A Fully Annotated Corpus for Studying the Effect of Cognitive Ageing on Users' Interactions with Spoken Dialogue Systems

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Research Questions

- How does cognitive aging affect users' interaction with spoken dialogue systems?
- How can we design dialogue systems to adapt to
  - range of cognitive abilities
  - older people's interaction styles
- In particular, which dialogue strategies lead to more successful/efficient/satisfying interactions?

MATCH Corpus

- Designed to enable in-depth analyses of older users' interaction with SDSs
- Includes
  - 447 dialogues with older and younger users interacting with a WoZ appointment scheduling system
  - comprehensive range of cognitive measures for each participant
  - extensive user satisfaction assessments for each dialogue
  - user responses to recall question

Cognitive Assessments

- Participants assessed for
  - Fluid intelligence (linked to abstract reasoning, Raven's Progressive Matrices)
  - Crystallised intelligence (linked to acquired knowledge, Mill Hill vocabulary test)
  - Speed of information processing (Digit/Symbol Substitution)
  - Working memory capacity

Dialogue Strategies

- Manipulated two aspects of dialogue policy:
  - the number of options that users were presented with (one option, two options, four options)
  - the confirmation strategy employed (explicit confirmation, implicit confirmation, no confirmation)
- The combination of these 3 X 3 design choices yielded 9 different dialogue policies (or systems)
- Participants interact with Wizard-of-Oz (WoZ) system that implements the 9 policies

Appointment Scheduling Task

- Users asked to book health-care appointments by providing:
  - health care professional (e.g., diabetes nurse)
  - half-day (e.g., Monday morning)
  - time slot (e.g., 10:30 a.m.)
- After each scheduling dialogue, user
  - filled out a 39-item questionnaire
    - perceived task completion
    - overall impression
    - user satisfaction
  - responded to question asking them to recall 4 items
    - health professional, day, time, location

WoZ System Design

- The human wizard took over the function of:
  - speech recognition
  - language understanding
  - dialogue management
- Natural language generation using templates
- Text-to-speech using Cerevoice synthesiser (Aylett et al., 2006), which has been shown to be intelligible to older users (Wolters et al., 2007)

Presentation of Options

- 1 Option (Yes/No)
  - *Would you like to see the occupational therapist?*
- 2 Options
  - *Would you like to see the occupational therapist or the community nurse?*
- 4 Options
  - *Would you like to see the occupational therapist, the community nurse, the physiotherapist or the diabetes nurse?*

Confirmation Strategies

- Explicit:
  - User: I would like to see the occupational therapist please.
  - Sys: *You would like to see the occupational therapist. Is this correct?*
- Implicit:
  - User: I would like to see the occupational therapist please.
  - Sys: *When would you like to see the occupational therapist, on Monday afternoon or on Friday morning?*
- No confirmation:
  - User: I would like to see the occupational therapist please.
  - Sys: *When would you like to come, on Monday afternoon or on Friday morning?*

Example Dialogue (2 options, explicit confirmation)

System: *Good morning, this is your appointment scheduling system. Would you like to see the community nurse or the physiotherapist?*

User: The physiotherapist, please, and good morning to you.

System: *You would like to see the physiotherapist. Is that correct?*

User: That is correct, the physiotherapist, thank you.

System: *On which day would you like to come, Tuesday afternoon or Thursday afternoon?*

User: Tuesday afternoon is fine and Thursday afternoon is fine, you can just give me a time.

System: *You would like to make an appointment on Tuesday afternoon. Is that correct?*

User: That is correct. Anytime between two and four o'clock would be fine.

System: *At what time would you like to make an appointment, 2:00 p.m or 3:00 p.m?*

User: Three P.M.

MATCH Corpus

- Dialogues from
  - 26 older users (50-85)
  - 24 younger users (20-30)
- Total of 447 dialogues
  - 232 with older users
  - 215 with younger users
- Includes each user's
  - Results on cognitive assessments
  - Responses to user satisfaction surveys
  - Responses to recall question

Participant Statistics

	Demographics			Cognition			
	#Users	Age	%Female	MillHill	DSST	Ravens	WMS
Younger	24	22 ± 3	71%	42	75	54	37
Older	26	66 ± 9	61.5%	52	51	49	28
Δ Sig.	n/a	**	n.s	**	**	**	.

Participant statistics .: p<0.05, **: p<0.001 or better

Corpus Annotation

- All dialogues were:
  - recorded digitally with a sampling frequency of 48 kHz
  - transcribed orthographically by a human annotator with the tool Transcriber following the guidelines of the AMI meeting corpus (Carletta, 2007)
  - semi-automatically annotated with dialogue acts and dialogue context (Georgila et al., 2005; Georgila et al., 2008)
  - hand-corrected by human annotators
  - all transcriptions and annotations are stored in NXT format (Carletta et al., 2003)

Dialogue Act Annotations

Includes speech act and task, e.g.,

Sys: *Would you like to come on Monday afternoon?*
User: Monday afternoon please but not at two, better at four.

Dialogue Act:

[accept_halfday, social_polite, block_slot, provide_slot]

Speech Act:

[accept_info, social, block_info, provide_info]

Task:

[halfday, polite, slot, slot]

3 annotators annotated the same 36 dialogues (18 older, 18 younger, 4 for each dialogue system)

- Kappa = 0.82

Example User Speech Acts

- **Accepting/Rejecting System Suggestions**
  - accept_info (accept option suggested by the system)
  - confirm_pos (user confirms an option when asked for confirmation)
- **Correcting System / Indicating Misunderstandings**
  - correct_info (user corrects previously provided information)
  - request_info (user requests help, clarification, repetition)
- **Taking Initiative**
  - provide_info (user provides information about possible options)
  - reprovide_info (user provides information again in the same utterance or turn)
- **Social Interaction with the System**
  - acknowledgement (user shows that s/he understands system)
  - social (e.g. 'goodbye', 'thank you')

Information State Annotations

Each dialogue annotated as a sequence of Information States (Larsson and Traum, 2000).

Each IS includes the following fields:

- **Dialogue Level:** Speaker, TurnNumber, UtteranceNumber, DialogueAct, SpeechAct, UserInput, SystemOutput
- **Task Level:** Task, FilledSlot, FilledSlotValue, BlockedSlot, BlockedSlotValue, ConfirmedSlot, GroundedSlot
- **Low Level:** Segmentation
- **History Level:** FilledSlotsStatus, FilledSlotsValuesStatus, BlockedSlotsStatus, BlockedSlotsValuesStatus, ConfirmedSlotsStatus, GroundedSlotsStatus, DialogueActsHist, SpeechActsHist, TasksHist, FilledSlotsHist, FilledSlotsValuesHist, BlockedSlotsHist, BlockedSlotsValuesHist, ConfirmedSlotsHist, GroundedSlotsHist

Example Information State (not all fields are displayed)

DIALOGUE LEVEL
TurnNumber: 4
Speaker: user
DialogueAct: [accept_halfday,social_polite,block_slot,provide_slot]
SpeechAct: [accept_info,social,block_info,provide_info]
UserInput: Monday afternoon please but not at two better at four.

TASK LEVEL
Task: [halfday,polite,slot,slot]
FilledSlot: [halfday,slot]
FilledSlotValue: [monday pm,four pm]
BlockedSlot: [slot]
BlockedSlotValue: [two pm]
GroundedSlot: [hp]

LOW LEVEL
Segmentation: [monday afternoon],[please],[but not at two],[better at four]

HISTORY LEVEL
FilledSlotsStatus: [hp],[halfday],[slot]
FilledSlotsValuesStatus: [physiotherapist],[monday pm],[four pm]
BlockedSlotsStatus: [slot]
BlockedSlotsValuesStatus: [two pm]
GroundedSlotsStatus: [hp]
DialogueActsHist: greeting,suggest_hp_2,[accept_hp,social_polite],
suggest_halfday_2_implicit,[accept_halfday,social_polite,block_slot,provide_slot]

Differences between User Groups

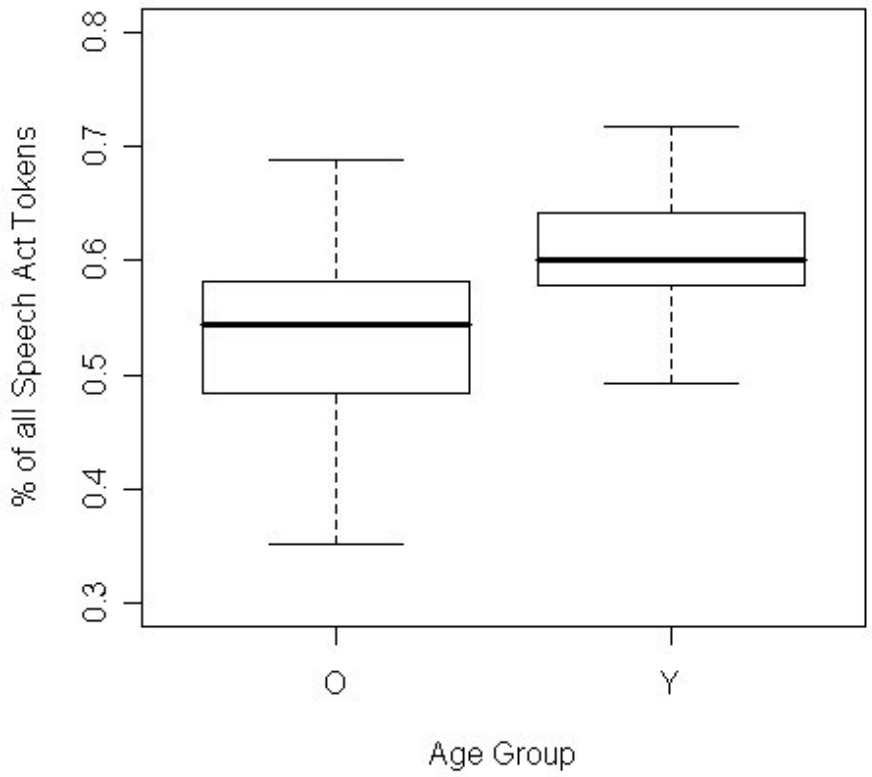
- No effect of age on task success
  - older users perform as well as younger users, no matter what the dialogue strategy (Wolters et al., submitted)
- No effect of cognitive ability levels on task success (Wolters et al., submitted)
- Strong effect of age on efficiency
  - older users less efficient than younger users (Wolters et al., submitted)
- Strong effect of age on interaction style (this presentation)

Overall Dialogue Level Differences

	Older	Younger	Sig.
# Turns	79	59	***
# Word Types	81	30	***
# Word Tokens	312	102	***
# Speech Act Types	14	9	***
# Speech Act Tokens	126	73	***

Counts summed over all dialogues and divided by the number of users (***: $p<0.0001$ or better)

Relative Frequency of 3 Most Frequent Speech Acts



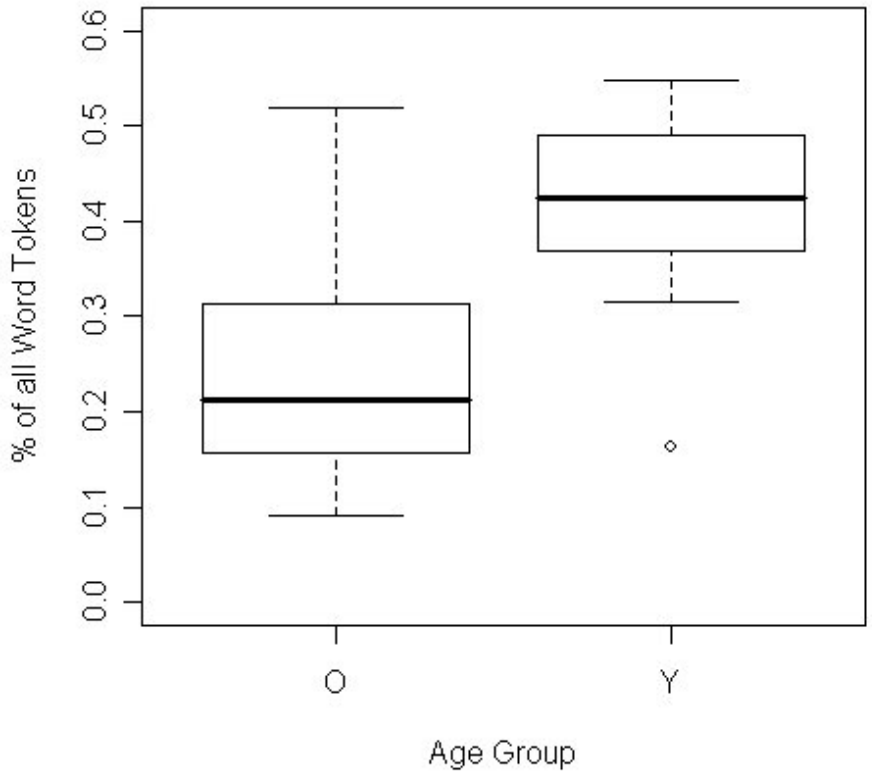
Older participants use wider range of speech acts

Differences in Relative Frequencies of Speech Acts

Speech Act	Older	Younger	Sig.
Accept_*	22.1	**32.1**	***
Confirm_*	28.3	**41.5**	***
Social	**17.9**	5.3	***
Acknowledge	**0.8**	0.0	***
Provide_*	**7.8**	3.4	*
Reprovide_*	1.8	0.2	**
Block	0.5	0.0	*
Garbage	**3.2**	0.5	***

*: $p<0.01$; **: $p<0.001$; ***: $p<0.0001$ or better

Relative Frequency of 3 Most Frequent Words



Older participants use a richer vocabulary

Differences in Relative Frequencies of Lexical Categories

Lexical Category	Older	Younger	Sig.
YesNo	13.0	33.8	***
PosNeg	4.1	1.8	*
SocWords	7.7	3.6	*
Thanks	2.3	0.3	***
Bye	1.2	0.2	***
Please	4.0	2.9	n.s.
Sorry	0.2	0.1	n.s.

*:p<0.01, **:p<0.001, ***:p<0.0001 or better

Summary

- MATCH corpus is a collection of fully annotated interactions of older and younger users with 9 WoZ dialogue systems in the appointment-scheduling domain
- The corpus is useful for:
  - investigating how older users interact with dialogue systems (Wolters et al., 2008)
  - assessing the impact of cognitive ageing on human-machine interaction
  - learning dialogue management strategies
  - creating realistic user simulations (Georgila et al., 2008)
  - adapting speech recognisers to older voices
- Corpus available at end of project (Dec 2009)