IMPROVING DIVERSITY IN CONTENT RECOMMENDATIONS

By Nina Alblas, Nikki Kramer, Lisanne Lageweg,
Meagan Loerakker, Bo-Ian Schouten

INTRODUCTION

Goal: (ABC's) stakeholders want *accuracy*

→ Engagement maximization [9]

→ Influences behaviour [1]

Problem:

- *Ethics*: lack of diversity and autonomy [6]
- Exposure control: filter bubbles [2, 3, 4]
- Lack of feedback mechanism usage [5]

Solution: autonomy and diversity (?)

- Engaging, concrete feedback mechanisms (?)
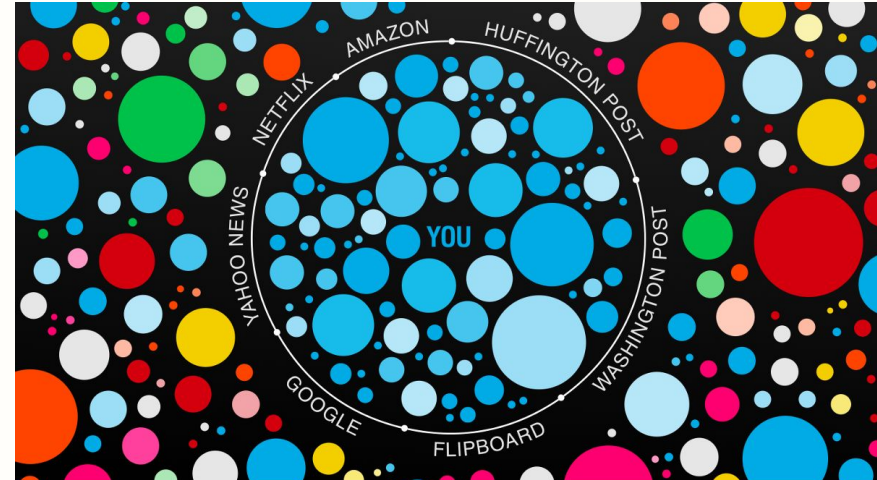- *Exposure diversity*: greater satisfaction & engagement [7, 8]

Image taken from Eli Pariser's TED talk *Beware online "filter bubbles"* (URL: https://youtu.be/B8ofWFx525s)

WHY & HOW?

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Conducted (online) interviews (*n*=18)

- Transparency   ++
- Diversity   +
- Autonomy   +/-

Diversity in combination with transparency

Personas:

1. Lazy Young Adult
2. Adventurer
3. Personalisation Fanatic

Most popular suggestions:

- Separate regular & diverse recommendations
- *Context*: what recommendations are based on
- Personal settings

	Suggestion / finding
(red)	*The recommender s... feedback mechanis...*
(orange)	*Option to allow use... base their choices o...*
(yellow)	*Option to have an o...*

Colour	Label
Yellow	Agreeable with transparency
Light green	Disagreeable with transparency
Light purple	Nuanced opinion on transparency
Light pink	Agreeable with personal settings (autonomy)
Neon blue	Disagreeable with personal settings (autonomy)
Neon orange	Nuanced opinion on personal settings (autonomy)
Light red	Agreeable with diversity
Light blue	Disagreeable with diversity
Light orange	Nuanced opinion on diversity

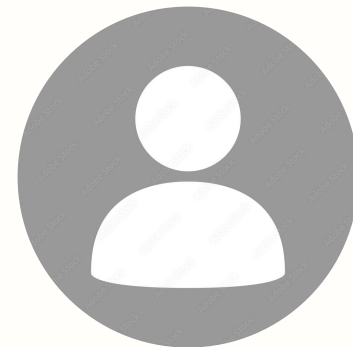| (cyan) | A company/organi... transparency into ho... |
| (magenta) | *Some accounts may... diversity.* For exam... recommend horror ... |

ABC AUSTRALIA USER DATA
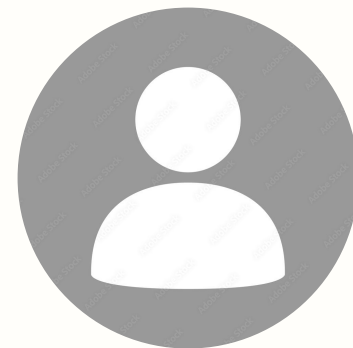
- Synthesizing user data → 1,000 users
- Data preprocessing

	dob	email	first_name	gender	key	last_name	location	password	pref_genre	pref_years	pref_rating	pref_title_type	top10
0	1996-09-03	xnikkikramer@hotmail.com	Nikki	Female	kramernikki	Kramer	Amsterdam	020forlive	['EDUCATION']	[2018, 2023]	['No preference']	['Movie', 'tv']	["Kumi's Japan", 'Play School: Stop, Look, Listen", "Alva's World", 'Against All C
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title	series	episode_name	description	description2	image	more	tags	tags2	publication_	ratin	duration	title_type	genre
Spicks And Specks	Spicks And Specks	Series 9 Missy Higgins,	Join Adam Hills, Myf W:	Missy Higgins and Dave	https://cdn.iviev	Hosts Adam Hills, My	['ABC TV', 'PANI	['abc1', 'australi:	2021-06-20	PG	2701.0	Panel_Discussion	['PANEL & DISCUSSION']
Would I Lie To You?	Would I Lie To You?	Series 13 Episode 4	Rob Brydon is back in t	Host Rob Brydon and te:	https://cdn.iviev	Host Rob Brydon	['ABC TV Plus', '	['abc2', 'uk', 'co	2022-02-08	PG	1737.0	Panel_Discussion	['COMEDY', 'PANEL & DISCUSSION']
Whovians	Whovians	Series 3 Episode 9	Join Rove McManus, Te	Rove McManus, Tegan H	https://cdn.iviev	Hosts Rove McManu	['ABC TV Plus', '	['abc2', 'aussie',	2020-03-05	PG	2090.0	Panel_Discussion	['COMEDY', 'PANEL & DISCUSSION']
Mock The Week	Mock The Week	Series 20 Episode 13 E	Fast-tracked from the U	Dara O'Briain and Hugh	https://cdn.iviev	Hosts Dara O'Briain,	['ABC TV Plus', '	['abc2', 'uk', 'co	2021-12-30	M	1850.0	Panel_Discussion	['COMEDY', 'PANEL & DISCUSSION']
Gruen	Gruen	Series 13 Episode 1	The Gruen team decod	We return with a jab at th	https://cdn.iviev	Host Wil Anderson	['ABC TV', 'COM	['abc1', 'comedy	2021-10-13	MA	2145.0	Panel_Discussion	['COMEDY', 'PANEL & DISCUSSION']
QI	QI	Series 20 Episode 9 'S'	Sandi Toksvig hosts the	Join Sandi Toksvig, Alan	https://cdn.iviev	Host Sandi Toksvig	['ABC TV', 'PANI	['abc1', 'uk', 'pai	2022-03-23	M	1767.0	Panel_Discussion	['PANEL & DISCUSSION']
Mock The Week	Mock The Week	Series 20 Episode 3	Fast-tracked from the U	Dara O'Briain and Hugh	https://cdn.iviev	Hosts Dara O'Briain,	['ABC TV Plus', '	['abc2', 'uk', 'co	2021-11-11	M	1846.0	Panel_Discussion	['COMEDY', 'PANEL & DISCUSSION']
Gruen Pitch	Gruen Pitch	Series 12 Episode 4	The Pitch take us into th	This week, The Pitch can	https://cdn.iviev	Host Wil Anderson	['ABC TV', 'COM	['abc1', 'aussie',	2020-11-06	M	278.0	Panel_Discussion	['COMEDY', 'PANEL & DISCUSSION']

METHOD

- **Clustering**
    - K-Modes (categorical variables)
    - K-Prototypes (mixed data types)
- **Generating recommendations**
    - Regular vs Diverse
    - Collaborative vs Content-based vs Hybrid

METHOD

- **Clustering**
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5x REGULAR RECOMMENDATIONS

1. Similar content
2. Users with similar favorite titles
3. Users with similar demographics
4. Users with similar preferences
5. Most favorited content in user's preferred genre(s)

+ filtered on preferences!

ABC AUSTRALIA METHOD

- **Clustering**
  - K-Modes
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5x REGULAR RECOMMENDATIONS

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3x DIVERSE RECOMMENDATIONS

1. Least similar content from similar genre
2. Least similar favorites from users with similar favorites
3. Least similar favorites from users with similar demographics

+ filtered on preferences!

RECOMMENDATIONS

	REGULAR	DIVERSE
COLLABORATIVE	-	Least similar favorites from users with similar demographics
		Least similar favorites from users with similar favorites
CONTENT-BASED	Content similar to user's favorites	Least similar content from similar genre
	Most favorited content in user's preferred genre(s)	
HYBRID	Users with similar favorite titles	-
	Users with similar demographics	
	Users with similar preferences	
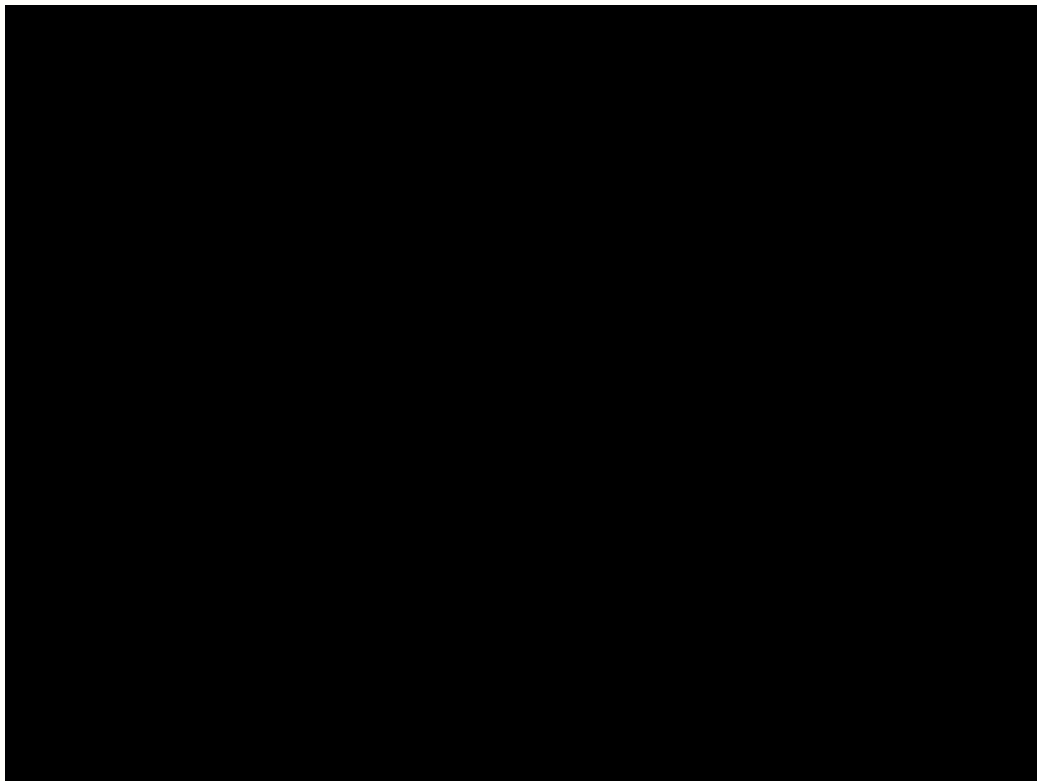
K-Modes   K-Prototypes

ABC AUSTRALIA CONCLUSION / DISCUSSION

- Does our recommender system improve diversity?

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- Does our recommender system improve diversity? We don't know (yet)

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  - Compare **intra-list similarity** before and after

- Does our recommender system improve diversity? We don't know (yet)
  - Compare **intra-list similarity** before and after

- Limitations of K-Modes / K-Prototypes
  - Sensitive to initial modes
  - No guarantee of global optimum
  - Sensitive to outliers
  - Difficult to validate results

CONCLUSION / DISCUSSION

- Does our recommender system improve diversity? We don't know (yet)
    - Compare **intra-list similarity** before and after

- Limitations of K-Modes / K-Prototypes
    - Sensitive to outliers
        → Small clusters
        → Less (accurate) recommendations
    - Difficult to validate results

- Future research → More advanced recommendations
    - Text analysis of descriptions
    - Image analysis
    - "DON'T recommend horror movies to me"
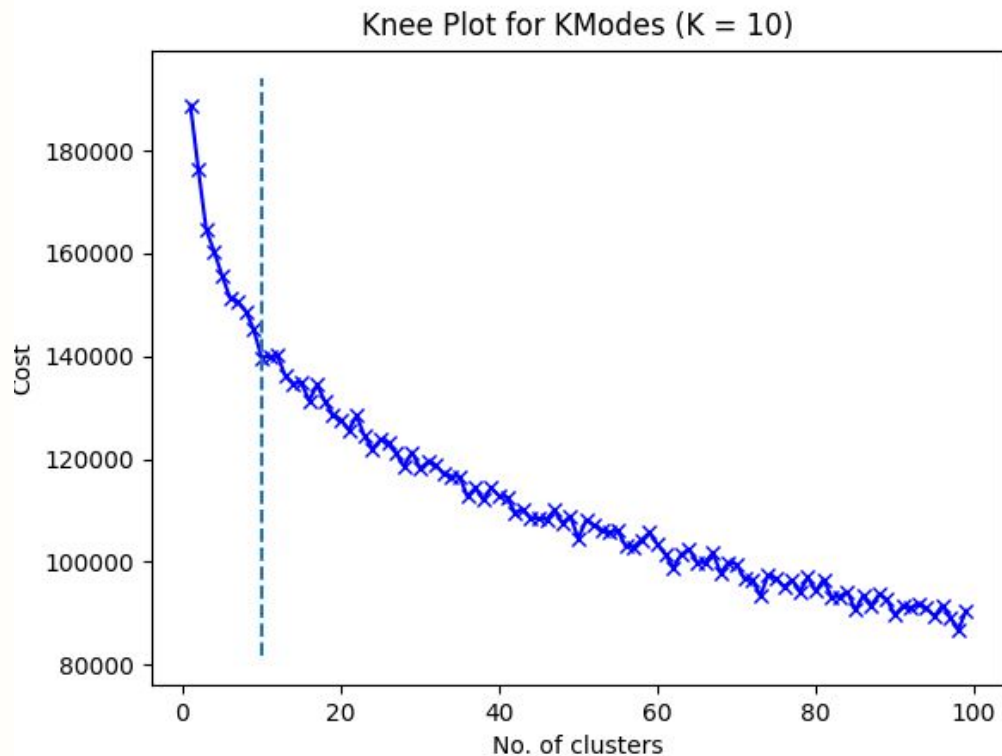   → prevent unpleasant surprise & improve autonomy
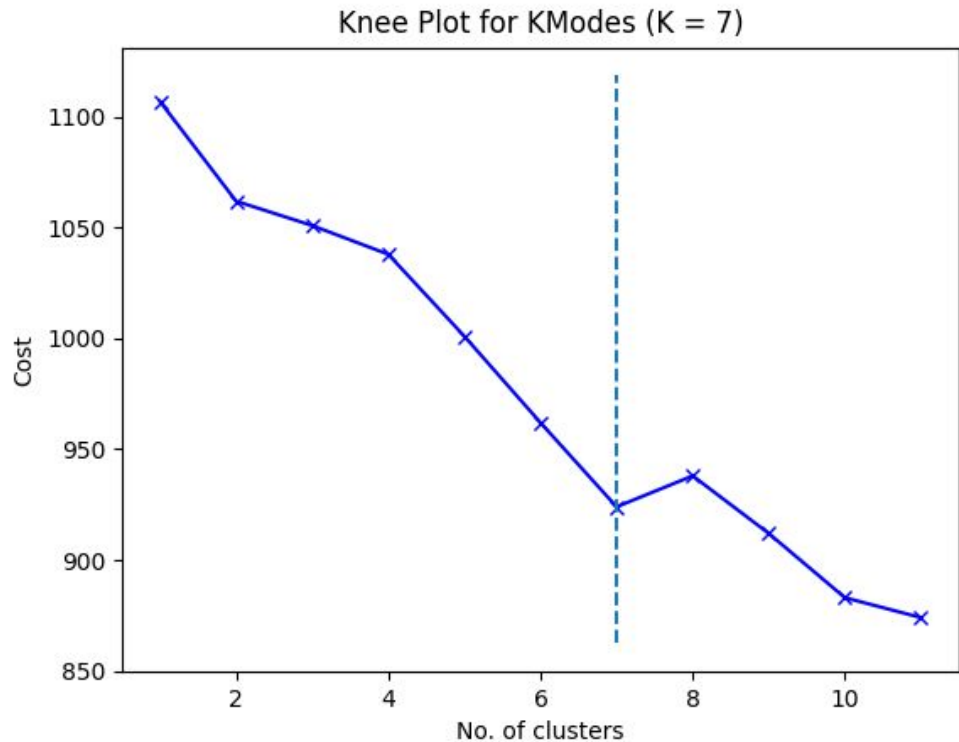
REFERENCES

[1] Knijnenburg, B. P, Sivakumar, S. & Wilkinson, D. (2016). Recommender Systems for Self-Actualization. In Proceedings of the 10th ACM Conference on Recommender Systems (RecSys '16). 11–14. https://doi.org/10.1145/2959100.2959189

[2] Wu, T. (2018). Is the First Amendment Obsolete? Michigan Law Review 117, 3, 547–581

[3] Pariser, E. (2011). *The filter bubble: What the Internet is hiding from you*. penguin UK.

[4] Pariser, E. (2011a). *The filter bubble: How the new personalized web is changing what we read and how we think.* Penguin.

[5] Varela, D., & Kaun, A. (2019). The Netflix experience: a user-focused approach to the Netflix recommendation algorithm. In: Theo Plothe, Amber M. Buck (ed.), Netflix at the Nexus: Content, Practice, and Production in the Age of Streaming Television (pp. 197-211). New York: Peter Lang Publishing Group.

[6] Anderson, J., Rainie, L., & Luchsinger, A. (2018). Artificial intelligence and the future of humans. *Pew Research Center*, *10*(12).

[7] Hurley, N., & Zhang, M. (2011). Novelty and Diversity in Top-N Recommendation -- Analysis and Evaluation. *ACM Transactions on Internet Technology*, *10*(4), 1–30. https://doi.org/10.1145/1944339.1944341

[8] Zhou, T., Kuscsik, Z., Liu, J., Medo, M., Wakeling, J. R., & Zhang, Y. (2010). Solving the apparent diversity-accuracy dilemma of recommender systems. *Proceedings of the National Academy of Sciences of the United States of America*, *107*(10), 4511–4515.

[9] Shani, G., & Gunawardana, A. (2011). Evaluating Recommendation Systems. *Springer EBooks*, 257–297.
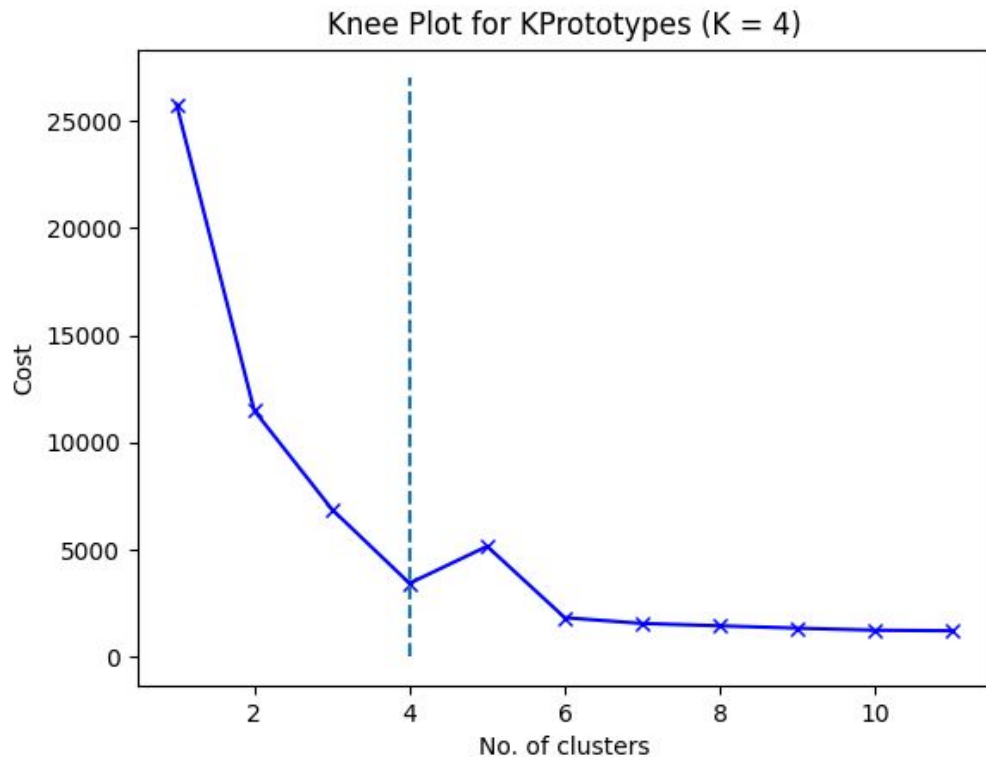
ABC AUSTRALIA CLUSTER USERS (PREFERENCES)

Knee Plot for KModes (K = 5)
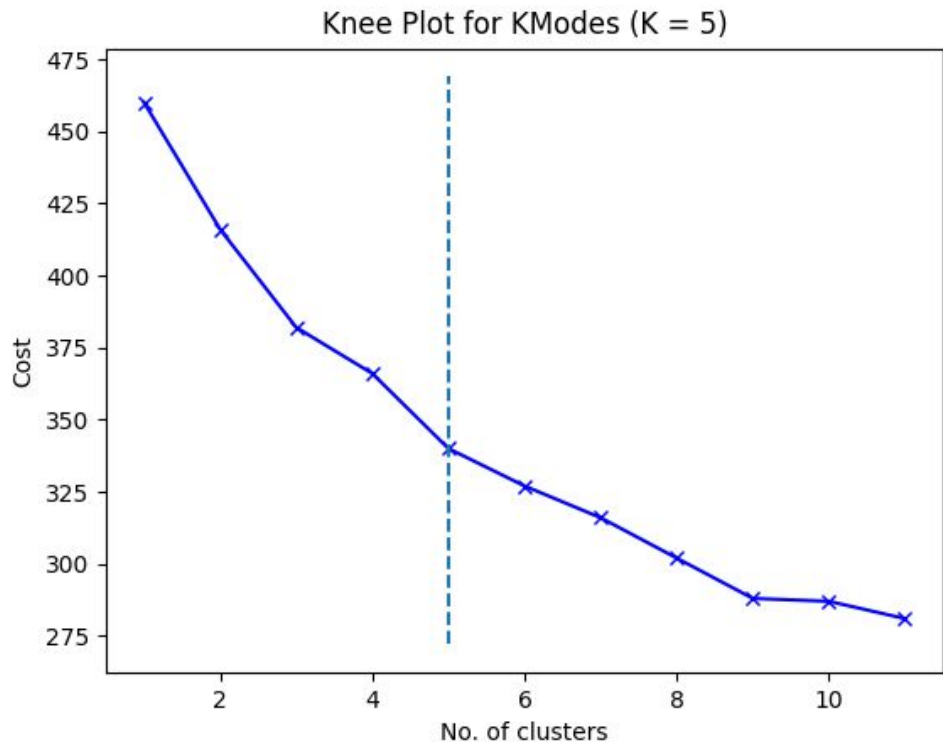
CLUSTER USERS (FAVORITES)

Knee Plot for KModes (K = 7)

ABC AUSTRALIA

CLUSTER USERS (DEMOGRAPHICS)

Knee Plot for KPrototypes (K = 4)

EXTRA TABLE: PARTICIPANT INFO

Study ID	Gender	Age (range)	Education
P1	Male	23	Studied bachelor at University of Applied Sciences
P2	Female	19	Following pre-university education (*VWO*)[18]
P3	Female	21	Studying bachelor at University of Applied Sciences
P4	Female	23	Completed bachelor at University
P5	Female	23	Studying master at University
P6	Female	25	Studying master at University
P7	Male	23	Studying bachelor at University
P8	Female	23	Studying master at University
P9	Male	24	Studying master at University
P10	Female	24	Studying master at University
P11	Female	28	Studying master at University
P12	Male	25	Studying master at University
P13	Male	21	Studying bachelor at University of Applied Sciences
P14	Male	25	Studying bachelor at University of Applied Sciences
P15	Male	26	Studying bachelor at University of Applied Sciences
P16	Female	55	Completed bachelor at University of Applied Sciences
P17	Male	21	Studying bachelor at University
P18	Male	57	Completed master at University