multi-disciplinary and multi-sector approach that includes Physicians, neuropsychologists, healthcare professionals, a

stroke charity, engineers and industrial partners with expertise in commercial exploitation and medical devices markets.

The Proposed Solution

CogWatch will use sensors embedded in everyday tools and objects (e.g., cutlery, plates, boxes, toaster, kettle), a wearable wrist device '***the CogWatch'*** that provides feedback about a task, using images sounds and vibrations, and a *Virtual Task* Execution (VTE) module – which is a large screen (see figure 1 below) that can guide patient's actions by providing words or images of the task being undertaken. The VTE module will synchronise virtual hand movements with the position of the users' hands using feedback from the sensors in each intelligent tool. Using movement prediction programs developed by the CogWatch partners, the system will identify the task being carried out and provide appropriate feedback. This feedback will:-

- Guide patients' actions
- Make patients aware of cognitive errors when they occur
- Make patients aware of the actions that they need to take in order to correct the errors
- Alert patients if their safety is at risk when handling tools and objects inappropriately



Schematic representation of the CogWatch System

Data collected by the CogWatch system can also be transmitted to a database at a healthcare centre or hospital where it will be available for relevant health professionals to access and use to monitor patients progress (Telesupervision).

Due to the nature of this project, the data will also be available to scientists and engineers who will use the information collated by the system to increase their understanding of AADS and improve the effectiveness of CogWatch

The CogWatch project will explore a scenario in which the three basic tasks of *meal preparation* and *eating*, *dressing* and *grooming* will be addressed. These tasks are used as a measure to assess patient's independence before they are discharged from hospital.
If CogWatch is successful it will enable stroke patients with AADS to enhance their cognitive deficits thus increasing their independence and quality of life.

Study Design

CogWatch has been funded by the European Commission; it is co-ordinated by the University of Birmingham includes several partners across various disciplines and industries. CogWatch will take approximately 3 years to develop:-

Months 1 – 18 – Pilot Phase

Development of prototype One based on information gained from professionals, carer givers and users including studies of 100 patients, using psychological and statistical action modelling, and then tested with patients in a laboratory setting.

Months 17 – 36 – Development of Prototype two based on information gained from Health Professional's, carers and service users. This will then be tested in the lab and the home for acceptability and efficacy.

Participation in the study

CogWatch was launched in November 2011 and during the first 6 months the project gained views of healthcare professionals, carers and service users. This information contributed to the development of the first Prototype.

Over the next 3 months we aim to test the usability, effectiveness and practicality of the CogWatch system – Prototype one. Therefore we aim to do this through conducting focus groups with patients, healthcare professionals, community workers and family members in order to assess the following:

a) How well the technology is received by patients, their families and carers.

b) Reductions in care needs associated with provision of CogWatch

c) Utilisation of information provided by CogWatch by healthcare professionals

We are hoping to gather a number of opinions from healthcare professionals, care givers and users, in order to ensure that the CogWatch device best meets the needs of people with AADS once they return to live in the community; therefore, we would be most grateful if you wish to take part in a focus group to complete the enclosed consent form.

If you require further information or have any questions regarding this project please do not hesitate to contact:-

Alexa Hazell – Senior Occupational Therapist
A.hazell@headwise.org.uk

Appendix G

CogWatch

Developing rehabilitation tools for stroke survivors with mental difficulties

This information booklet is aimed at:

- Stroke patients
- Family members
- Community carers

The Problem:

After a stroke, patients can suffer from a wide range of problems depending on which area of their brain was affected. ***Physical*** impairments, such as problems with motor movements, vision or balance, are addressed with physical therapy but ***mental*** impairments, such as problems with language, memory or problem solving, can be harder to identify and can get overlooked during a patient's rehabilitation.

Stroke patients can have trouble performing ***ordered sequences of movements***, such as those required to make a cup of tea or to brush their teeth. Patients with normal movement of their hands and arms find themselves unable to complete everyday activities because they cannot execute the correct sequence of movements necessary to complete a task.

This type of impairment is termed 'Apraxia and Action Disorganisation Syndrome' (AADS) by doctors and, although it is hard to diagnose, it is actually quite common. Recently, scientists in the UK found that perhaps as many as 68% of stroke patients have problems typical of AADS.

AADS can have a significant effect on a patient's recovery after stroke and on their ability to live independent lives in their own homes.

The

Mental impairments are called '***cognitive problems***' by doctors as they are problems with ***cognition***, which means mental processes.

Proposed Solution: CogWatch

The **CogWatch** project aims to develop a personalized home rehabilitation system for people with the symptoms of AADS. Installed in patients' homes, the system will silently monitor the patient as they go about their everyday activities. When an error is detected, the **CogWatch** with provide helpful and relevant guidance cues to assist the patient in completing the particular task.

The **CogWatch** researchers are developing intelligent everyday objects such as cutlery, a kettle, a toothbrush and a vest which will sense the way the objects are being used and wirelessly transmit the information back to a central device. The objects contain sensors to monitor orientation, motion and grip strength that, when used in combination, will provide a detailed description of how the objects are being used by the patient.

During a task, such as making a cup of tea, a screen will display relevant images to the patients that will:

- Guide their actions to complete the task.
- Make them more aware of the mental errors they commit.
- Instruct patients on how to overcome the error.
- Alert patients if their safety is at risk when handling tools and objects inappropriately.

How can you help?

CogWatch is currently in the development phase; however the first prototype has now been produced. To ensure the final rehabilitation system best meets the needs of people with AADS, the CogWatch group would like to run a series of focus groups for stroke patients, family members and carers.

The focus groups will be informal sessions with small groups of 6-8 where we collect the views of patients and caregivers on how they feel this type of technology could enhance their independence. We will discuss the kinds of difficulties experienced after a stroke, and how this technology could be used to assist patients with their everyday activities. We will look at the features of the first Prototype and discuss how it can be improved. We would also like to gather opinions on the ability of stroke patients and their carers to work with high-tech devices.

If you would be interested in participating in a focus group, please contact Alexa Hazell – Senior Occupational Therapist at:

A.hazell@headwise.org.uk

Tel: 0121 2225342

Prepared by The Stroke Association on behalf of The CogWatch partners

COG WATCH

Cognitive Rehabilitation of Apraxia & Action Disorganisation Syndrome

Appendix H

COGWATCH
HEALTH PROFESSIONALS CONSENT FORM

I _____ understand the information contained in the CogWatch information sheet.

I give my consent to:

a) **Participate in a focus group** at _____ on _____

and/or (delete as appropriate)

b) **Provide/collect information via a questionnaire**

I understand that all information I share will be kept anonymous. No identifying information will be taken, and all data will be stored securely. ☐

I understand that I will not be able to withdraw my participation later as all my data is being recorded anonymously. ☐

SIGNED: _____ DATE:_____

ROLE/PROFESSION: _____

Appendix I

COGWATCH
STROKE SURVIVOR CONSENT FORM

I _____ understand the information contained in the CogWatch information sheet.

I give my consent to:

a) **Participate in a focus group** at _____ on _____

and/or (delete as appropriate)

b) **Provide information via a questionnaire**

I understand that all information I share will be kept anonymous. No identifying information will be taken, and all data will be stored securely. ☐

I understand that I will not be able to withdraw my participation later as all my data is being recorded anonymously. ☐

SIGNED: _____

DATE: _____

Appendix J

COGWATCH

CARER/FAMILY MEMBER CONSENT FORM

I _____ understand the information contained in the CogWatch information sheet.

I give my consent to:

a) **Participate in a focus group** at _____ on _____

and/or (delete as appropriate)

b) **Provide information via a questionnaire**

I understand that all information I share will be kept anonymous. No identifying information will be taken, and all data will be stored securely. ☐

I understand that I will not be able to withdraw my participation later as all my data is being recorded anonymously. ☐

SIGNED: _____ DATE:_____

RELATIONSHIP TO STROKE SURVIVOR: _____

Appendix K

Rehabilitation of daily activities after stroke – a survey for occupational therapists

This survey aims to gather information about the current provision of therapy to rehabilitate activities of daily living after stroke. We are asking Occupational Therapists working in the UK to tell us how much of their therapy time and resources involve helping patients to become more independent in certain daily tasks.

The information collected will be used to determine the possible cost benefits of a new a new home-based cognitive rehabilitation system called CogWatch. This new technology will support rehabilitation of certain cognitive deficits after stroke and allow Occupational Therapists to supervise extended therapy in the patient's own home. Please see the attached information sheet for more details about the CogWatch project.

We would be very grateful if you could complete the following 8 questions. The first questions are about your current professional banding and experience. This information will be used to estimate how much cognitive rehabilitation after stroke currently costs in the UK.

Please give consent to take part:

☐ I volunteer to take part in this survey and I give my permission for my responses to be used in this research. I understand that I will not be able to withdraw my participation later as my data is being recorded anonymously.

☐ I do not wish to take part in this survey.

Question 1- Please indicate your current professional banding

☐ Band 5 ☐ Band 7

☐ Band 6 ☐ Other, *please specify* ……..

Question 2- How many years have you been qualified? .....years

Question 3- What region(s) of the country do you work in?

☐ East of England ☐ Northern Ireland ☐ SW England

☐ East Midlands ☐ NW England ☐ W Midlands

☐ London ☐ Scotland ☐ Wales

☐ NE England ☐ SE England ☐ Yorkshire/ Humberside

Question 4- How many years' experience do you have working with stroke survivors?

☐ None ☐ 5-10 years

☐ 0-2 years ☐ More than 10 years

☐ 2-5 years

Question 5a- In what setting(s) do you currently work? *Please tick all that apply*

☐ Hospital
☐ Specialist stroke service
☐ Residential setting
☐ Community
☐ Other, *please specify* .....

Question 6- In an average week, how much therapy time do you typically spend working on the following tasks with clients?

Please indicate the number of hours spent in total for all your clients.

Task	Hours spent per week
Hot drink preparation	
Breakfast preparation	
Snack preparation	
Main meal preparation	
Personal grooming, washing	
Dressing	

Question 7- In an average week, how much time do you typically spend on the following tasks?

Please indicate the number of hours spent in total for all your clients.

Task	Hours spent per week
Writing up patient notes, filling forms, etc	
Reviewing patient progress	
Devising new therapy programmes	
Travelling to and from client houses	
Other significant tasks....*please specify*	

Question 8: Do you wish to expand on any of the answers you have provided? If you do, please enter further details below.

Many thanks for taking the time to complete this survey.

If you want to be added to a mailing list to receive updates about the CogWatch project, please email Alexa Hazell: A.hazell@headwise.org.uk

Appendix L

Hot Drink preparation form

As part of the CogWatch pilot data collection we are interested in getting data from real world tasks to inform the development of the prototype. Please complete this form as best you can when undertaking hot drink making with a client.

Please remember to time the session

Many thanks.

Therapist grade completing session:-

Patient identifier (Therapist to decide either number or letter to maintain anonymity- purely for data analysis only):-

Patient age:- Gender of the patient:- Date of Stroke:-

Dominant hand: R L Affected side: R L

Hand used in task: R L Both

Does the client have aphasia: Yes ☐ No ☐

1. Is the patient mobile? Yes ☐ No ☐

   If yes move to Q3

2. Is the patient completing the task in seating?

3. Please tick the relevant statement:-

- *All items required are at hand* ☐
- *The patient is required to collect all relevant items to complete task* ☐

4. During the session has the patient required interventions in order to complete task – Please tick all that are relevant

- *None required completed independently* ☐
- *Verbal prompting required to complete task* ☐ *(please go to Q5)*
- *Physical prompts required to complete task* ☐
  Details:-
- *Task stopped as unable to complete safely* ☐

5. Please tick if any of the following were observed during this activity:-

Sequence addition: Adding an extra component action that is not required in the action sequence Example: adding two teabags	
Sequence anticipation: Performing a subtask earlier than usual Example – pouring water into cup before it has boiled	
Sequence omission: An action sequence in which one subtask is not performed Example – not heating water, not adding teabag	
Sequence: Performing a subtask much later than usual Example: Switching kettle on after preparing the drink	
Ingredient omission: Failing to add an ingredient required to complete the task goal Example: Forgets to add teabag or coffee to cup	
Ingredient substitution: An intended action carried out with an unintended ingredient	
Object substitution: An intended action carried out with an unintended object Example: uses a fork	
Execution: An error in the execution of the task Example: dropping cup, spilling water	
Misestimation: Using grossly too much or too little of some substance Example: pours too much milk into cup	
Mislocation: An action that is appropriate to the object, but is performed in the wrong place Example: pouring water onto the table instead of into cup	
Perseveration: The unintentional repetition of a step or subtask	

6. Total time taken to complete task _____ minutes _____ seconds

7. Do you feel the patient requires further sessions in hot drink preparation

   Yes ☐ No ☐

   If yes please tick below all the reasons that apply

- To increase independence ☐
- Learning compensatory strategies ☐
- Improving safety ☐
- Other (please state) ☐

Appendix M

Service User Care Needs and Demographics Form

As you will see from the information leaflet provided, the CogWatch project is aiming to develop technology that will support people with certain difficulties to carry out everyday tasks in their own home with greater independence following stroke. Everyday living tasks can be defined as *'activities that people carry out on a day to day basis, e.g. getting washed and dressed, and preparing food'*

The purpose of this information gathering session is to better understand the difficulties that people face following stroke and to ask your opinions and experiences on assistive technology, *including your opinions on the development of the CogWatch prototype to date. Assistive technology* can be defined as *'Technology used by individuals with disabilities in order to perform functions that might otherwise be difficult or impossible'*

We would like to gather some basic background information about you. Any information you choose to share will remain anonymous. If you require any assistance to complete this form please let us know.

1. **What is your date of birth (day/month/year)?** ☐ / / ☐

2. **What is your gender?** Male ☐ Female ☐

3. **What is your ethnic group?** – please circle from the list below

White

A British

B Irish

C Any other White background

Mixed

D White and Black Caribbean

E White and Black African

F White and Asian

G Any other mixed background

Asian or Asian British

H Indian

J Pakistani

K Bangladeshi

L Any other Asian background

Black or Black British

M Caribbean

N African

P Any other Black background

Other Ethnic Groups

R Chinese

S Any other ethnic group

Z Not stated

4. When did you have a stroke (month/year)?

(If you have had more than one stroke please tell us the month and year of the most recent stroke) ☐ /

5. What were your living arrangements before you had a stroke?

a. Living alone ☐

b. Living with family ☐

c. Living in sheltered accommodation, e.g. warden controlled premises ☐

d. Living in a residential service ☐

e. Other (please specify) _____ ☐

6. What were your support needs before you had a stroke.

For the purpose of question 5 and 7 support is defined as *'needing and receiving some level of help with everyday living tasks within the home, e.g. getting washed and dressed, preparing food'*

a. No support needs, I was independent in all everyday living tasks ☐

b. I received support from an unpaid carer or family member ☐

c. I received less than 2 hours support per day from a paid carer ☐

d. I received between 2 and 4 hours support per day from a paid carer ☐

e. I received more than 4 hours support per day from a paid carer ☐

f. Staff were available to help me 24 hours per day ☐

g. I used some sort of assistive technology to help with everyday living tasks (please refer back to definition above if needed) ☐

7. What are your living arrangements since you had a stroke?

a. Living alone ☐

☐

b. Living with family

c. Living in sheltered accommodation, e.g. warden controlled premises ☐

d. Living in a residential service ☐

e. Other (please specify) _____ ☐

8. What are your support needs since you had a stroke.

a. No support needs, I am independent in all everyday living tasks ☐

b. I receive support from an unpaid carer or family member ☐

c. I receive less than 2 hours support per day from a paid carer ☐

d. I receive between 2 and 4 hours support per day from a paid carer ☐

e. I receive more than 4 hours support per day from a paid carer ☐

f. Staff are available to help me 24 hours per day ☐

g. I use some sort of assistive technology to help with everyday living tasks (please refer back to definition above if needed) ☐

9. For each of the items below please rate from 1 – 10 how severe you feel this difficulty is (where 1 = no difficulty, and 10 = extreme difficulty) and how much the difficulty impacts upon your quality of life (where 1 = it does not affect my quality of life, and 10 = it has a very serious negative impact on my life).

Physical problems, e.g. walking, moving around the home, feeling weak

Severity ☐ Impact on quality of life ☐

Communication problems, e.g. finding the words I want to use, understanding what people are saying to me

Severity ☐ Impact on quality of life ☐

Swallowing, e.g. choking when eating and/or drinking

Severity ☐ Impact on quality of life ☐

Thinking problems, e.g. forgetting things, problems concentrating, making decisions

Severity ☐ Impact on quality of life ☐

Emotional Problems, e.g. feeling depressed, feeling angry

Severity ☐ Impact on quality of life ☐

9. For the following tasks please rate your current level of independence.

Making a hot drink

I do this without help ☐
I need someone to give me verbal instructions, ☐
e.g. tell me the order to do things
I need physical help to do this task, e.g. lifting kettle ☐
I need verbal and physical help with this task ☐
Somebody does this for me ☐

Making breakfast

I do this without help ☐
I need someone to give me verbal instructions, ☐
e.g. tell me the order to do things
I need physical help to do this task, e.g. pouring cereal ☐
I need verbal and physical help with this task ☐
Somebody does this for me ☐

Cleaning my teeth

I do this without help ☐
I need someone to give me verbal instructions, ☐
e.g. tell me the order to do things
I need physical help to do this task, e.g. toothpaste on brush ☐
I need verbal and physical help with this task ☐
Somebody does this for me ☐

Getting dressed

I do this without help ☐
I need someone to give me verbal instructions, ☐
e.g. tell me the order to do things
I need physical help to do this task, e.g. putting socks on ☐
I need verbal and physical help with this task ☐
Somebody does this for me ☐

10. For the tasks listed in question 9 please indicate the extent to which you have experienced the difficulties below:

I miss steps out e.g. pouring water from kettle without turning it on ☐ ☐ ☐ ☐

Never Occasionally Regularly All the time

I do the wrong action e.g. stabbing tea with teaspoon rather than stirring it

Never ☐ Occasionally ☐ Regularly ☐ All the time ☐

I get the order mixed up e.g. putting milk in bowl before cereal

Never ☐ Occasionally ☐ Regularly ☐ All the time ☐

I add extra steps that are wrong or not needed

Never ☐ Occasionally ☐ Regularly ☐ All the time ☐

I use an object whose use is similar but not correct for this task, e.g. eating cereal with a fork

Never ☐ Occasionally ☐ Regularly ☐ All the time ☐

I get stuck on an action e.g. I keep stirring tea even though the sugar is dissolved

Never ☐ Occasionally ☐ Regularly ☐ All the time ☐

The way I carry out the task affects the quality e.g. I use too few or too many ingredients

Never ☐ Occasionally ☐ Regularly ☐ All the time ☐

I use the tools incorrectly, e.g. holding the spoon upside down to eat cereal

Never ☐ Occasionally ☐ Regularly ☐ All the time ☐

I toy with objects e.g. holding an object that I don't need to use

Never ☐ Occasionally ☐ Regularly ☐ All the time ☐

I undo actions e.g. turn the kettle off before it has boiled

Never ☐ Occasionally ☐ Regularly ☐ All the time ☐

11. Are there any other day to day tasks within the home that you find difficult since having a stroke? Please list:

Appendix N

Informal Carer Questionnaire

As you will see from the information leaflet provided, the CogWatch project is aiming to develop technology that will support people with certain difficulties to carry out everyday tasks in their own home with greater independence following stroke. Everyday living tasks can be defined as *'activities that people carry out on a day to day basis, e.g. getting washed and dressed, and preparing food'*

The purpose of this information gathering session is to better understand the difficulties that people face following stroke and to ask your opinions and experiences on assistive technology, including your opinions on the development of the CogWatch prototype to date. Assistive technology can be defined as *'Technology used by individuals with disabilities in order to perform functions that might otherwise be difficult or impossible'*

We would like to gather some basic background information about the needs of the person you care for. Any information you choose to share will remain anonymous. If you require any assistance to complete this form please let us know.

10. What is your relationship to the person you care for?

a. I am their spouse ☐

b. I am their parent ☐

c. I am their child ☐

d. I am their sibling ☐

e. I am their friend ☐

f. Other (please specify) _____

11. **Are you their main carer?** Yes ☐ No ☐

12. When did the person you care for have a stroke (month/year)?

(If they have had more than one stroke please tell us the month and year of the most recent stroke) ☐ /

13. When did you begin providing them with care/support (month/year?)

☐ /

14. **Do you live with the person you care for?** Yes ☐ No ☐

15. What were their living arrangements before the stroke?

Living alone ☐

Living with family ☐

Living in sheltered accommodation, e.g. warden controlled premises ☐

Living in a residential service ☐

Other (please specify) _____ ☐

16. What were their support needs before the stroke?

For the purpose of question 6 and 8 support is defined as *'needing and receiving some level of help with everyday living tasks within the home, e.g. getting washed and dressed, preparing food'*

No support needs, they were independent in all everyday living tasks ☐

They received support from an unpaid carer or family member ☐

They received less than 2 hours support per day from a paid carer ☐

They received between 2 and 4 hours support per day from a paid carer ☐

They received more than 4 hours support per day from a paid carer ☐

Staff were available to help them 24 hours per day ☐

They used some sort of assistive technology to help with everyday living tasks (please refer back to definition above if needed) ☐

17. What are their living arrangements since the stroke?

Living alone ☐

Living with family ☐

Living in sheltered accommodation, e.g. warden controlled premises ☐

Living in a residential service ☐

Other (please specify) _____ ☐

18. What are their support needs since the stroke?

No support needs, they are independent in all everyday living tasks ☐

They receive support from an unpaid carer or family member ☐

They receive less than 2 hours support per day from a paid carer ☐

They receive between 2 and 4 hours support per day from a paid carer ☐

They receive more than 4 hours support per day from a paid carer ☐

Staff are available to help them 24 hours per day ☐

They use some sort of assistive technology to help with everyday living tasks (please refer back to definition above if needed) ☐

19. **In an average week, how much time do you spend supporting the person you care for with the following tasks?**

Task	Hours spent per week
Hot drink preparation	
Breakfast preparation	
Snack preparation	
Main meal preparation	
Personal grooming, washing	
Dressing	

20. **Are there any other day to day tasks within the home environment that you support the person you care for with? Please list:**

21. **Using the scale below please rate how much your carer responsibilities impact upon your quality of life:**

_____

-10 -9 -8 -7 -6 -5 -4 -3 -2 -1 0 1 2 3 4 5 6 7 8 9 10

Very negative impact upon my life — Does not impact upon my life — Very positive impact upon my life

Please add any further comments you wish to make

Thank you very much for your participation