Analyzing Interactions in an Evidence-based Consumer Health Information System

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Introduction

A⁺CHIS is a FWF-funded *research group* project to establish an evidence-based, visual Consumer Health Information System (CHIS) on Type 2 Diabetes Mellitus. Our CHIS will be adaptive, personalized, and interactive. RQs: *What are the applied (cognitive) processes for a range of tasks / information needs of users? What useful methods can be applied to analyze these processes and what are their strenghts and weaknesses?*

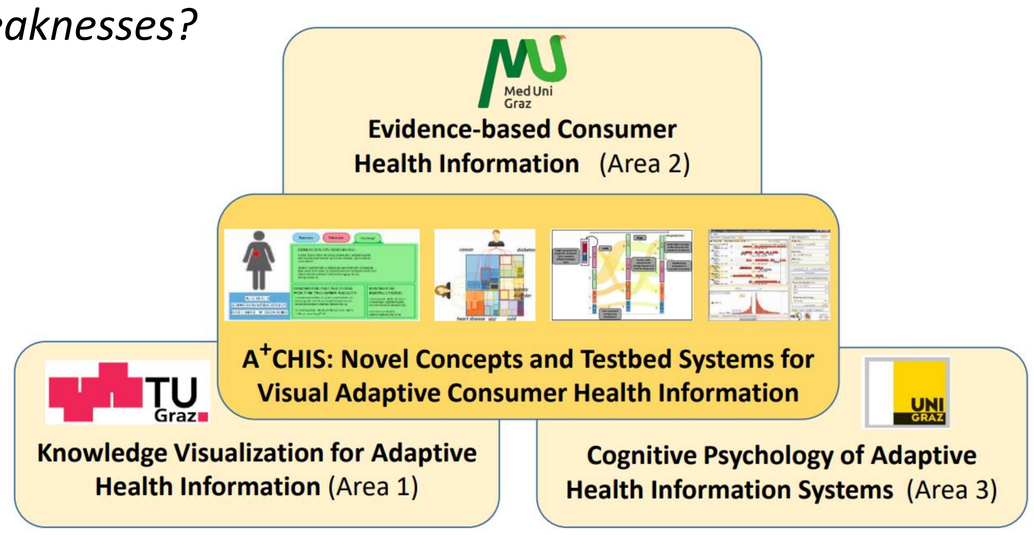


Fig. 1: The A⁺CHIS consortium partners and their roles

Method

Twelve participants engaged in eleven tasks (e.g., finding a certain figure, comparing two chapters, etc.) while ‚thinking-aloud'. Screen- and audio were recorded. 28 processes (e.g., interpreting, scrolling, etc.) were pre-defined for coding; resulting in sequences of overall 1.870 quadruples in the form ⟨$tool_{src}$, *process*, $tool_{tar}$, *duration*⟩ whenever duration ≤ 1 sec. For applying methods, eleven ‚clusters' (e.g., Reading, Navigating, etc.) were defined.

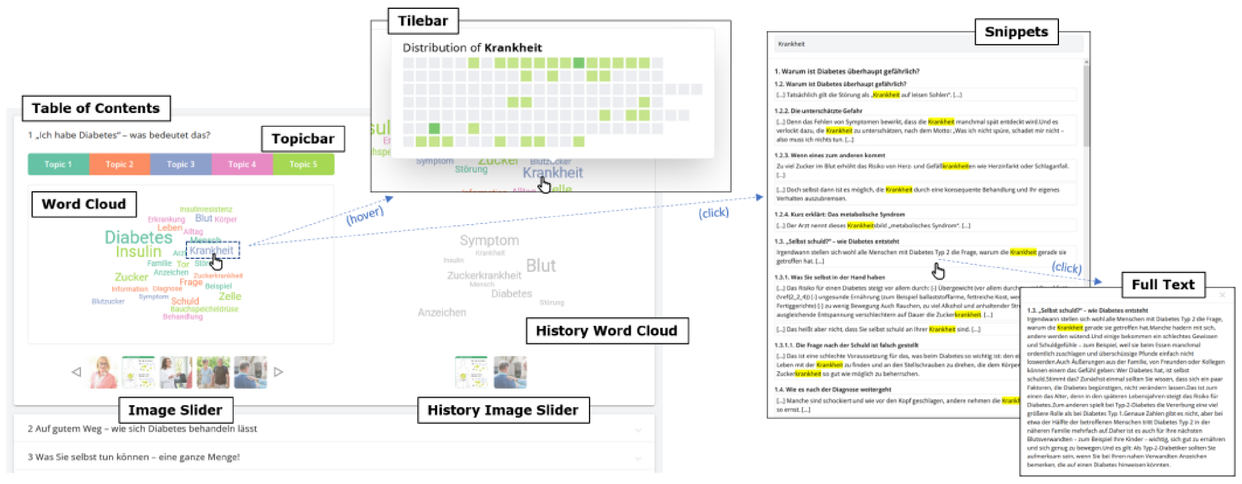
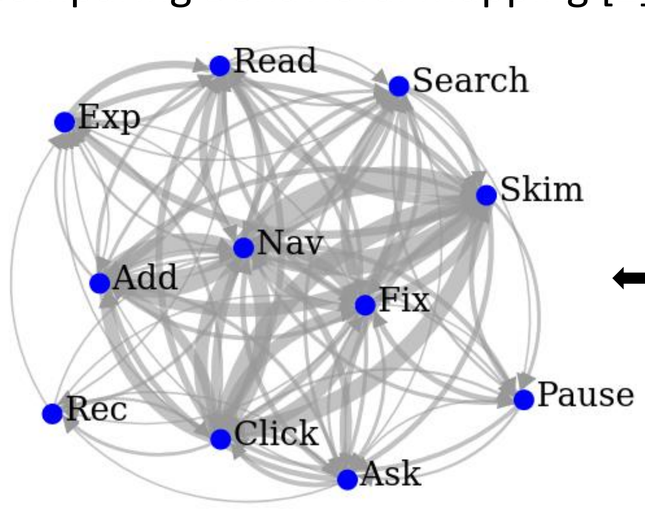


Fig. 2: The A⁺CHIS platform and its tools / components

Results & Conclusions

Comparing Behavioral Mapping [1], (Weighted) Graphs, Lag-sequential analysis (LSA, [2]), Formal Concept Analysis (FCA, [3])



	Fix	Nav	Read	Ask	Add	Skim	Click	Exp	Pause	Rec	Search
Fix	9	20	7	3	5	28	46	0	1	1	19
Nav	24	158	17	12	64	155	62	2	7	3	6
Read	5	13	0	4	18	6	11	5	0	1	1
Ask	2	7	0	0	8	10	6	1	1	1	3
Add	7	74	4	4	5	7	25	2	2	0	3
Skim	25	128	21	7	43	36	76	16	3	0	4
Click	36	45	12	4	40	91	121	1	2	3	17
Exp	1	1	13	0	1	10	3	2	0	0	0
Pause	8	4	0	2	0	6	5	0	0	0	2
Rec	1	1	0	1	0	0	2	1	0	0	0
Search	5	5	2	1	18	8	14	1	1	0	3

z-values > 1.96

	Fix	Nav	Read	Ask	Add	Skim	Click	Exp	Pause	Rec	Search
Fix	-0,60	-3,95	0,92	-0,05	-1,84	-0,07	3,18	-1,64	-0,81	0,80	7,15
Nav	-3,17	0,96	-0,50	0,20	4,94	6,45	-6,06	-2,83	-0,39	1,11	-3,23
Read	-0,02	-1,62	-1,59	2,20	6,27	-2,27	-0,84	3,71	-1,02	1,69	-0,81
Ask	-0,65	-1,58	-1,24	-0,96	3,05	0,78	-0,93	0,37	0,52	2,39	1,53
Add	-1,50	6,92	-0,43	0,62	-1,76	-4,56	-0,55	-0,25	-0,05	-0,71	-0,72
Skim	-0,73	2,94	2,44	-0,42	3,46	-5,59	-0,13	4,29	-1,24	-1,25	-2,63
Click	1,23	-8,25	-0,53	-1,72	2,53	2,04	6,03	-2,49	-1,79	1,71	1,49
Exp	-0,97	-3,22	11,40	-0,85	-0,94	1,61	-1,61	1,98	-0,71	-0,33	-1,04
Pause	4,22	-1,67	-1,02	1,82	-1,51	0,20	-0,37	-0,71	-0,66	-0,31	1,19
Rec	0,80	-0,68	-0,48	2,39	-0,71	-1,25	0,71	2,76	-0,31	-0,14	-0,46
Search	0,21	-3,53	-0,10	-0,27	6,81	-1,31	0,51	-0,04	0,11	-0,46	0,79

Yule's *Q* Values ≥ .30

	Fix	Nav	Read	Ask	Add	Skim	Click	Exp	Pause	Rec	Search
Fix	-0,03	-0,37	0,09	0,00	-0,58	0,00	0,30	-1,00	-0,16	0,19	0,73
Nav	-0,27	0,17	-0,19	0,05	0,06	0,38	-0,42	-0,72	0,26	0,09	-0,58
Read	0,06	-0,17	-1,00	0,53	0,52	-0,44	-0,14	0,69	-1,00	0,54	-0,38
Ask	-0,16	-0,24	-1,00	-1,00	0,33	0,15	-0,20	0,19	0,47	0,69	0,43
Add	-0,24	0,60	-0,21	0,18	-0,56	-0,67	-0,06	-0,09	0,24	-1,00	-0,21
Skim	0,00	0,28	0,20	-0,07	0,02	-0,46	-0,01	0,62	-0,10	-1,00	-0,57
Click	0,21	-0,52	-0,19	-0,40	-0,06	0,14	0,37	-0,79	-0,35	0,30	0,21
Exp	-0,39	-0,83	0,90	-1,00	-0,60	0,30	-0,44	0,60	-1,00	-1,00	-1,00
Pause	0,71	-0,35	-1,00	0,58	-1,00	0,05	-0,09	-1,00	-1,00	-1,00	0,41
Rec	0,46	-0,28	-1,00	0,80	-1,00	-1,00	0,30	0,84	-1,00	-1,00	-1,00
Search	0,12	-0,59	-0,13	-0,12	0,57	-0,24	0,08	-0,02	0,29	-1,00	0,23

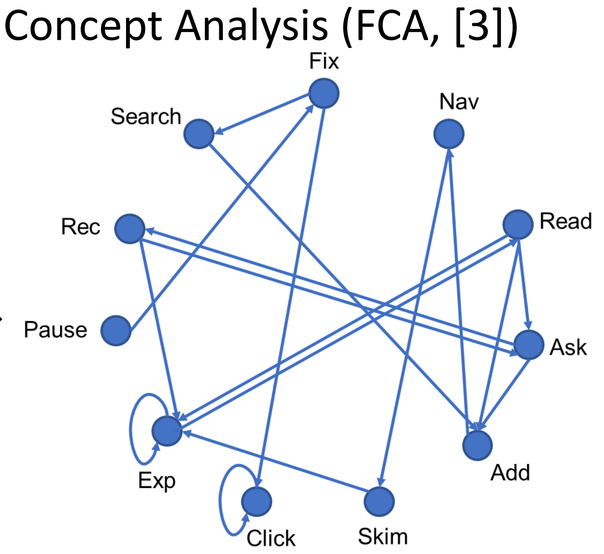


Fig. 3: The Adajacency Matrix (center left) is the starting point for many graphs (e.g., connectivity graph at the left) as well as for the LSA (right)

Weighted Graphs for qualitative impression (range of representations possible); LSA as quantitative, statistical method for sequences. In both cases, 3+ event chains are possible, however, visualizations get cluttered. FCA is quite flexible, however, dichotomization reduces richness of data.

Processes

Tasks	Fix	Nav	Read	Ask	Add	Skim	Click	Exp	Pause	Rec	Search
WC1	2	1	0	0	2	3	1	0	1	0	0
WC2	1	15	1	0	5	16	2	0	0	0	0
WC3	0	7	4	0	2	4	2	0	2	0	0
WC4	0	2	0	0	0	0	1	0	0	3	0
TB1	0	0	0	0	1	2	1	0	1	0	0
TB2	0	6	0	0	2	6	2	0	0	0	0
TB3	2	4	6	0	3	1	2	3	1	0	0
TB4	1	0	0	0	1	1	0	0	0	0	0
IS1	1	1	0	0	1	1	1	0	0	0	0
IS2	0	10	0	0	5	0	6	0	0	0	0
IS3	2	7	0	0	1	6	1	0	1	0	0

Processes

Tasks	Fix	Nav	Read	Ask	Add	Skim	Click	Exp	Pause	Rec	Search
WC1	X	X			X	X	X		X		
WC2	X	X	X		X	X	X				
WC3		X	X		X	X	X		X		
WC4		X					X			X	
TB1					X	X	X		X		
TB2		X			X	X	X				
TB3	X	X	X		X	X	X	X	X		
TB4	X				X	X					
IS1	X	X			X	X	X				
IS2		X			X		X				
IS3	X	X			X	X	X		X		

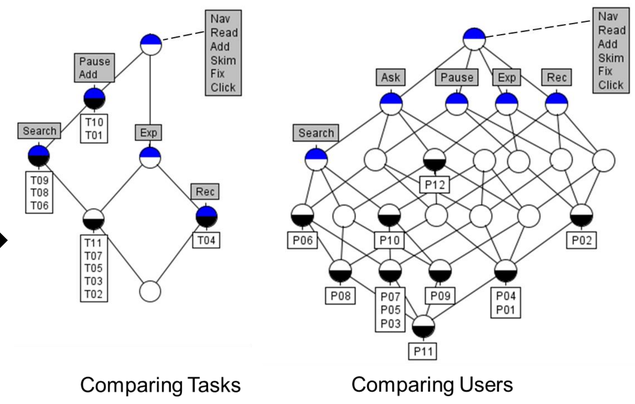


Fig. 4: The FCA requires a binary formal context (see cross table in the center) and allows any sets of elements in the columns and rows to establish concept lattices (see right)

Behavioral Mapping ‚traditionally' in physical contexts (e.g., activities and movements of people at workplace); transfer to ‚virtual space' while most metrics can be applied, such as durations or frequencies (of processes, tools, sequences / chains).

[1] Ng, C. F. (2016). Behavioral mapping and tracking. In R. Gifford (Ed.), *Research methods for environmental psychology* (pp. 29-51). John Wiley & Sons.
[2] Bakeman, R., & Gottman, J. M. (1997). *Observing interaction: An introduction to sequential analysis* (2nd ed.). Cambridge University Press.
[3] Wille, R. (2005). Formal concept analysis as mathematical theory of concepts and concept hierarchies. In B. Ganter, G. Stumme and R. Wille (Eds.), *Formal concept analysis: Foundations and applications* (pp. 1-33). Springer.