The effect of emotion-based diversification and visualization on user experience in recommendation systems

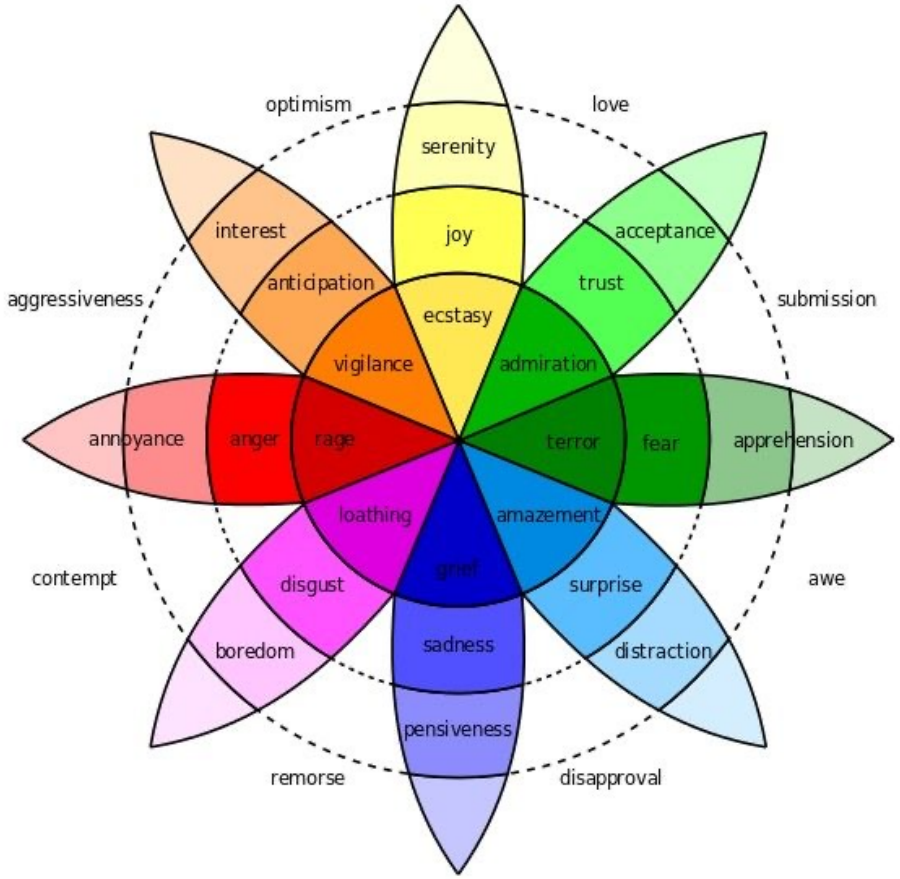
LIOR LANSMAN

Background:
The role of emotions in the decision-making process

- In recent years, researchers hypothesized that users' emotions describe the variance in user preferences and therefore could help in the improvement of personalized systems.
- Some studies started using emotions as a source of affective metadata for building item or user models.

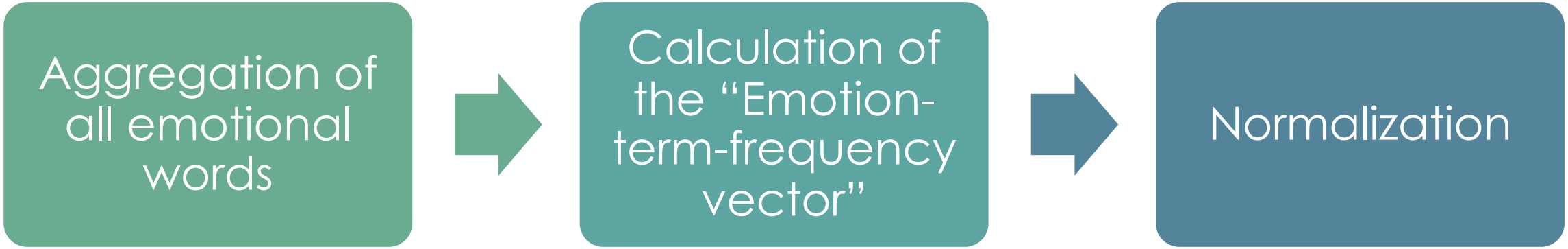
The emotional signature

- In 2017, Bader et.al. devised a visualization technique for the emotions expressed in movies' reviews.
- They extracted emotions from movies' online reviews to create "emotional signatures" of the movies.
- They used the NRC lexicon for both Plutchik's eight emotions and sentiment (positive vs negative).

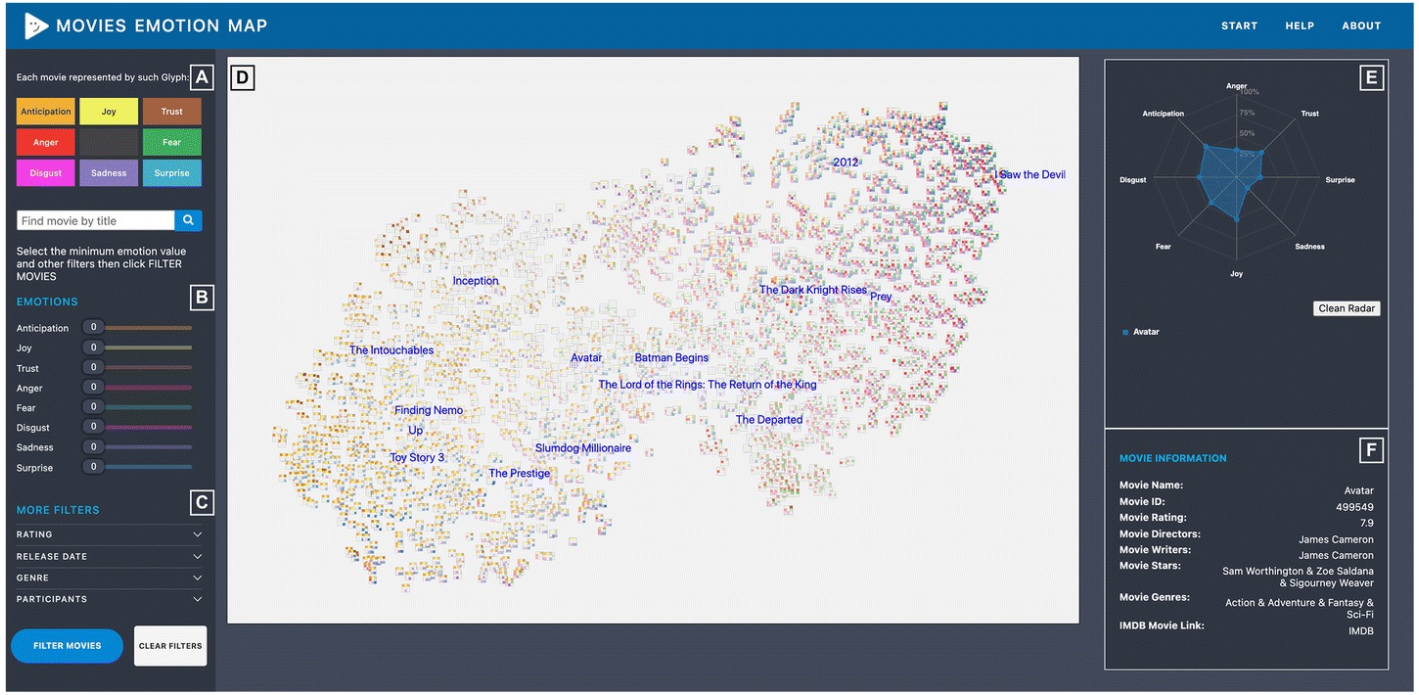


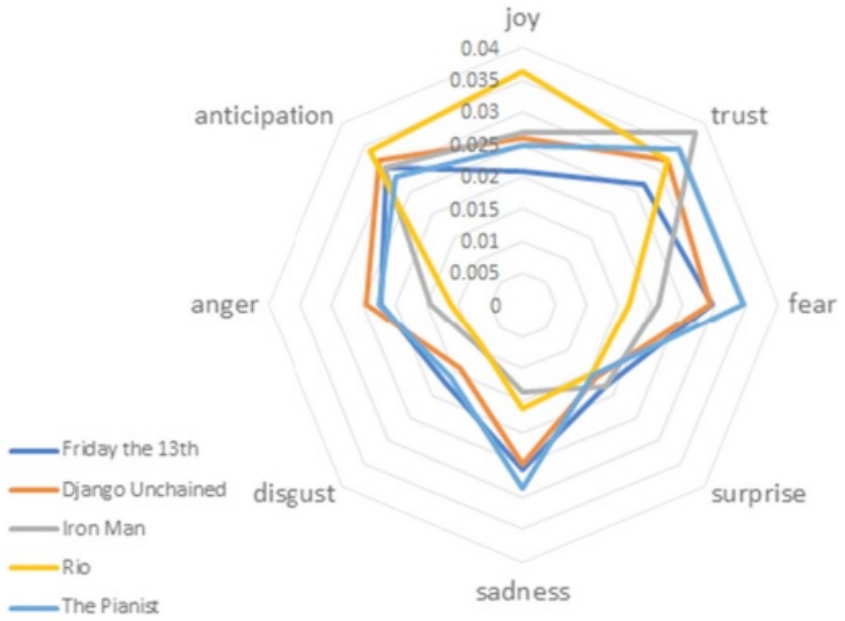
Plutchiks' wheel of emotions
(R. Plutchik, 1980)

How are emotional signatures created?

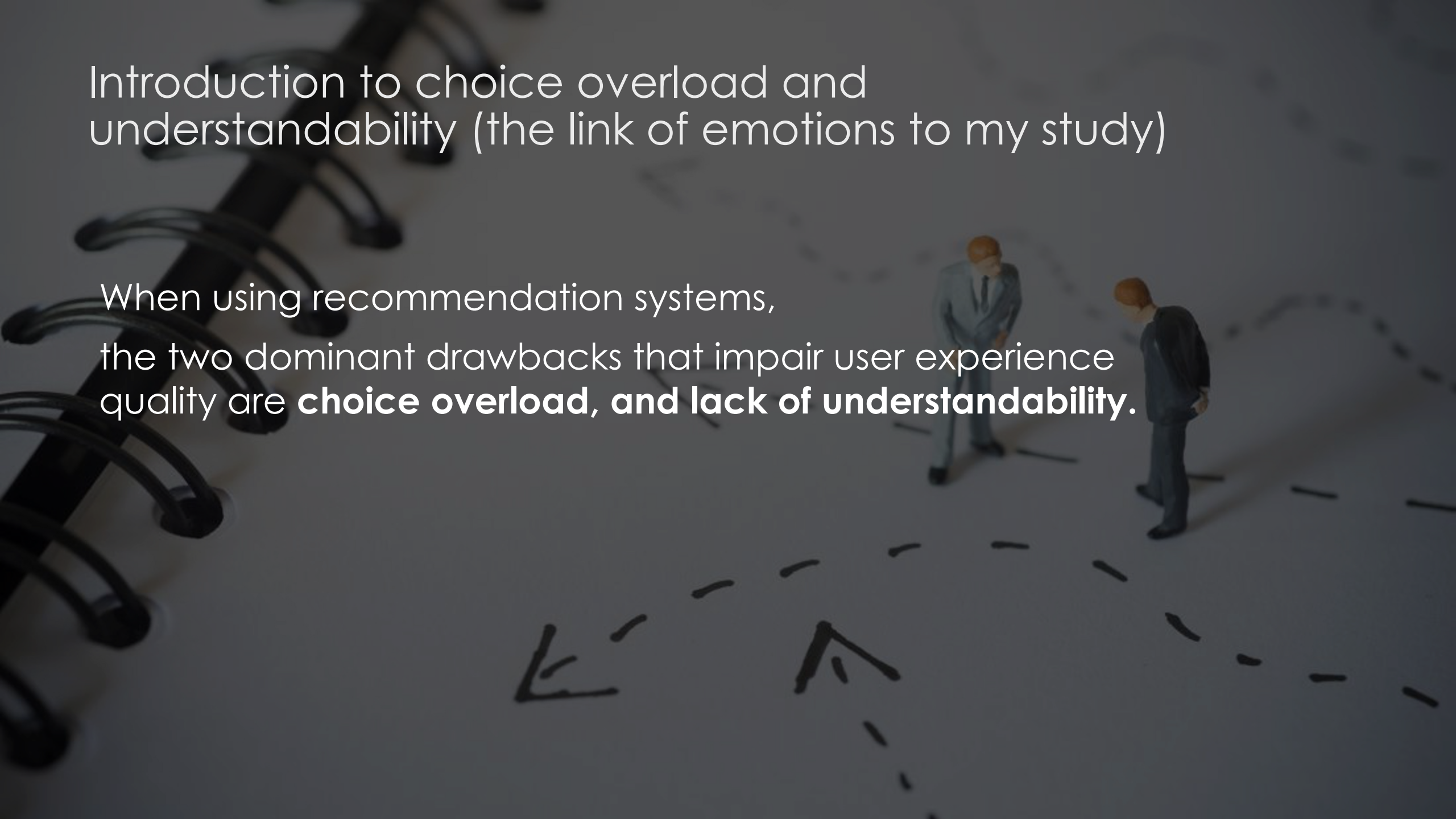


Movie emotions map (Cohen et al. 2021)





Introduction to choice overload and understandability (the link of emotions to my study)



When using recommendation systems,

the two dominant drawbacks that impair user experience quality are **choice overload, and lack of understandability.**

Choice overload

- Choice overload refers to the phenomenon that users experience when the recommended items are equally attractive and difficult to choose from.
- Willemsen et al. (2016) showed that diversification based on latent features keeps the average predicted rating constant, reducing the choice difficulty, and preventing choice overload.
- In this study, we use emotional signatures as a movie's attribute to examine the contribution of emotional-signature-based diversification as a tool to prevent choice overload while keeping the perceived recommendation quality high.

Understandability

- Understandability refers to how a human understands the cause for this recommendation.
- Understandability contributes to users' perceived control, perceived recommendation quality, and satisfaction with the system.
- One limitation of the widely used collaborative filtering algorithm is the lack of transparency regarding the recommendation process.
- In this study, we combine graph-based and feature-style explanations based on emotional signatures as a tool to enhance understandability.

My research questions

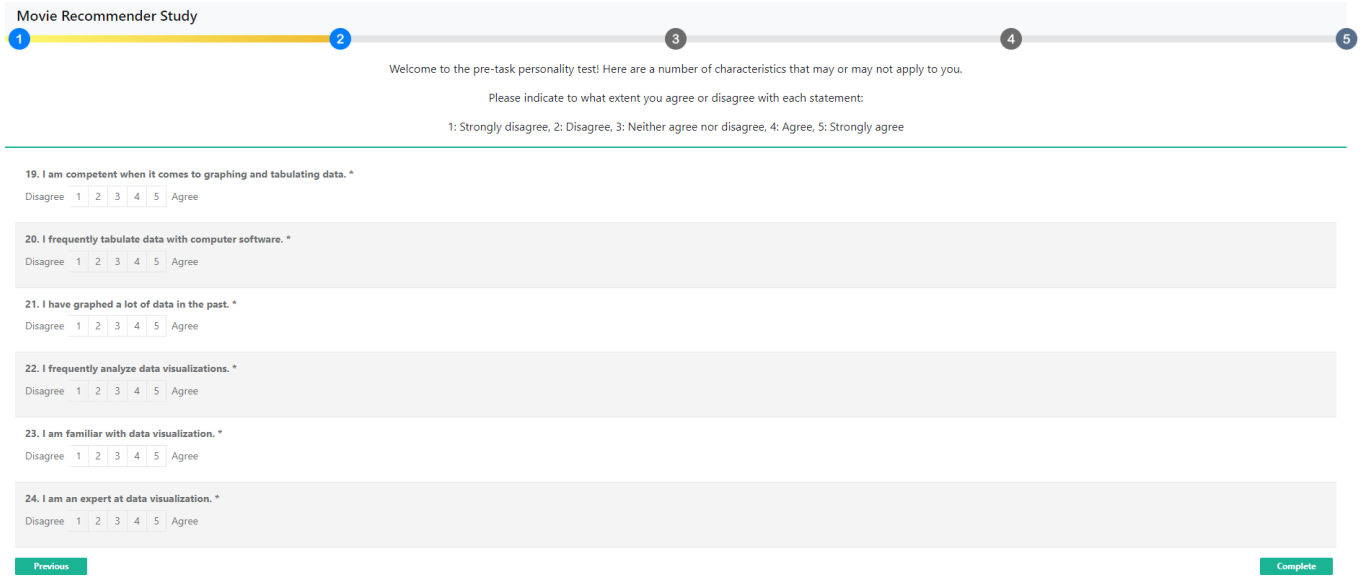
$\boldsymbol{RQ_0}$: How does emotion-based recommendation diversification contribute to the reduction of choice overload?

$\boldsymbol{RQ_1}$: How does emotion-based recommendation visualization contribute to understandability?

Methodology flow

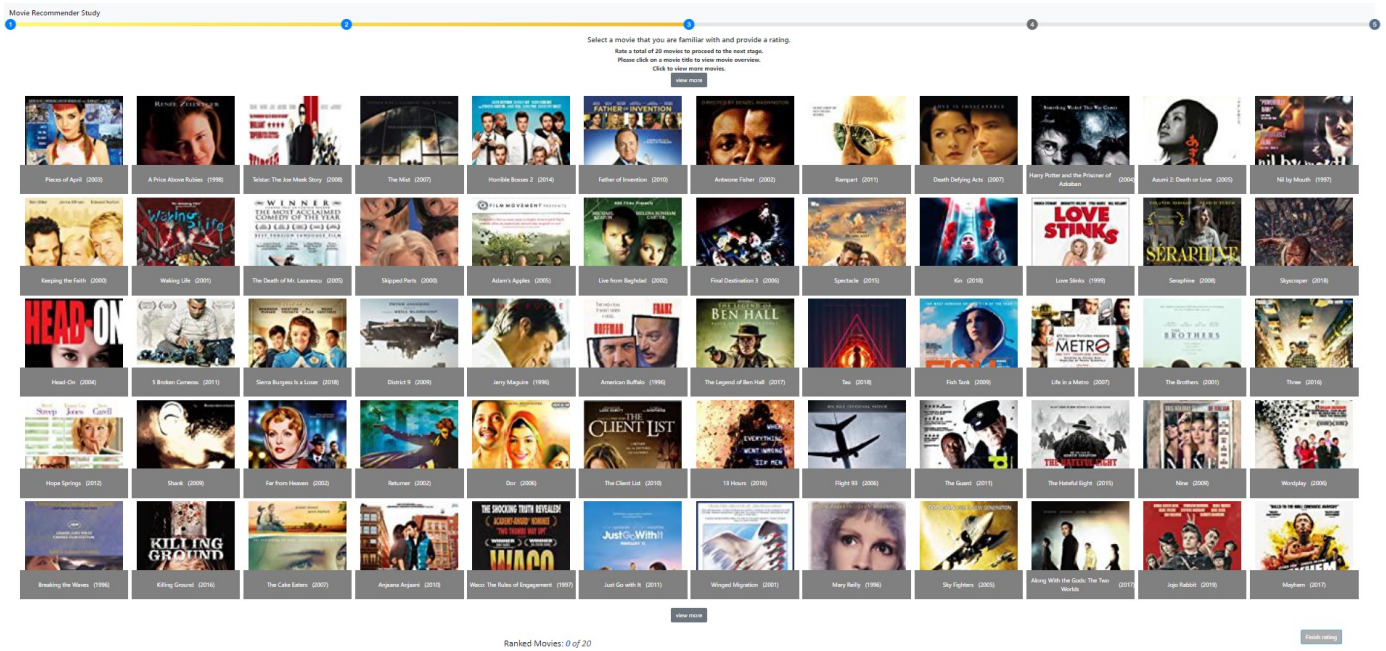
Methodology: The system

- Personality test



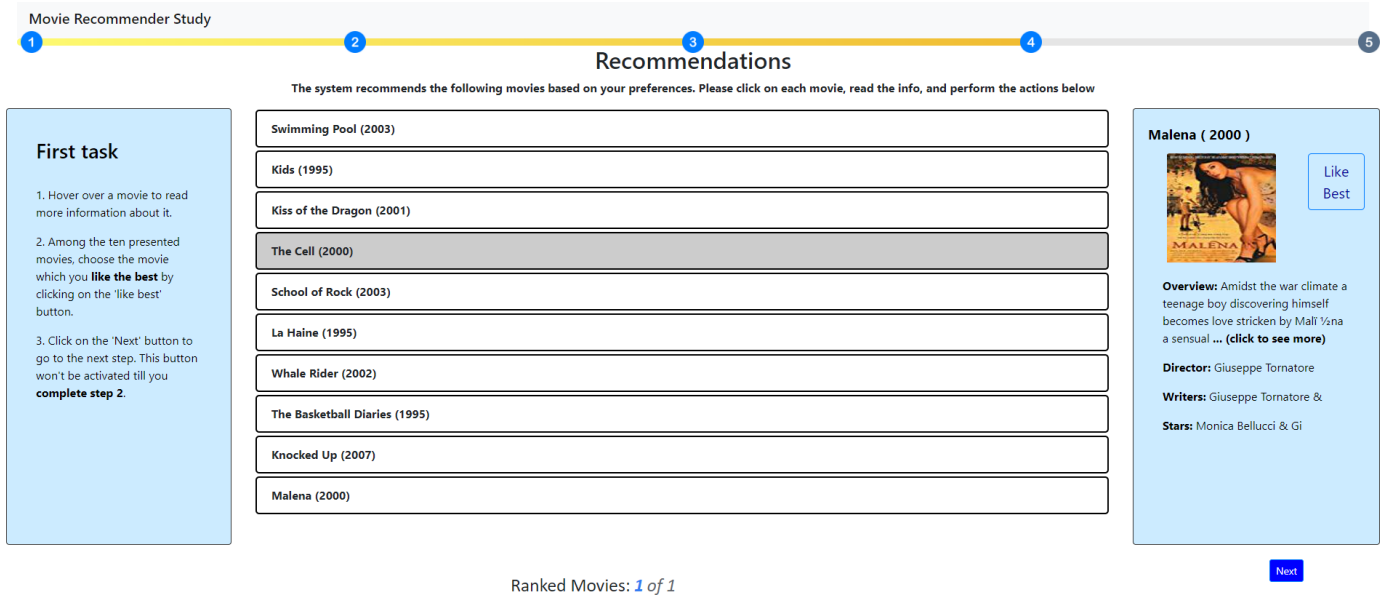
Methodology: The system

- Movie ranking



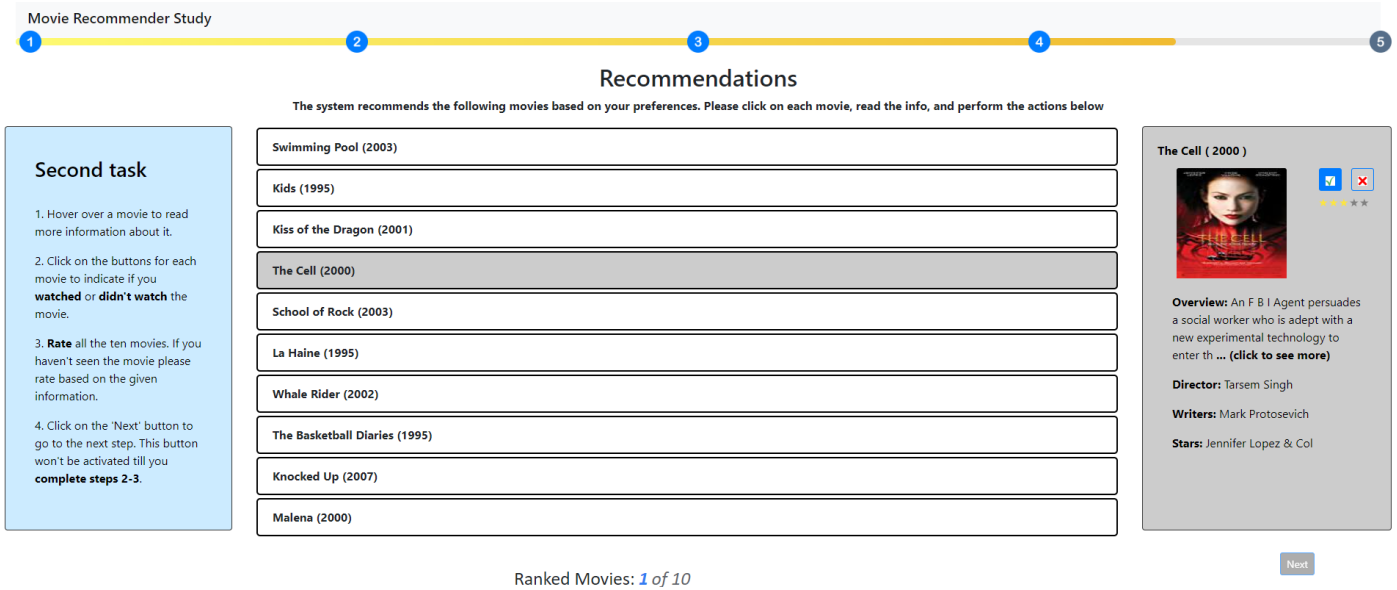
Methodology: The system

- 1st Recommendation task



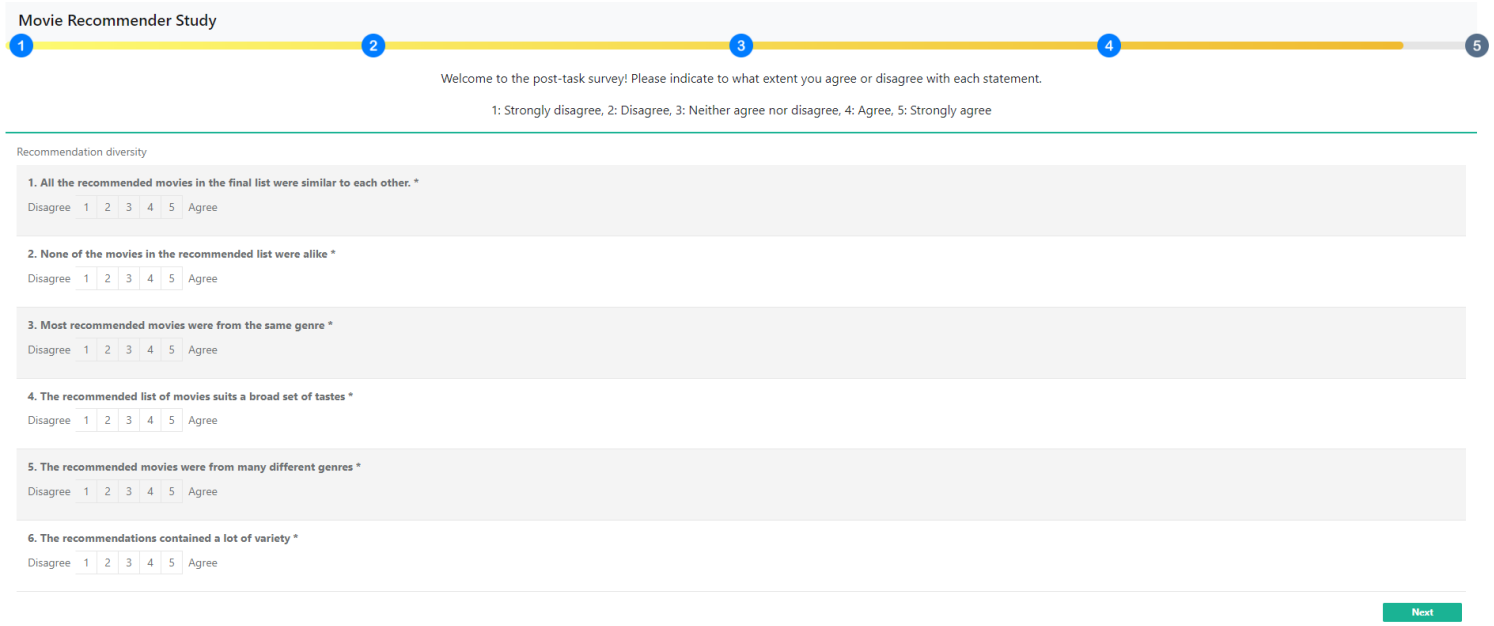
Methodology: The system

- 2nd Recommendation task



Methodology: The system

- Post-task survey



The experimental conditions

- The experiment is designed as an in between-subject research experiment
- The different experimental conditions refer to different combinations of recommendation visualization diversification and source.

Visualization	Diversification	Source
List view	Vanilla	Latent features
List view	Weighted	Latent features
List view	Vanilla	Emotional signature
List view	Weighted	Emotional signature
List view	None	Random
Graph	Vanilla	Latent features
Graph	Weighted	Latent features
Graph	None	Latent features
Graph	Vanilla	Emotional signature
Graph	Weighted	Emotional signature
Graph	None	Emotional signature

The diversification algorithms: Vanilla

- We applied the same diversification technique as presented by Willemsen et.al. (2016)
- Latent-based vanilla: maximizes the total distance between items each iteration
- Emotion-based vanilla: maximizes the emotion distance between items each iteration

```
Candidates ← Top N predictions by MF
R ← {}
FirstItem ← the i ∈ Candidates for which d(i, Centroid(Candidates)) is minimal
Insert FirstItem into R
Remove FirstItem from Candidates
while |R| < k do
        best ← the i ∈ Candidates for which ∑_{l∈R} d(i, l) is maximal
        Insert best into R
        Remove best from Candidates
end while
return R
```

The diversification algorithms: Weighted

- Different users perceive diversity differently. Therefore, their personal preferences should be reflected in the recommendation diversification.
- The weights refer to the latent feature or emotion, for which the user is most likely to be flexible.

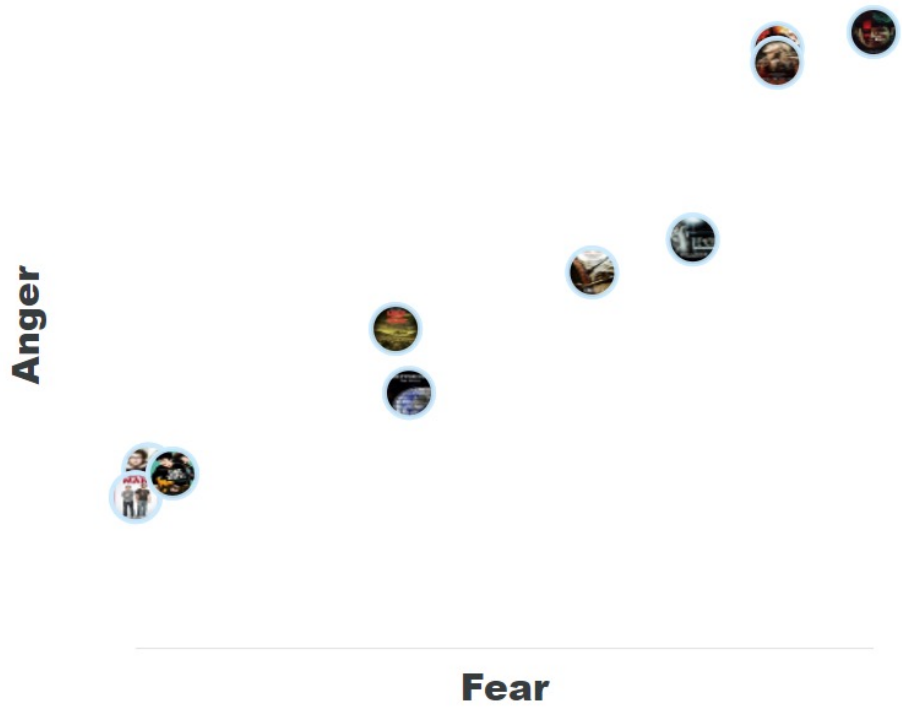
Algorithm 2: Weighted Diversification

Input: Top-N predicted items T,
Item latent features (or item emotional signatures) $Q_T = \{i \epsilon T, q_i \epsilon Q_T\}$,
h (number of diversified item set H) }

Get the weights vector $\vec{\sigma}$ with each element equals to the standard deviation of each dimension of the latent features (or the emotional signatures) over all the candidate top-N items;
Get weighted item latent features (or item weighted emotional signatures) set $wQ_T = \vec{\sigma} \times {Q_T}^t$;
Set $H = \{\}$, an empty set;
Get $centroid(wQ_T)$, take the average along each dimension of the latent features (or the emotional signatures) over all the candidate top-N items;
first-item = the $i \epsilon T$ for which $d(wQ_i, centroid(wQ_T))$ is minimal;
Add *first-item* to H and Remove it from T;
while $num(H) < h$:
next-item = the $i \epsilon T$ for which $\sum_{j \epsilon H} d(wQ_i, wQ_j)$ is maximal
Add *next-item* to H and Remove it from T
end

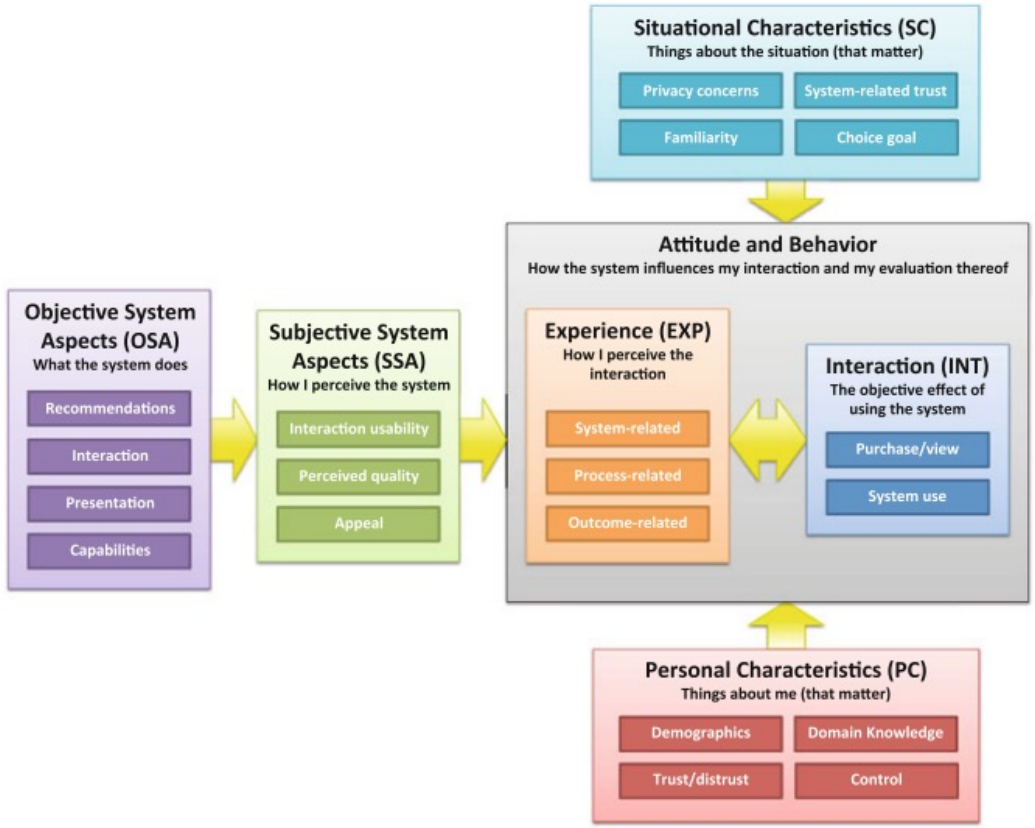
The visualizations: graph and list view

- 21 Jump Street (2012)
- The Cabinet of Dr. Caligari (1920)
- Fido (2006)
- The Science of Sleep (2006)
- Dunkirk (2017)
- Lady Vengeance (2005)
- The Pursuit of Happyness (2006)
- Neon Genesis Evangelion: The End of Evangelion (1997)
- The Dreamers (2003)
- Thor: Ragnarok (2017)



Measures

- In this study, we will employ the user-centric framework of UX of RSs (Knijnenburg et al, 2012) similarly to Willemsen et.al. (2016).
- The framework models how objective system aspects (OSA) can impact user experience (EXP) and user interactions (INT) and how these relations are mediated by the perceptions of users as measured by subjective system aspects (SSA). In addition, the framework models the role of situational characteristics (SC) and personal characteristics (PC).



Measures

Explicit feedback:

1. Personality test (PCs):
   - Personal characteristics
   - Visualization familiarity

2. Post-task survey (EXPs and SSAs):
   - perceived recommendation diversity
   - perceived recommendation quality
   - choice satisfaction
   - Tradeoff difficulty
   - Perceived taste coverage
   - satisfaction with the system
   - choice difficulty
   - understandability
   - perceived control

3. Recommendation phases:
   - Number of known movies among the recommendations
   - Average rating given to the recommendations

Implicit feedback:

1. Hovers and the time spent reading synopsis
2. Overall time in the different stages

.

The expected results:
The effect of emotions on choice overload

Objective System Aspects (OSA)

Subjective System Aspects (SSA)

Experience (EXP)

· Since choice overload is the phenomenon of choice difficulty reducing choice satisfaction, and since this chain of effects will eventually overcome the negative effect of choice difficulty on choice satisfaction, choice overload will be prevented.

Latent-based diversification is expected to increase perceived diversification but not perceived quality, while emotion-based diversification will increase both Perceived diversity and Perceived quality.

*** I didn't mention the PCs and INTs in the graph just for keeping it simple.**
But PCs are expected to affect all SSAs and EXPs,
and INTs are expected to be affected from all OSAs and affect all SSAs and EXPs.

The expected results:
The effect of emotions on understandability

Objective System Aspects (OSA)

Subjective System Aspects (SSA)

Experience (EXP)

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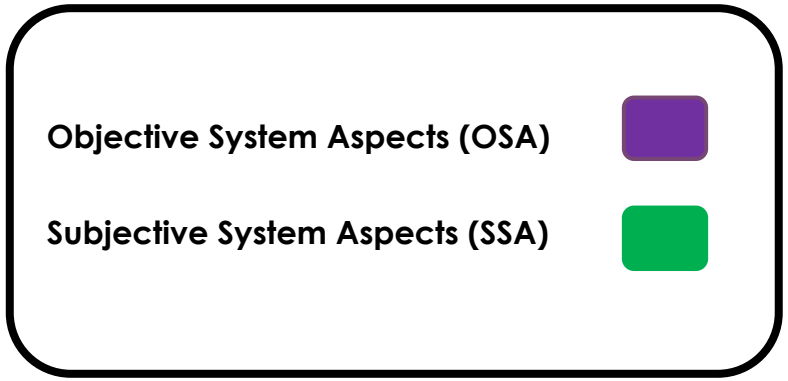
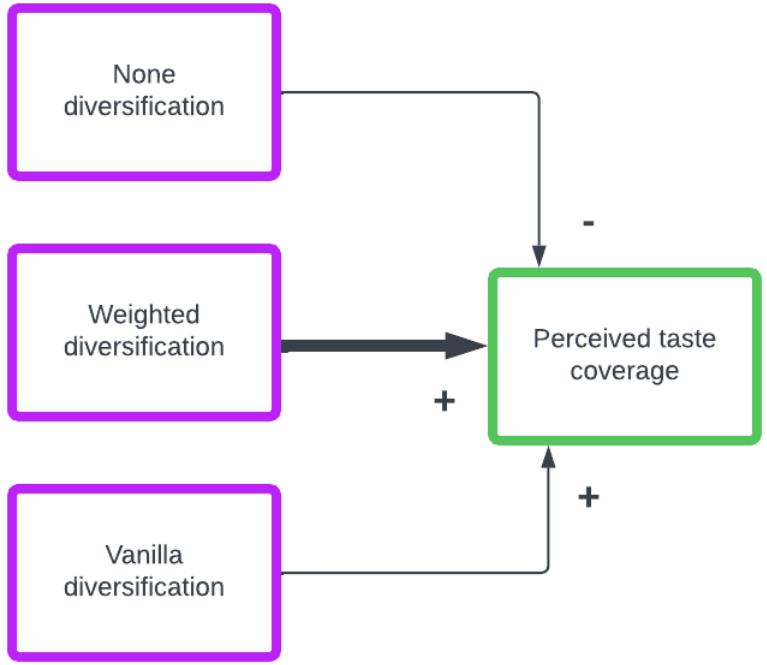
The expected results:

The effect of weighted diversification on perceived taste coverage





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But PCs are expected to affect all SSAs and EXPs,
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Preliminary results: mimic models

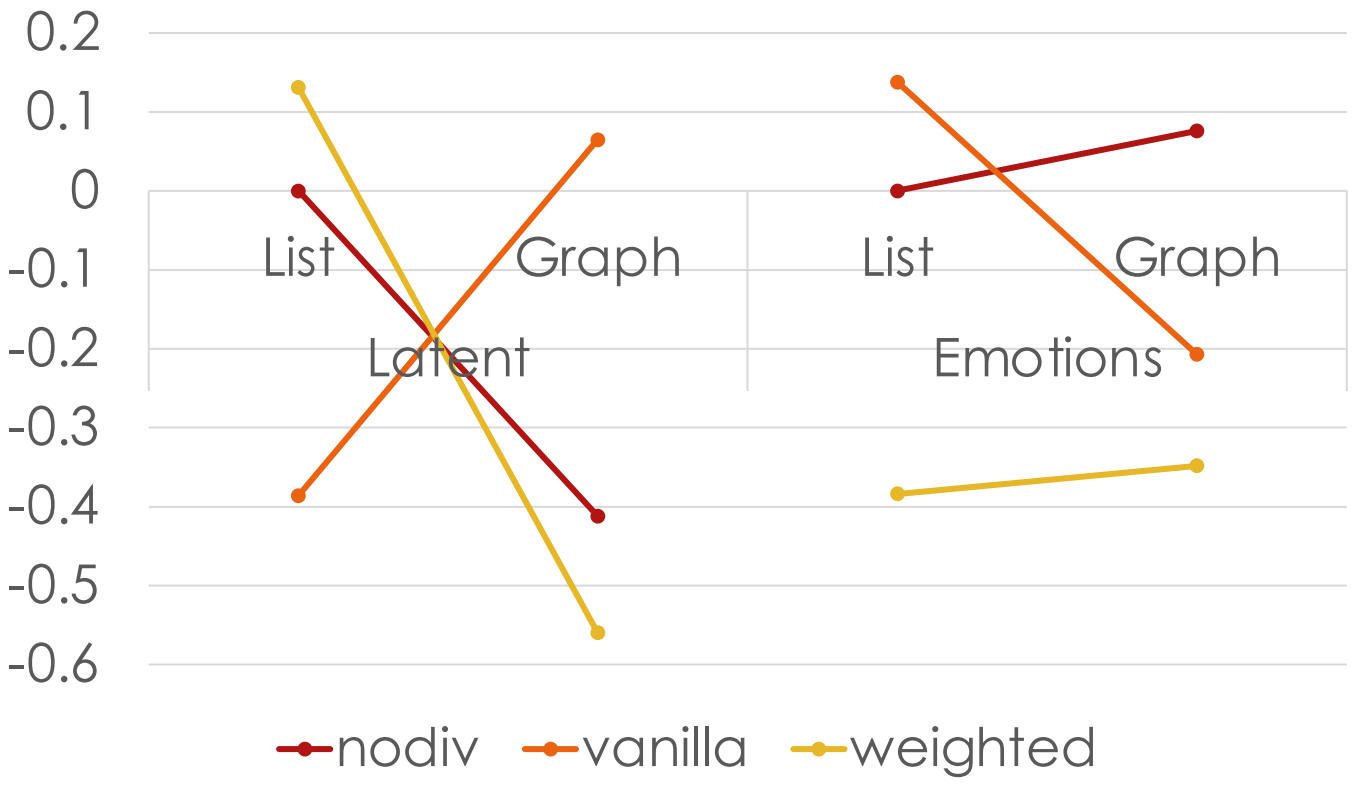
To see how the different constructs relate to each other and the different manipulations we will construct a structural equation model (SEM) similar to the one suggested by Kninjenburg et.al. (2015)

There are two approaches to two define OSAs dummies:

- Compare all conditions against a baseline condition (list + no diversification).
  e.g: ptc ~ lvl+lwl+lve+lwe+gvl+gwl+gnl+gve+gwe+gne
- Considering the conditions as interactions between manipulations of visualization (list, graph), diversification (none, vanilla, weighted), and source (latent v emotions).
  e.g.: ptc ~ vgraph+dvanilla+dweighted+semotions+vgdv+vgdw+sedv+sedw+vgse+vgdvse+vgdwse

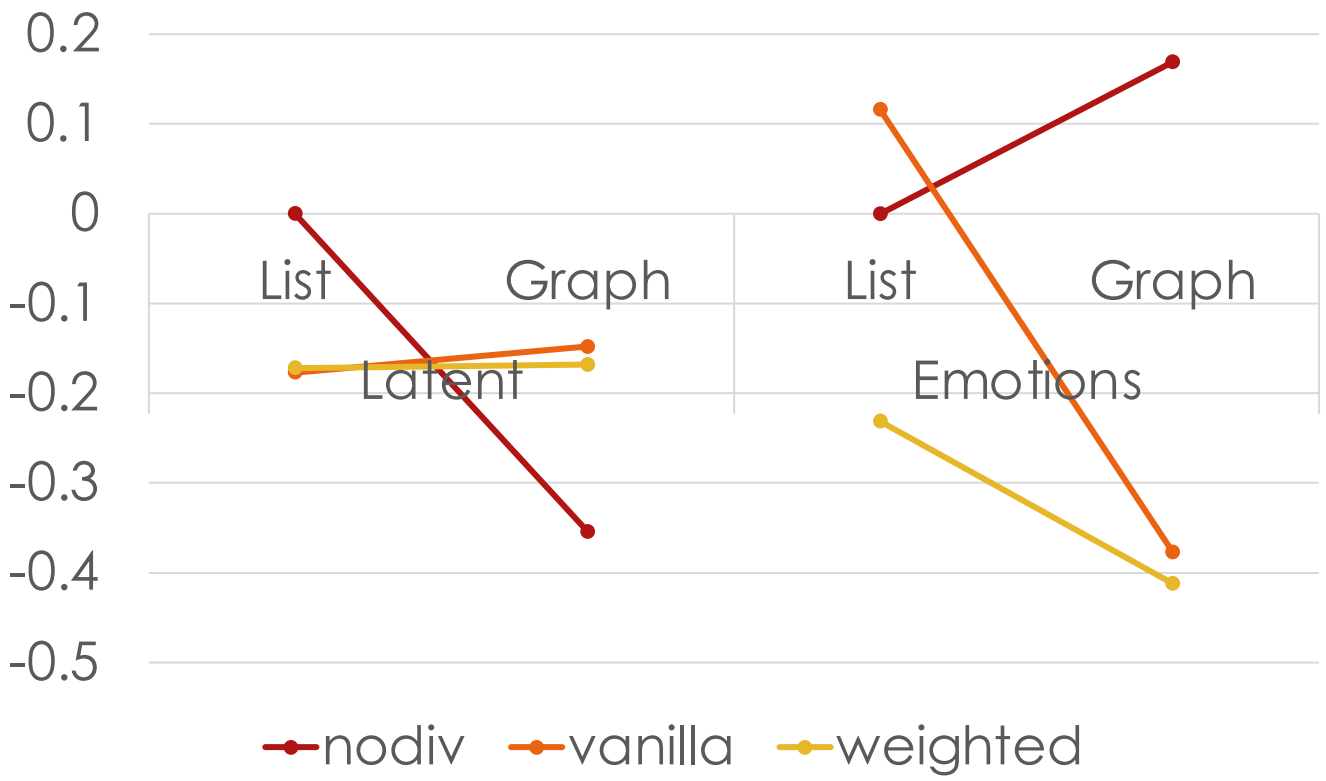
Preliminary results: mimic models

The effect of the experimental conditions on **understandability**



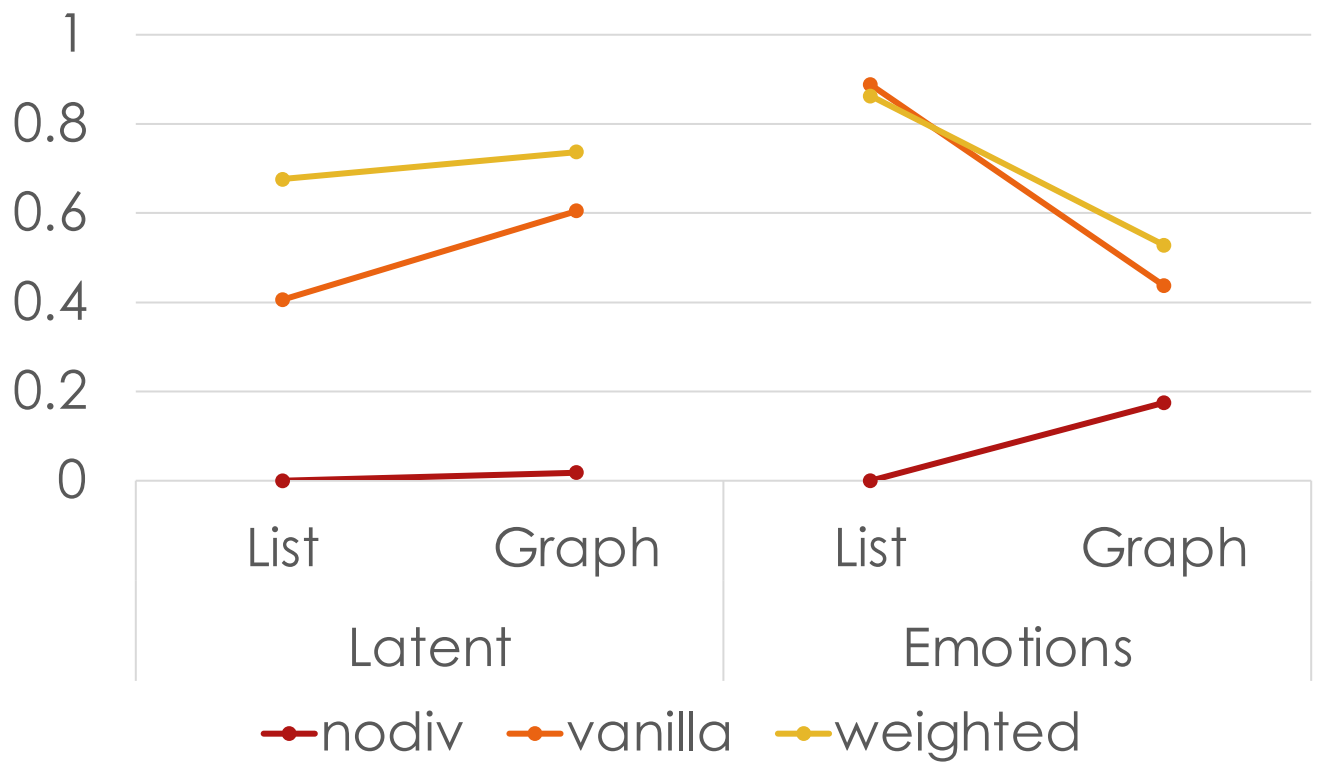
Preliminary results: mimic models

The effect of the experimental conditions on **perceived control**



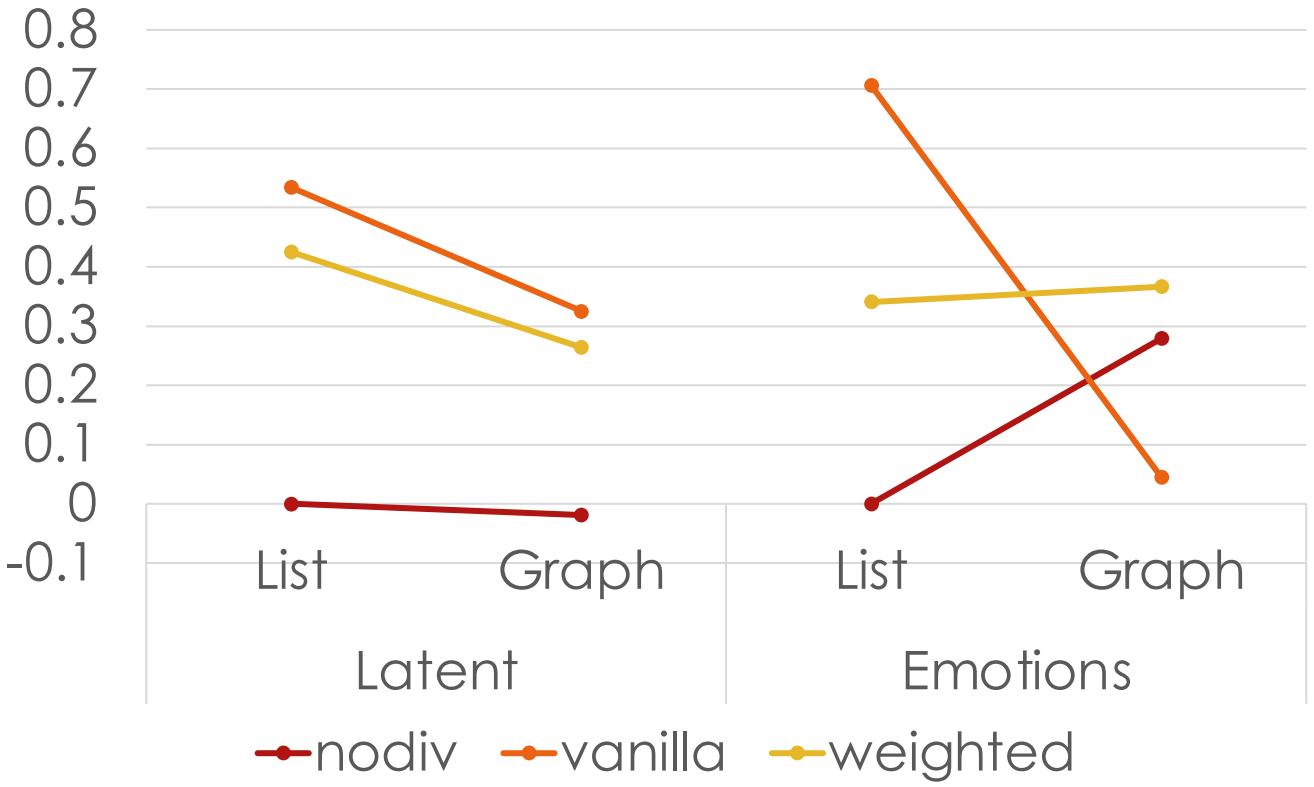
Preliminary results: mimic models

The effect of the experimental conditions on **perceived diversity**



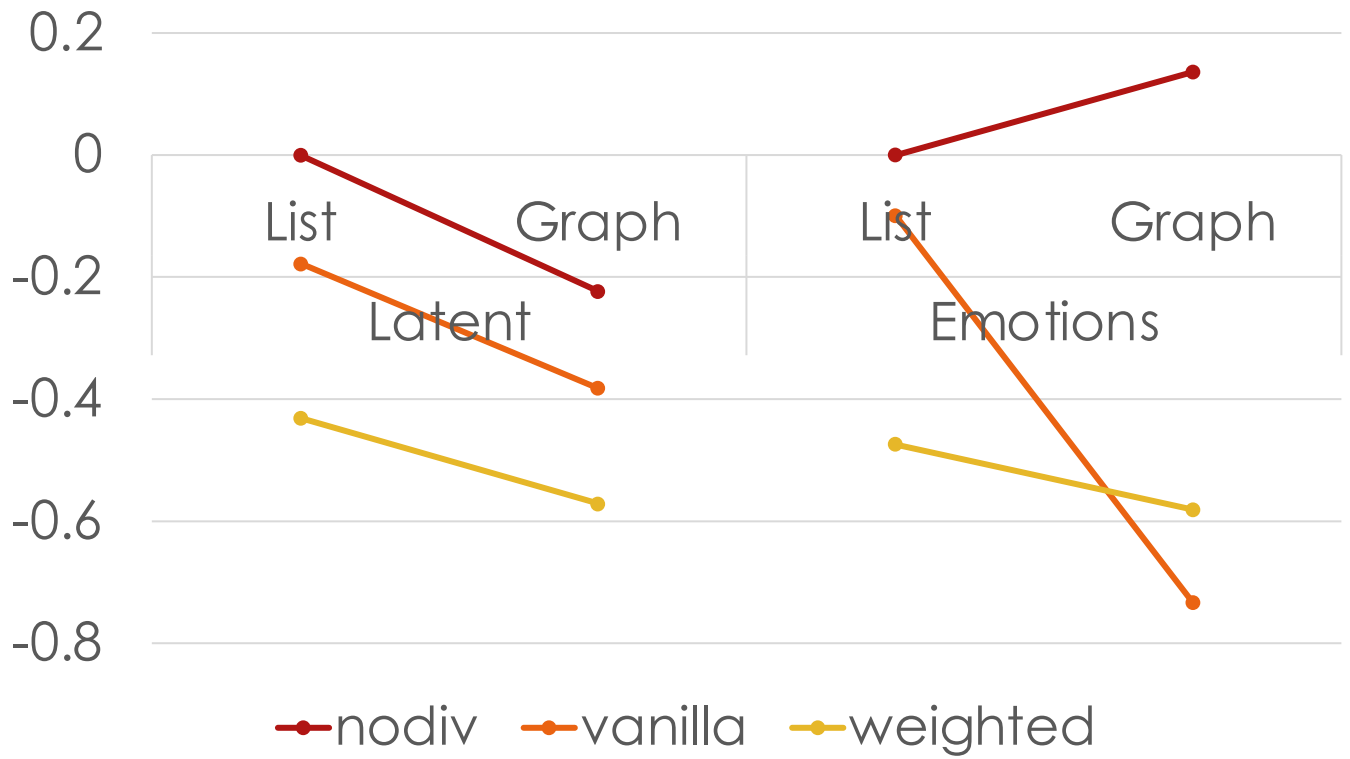
Preliminary results: mimic models

The effect of the experimental conditions on **perceived taste coverage**



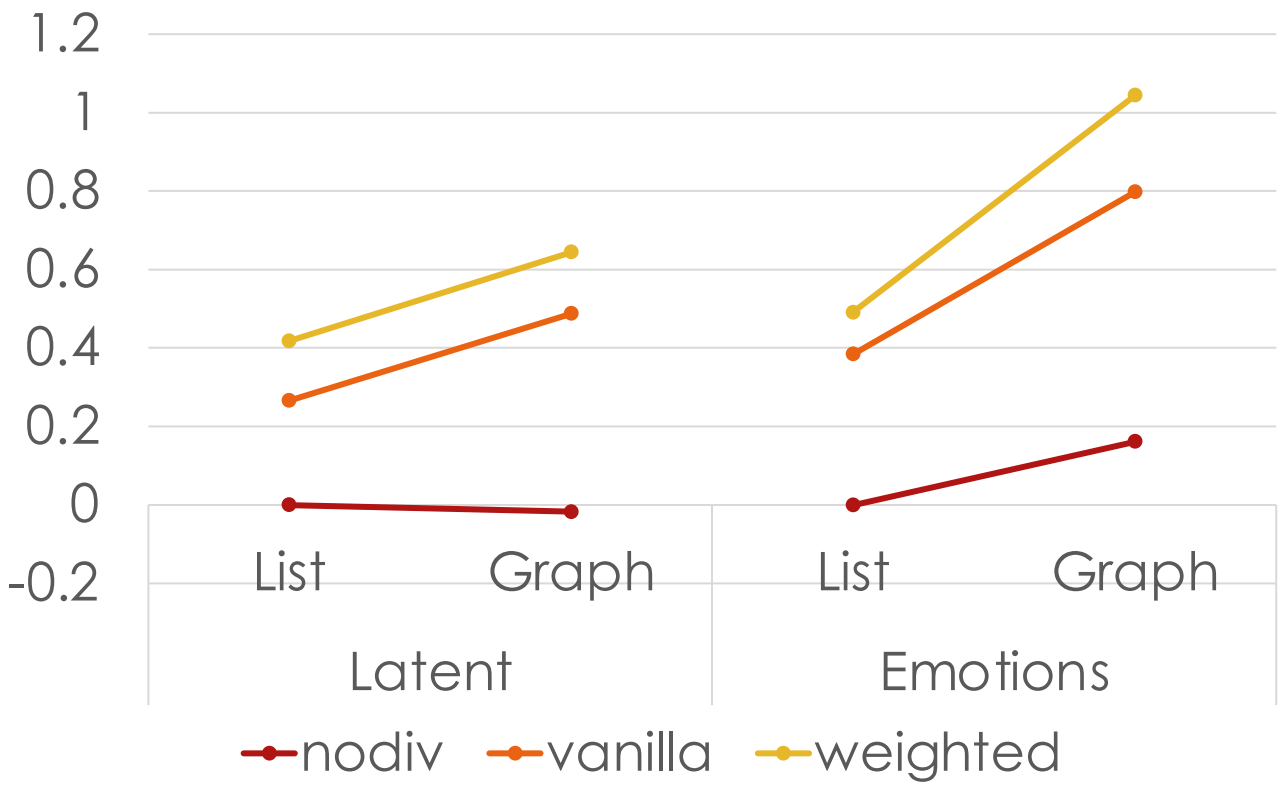
Preliminary results: mimic models

The effect of the experimental conditions on **perceived quality**



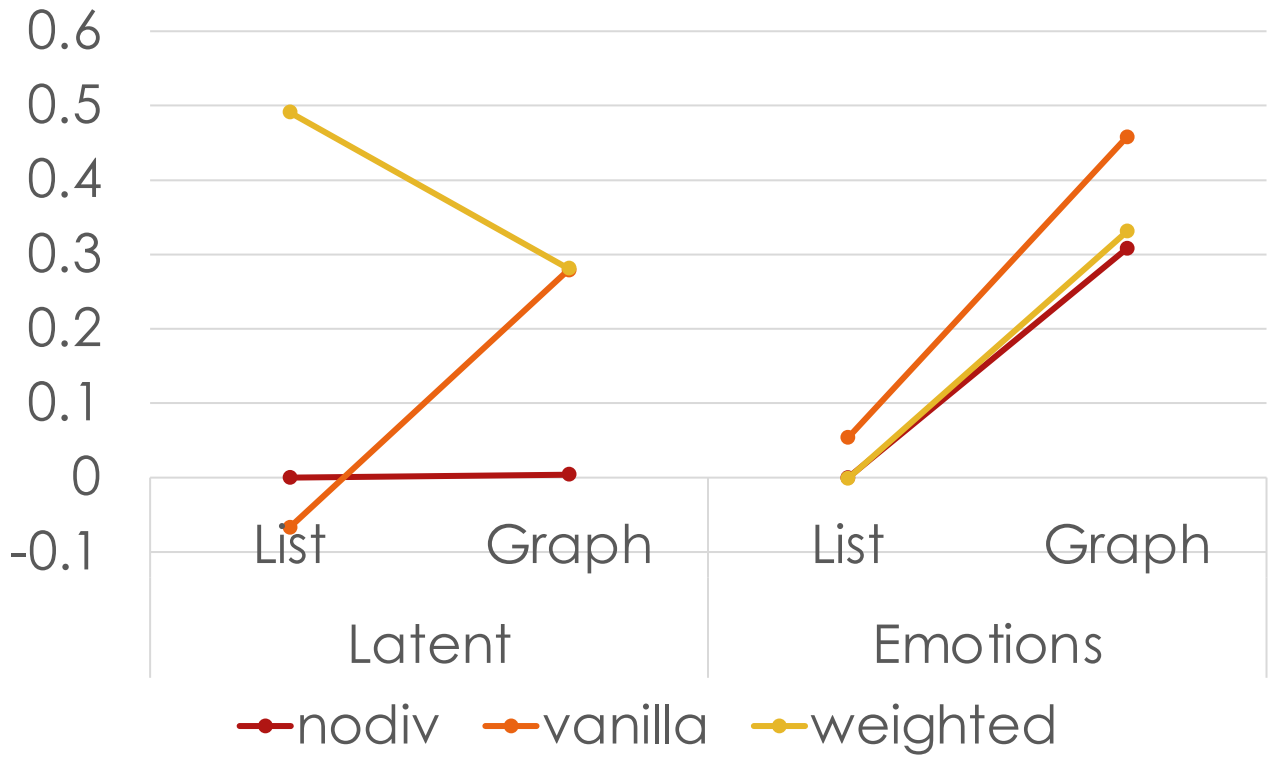
Preliminary results: mimic models

The effect of the experimental conditions on **tradeoff difficulty**



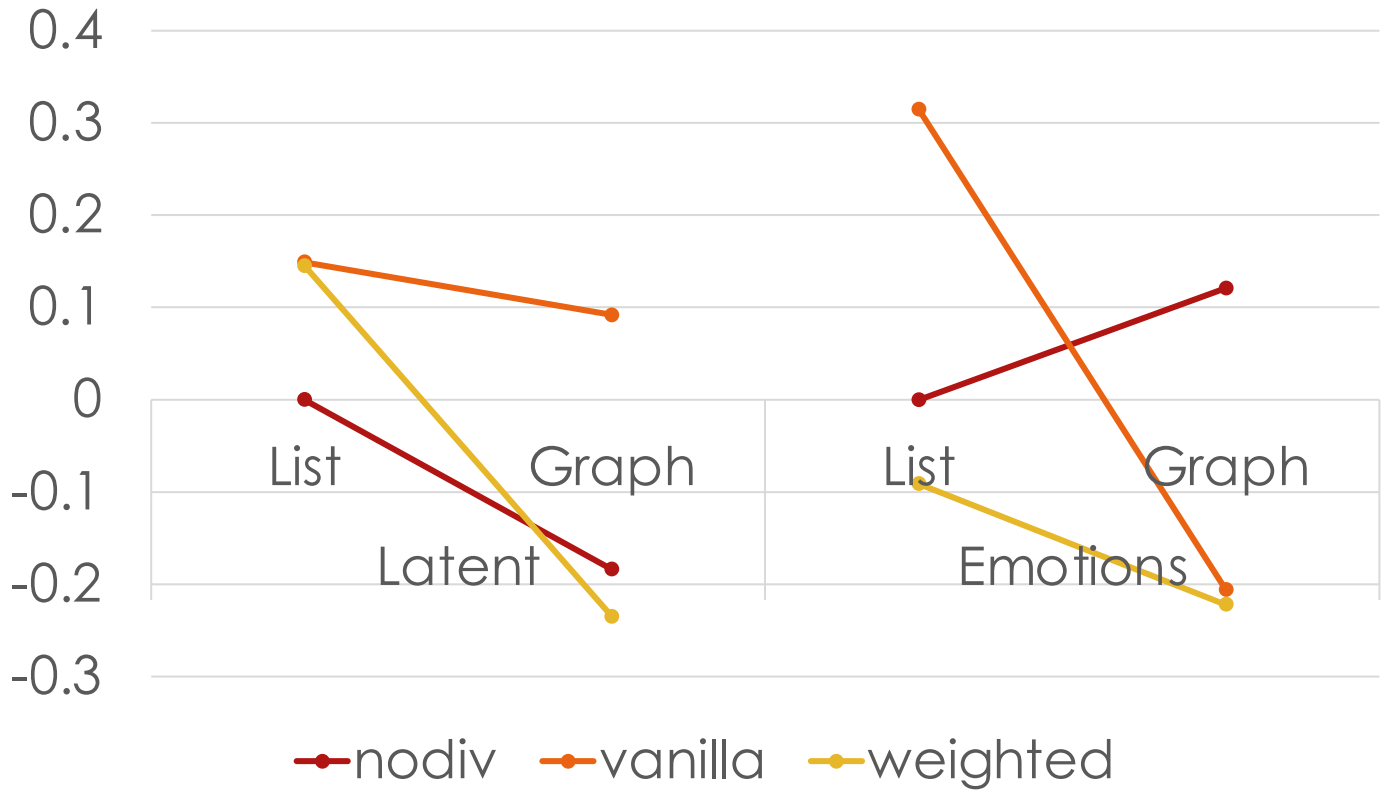
Preliminary results: mimic models

The effect of the experimental conditions on **choice difficulty**



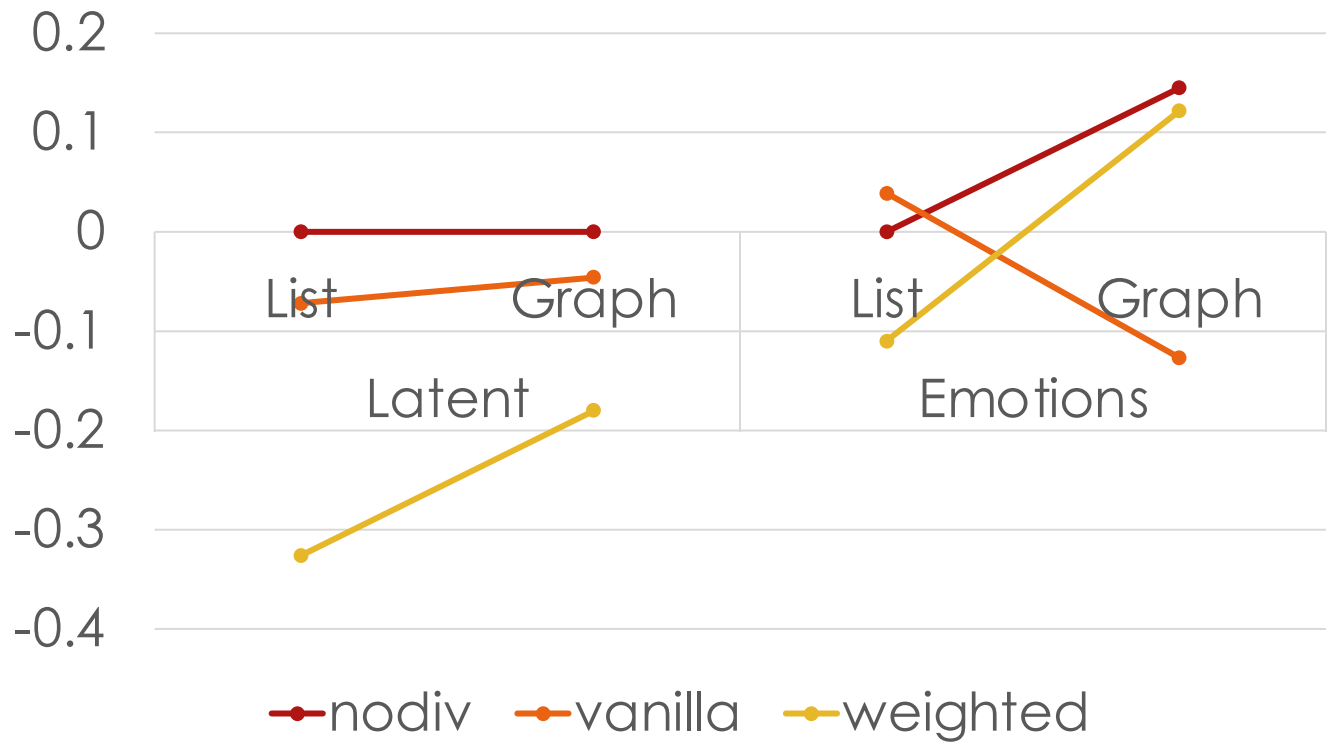
Preliminary results: mimic models

The effect of the experimental conditions on **satisfaction with the system**



Preliminary results: mimic models

The effect of the experimental conditions on **choice satisfaction**




ANY
QUESTIONS?

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Introducing Emotion for Diversification, Transparency, and Control

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How can we help users explore their preferences?

Four alternative recommendation lists (**RSSA features**) that go beyond the top-N

- *Things we think you'll hate (**hate items**)*
- *Things you'll be among the first to try (**hipster items**)*
- *Things we have no clue about (no-clue items)*
- *Things that are controversial (controversial item)*

Motivation

Support Self-Actualization:

Support rather than replace decision making

Focus on *exploration* rather than consumption

Attempt to cover users' *various* tastes

Emotions for Diversification, Visualization, and Interaction

- **Diversification**
  - Diversify the movies by the emotional signature
- **Visualization**
  - Visualize each recommendation on a radar graph or a bar graph to reveal the emotion feature
- **Interaction**
  - Allow users to specify their movie tastes from the perspective of emotions

Research Questions

1. Does using the evoked emotions from movie reviews for diversification contribute to users' perceived diversity of the recommendations?
2. How does the visualization influence the transparency of the recommender system that leverages the emotional signature?
3. Does users’ control over the recommender system improve their trust in the system and thus increase their satisfaction with the system?

Research Questions

4. How do users’ personal characteristics moderate the effects of the main features of the movie recommender on users' experience with system?
5. How do the new features of the movie recommender system contribute to solving the "filter bubble" problem?

Experimental Design

- Manipulations
  - Diversification
    - Diverse items vs. traditional top-N recommendations
  - Visualization
    - Visualization panel on vs. off
  - Interaction
    - Input panel on vs. off

Conditions

- 2 x 2 x 2 between subjects

Conditions	Allow input		No input	
	Visualization on	Visualization off	Visualization on	Visualization off
Diverse	Diverse items Emo viz: on Emo input: on	Diverse items Emo viz: off Emo input: on	Diverse items Emo viz: on Emo input: off	Diverse items Emo viz: off Emo input: off
Top-N	Top-N items, Emo viz: on Emo input: on	Top-N items, Emo viz: off Emo input: on	Top-N items, Emo viz: on Emo input: off	Top-N items, Emo viz: off Emo input: off

Design

1. Among the movies in your system, we predict that you will like these 7 movies the best based on your ratings.

2. You can hover over movies to see a preview of the poster, a short synopsis, and a radar graph depicting the movie's emotional feature in 8 emotions: joy, trust, fear, surprise, sadness, disgust, anger, and anticipation.

3. You can specify your preference of movies from the perspective of movie emotions in the following panel. Please adjust the emotion strength indicators bellow so we could fine-tune the recommendations for you.

Your taste on movie emotions

	Low	High	Ignore
Joy			✓
Trust		✓	
Fear			✓
Surprise	✓		
Sadness			✓
Disgust			✓
Anger			✓
Anticipation			✓

Reset Enter

Movies you may like


1. First Knight (1995)


2. Dead Man Walking (1995)


3. Father of the Bride Part II (1995)


4. Natural Born Killers (1994)


5. It Could Happen to You (1994)


6. The Truth About Cats & Dogs (1996)


7. Murder in the First (1995)


8. Toy Story (1995)


9. Just Cause (1995)


10. Lawnmower Man 2: Beyond Cyberspace (1996)

First Knight

Lancelot falls in love with Guinevere, who is due to be married to King Arthur. Meanwhile, a violent warlord tries to seize power from Arthur and his Knights of the Round

Emotions

Next

1

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Fear			✓
Surprise	✓		
Sadness			✓
Disgust			✓
Anger			✓
Anticipation			✓

Reset

Enter

Movies you may like

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Your taste on movie emotions

	Low	High	Ignore
Joy			✓
Trust		✓	
Fear			✓
Surprise	✓		
Sadness			✓
Disgust			✓
Anger			✓
Anticipation			✓

Reset Enter

Movies you may like

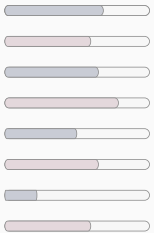
1. First Knight (1995)
2. Dead Man Walking (1995)
3. Father of the Bride Part II (1995)
4. Natural Born Killers (1994)
5. It Could Happen to You (1994)
6. The Truth About Cats & Dogs (1996)
7. Murder in the First (1995)
8. Toy Story (1995)
9. Just Cause (1995)
10. Lawnmower Man 2: Beyond Cyberspace (1996)

First Knight

Lancelot falls in love with Guinevere, who is due to be married to King Arthur. Meanwhile, a violent warlord tries to seize power from Arthur and his Knights of the Round

2

Emotions



Next

1. Among the movies in your system, we predict that you will like these 7 movies the best based on your ratings.

2. You can hover over movies to see a preview of the poster, a short synopsis, and a radar graph depicting the movie's emotional feature in 8 emotions: joy, trust, fear, surprise, sadness, disgust, anger, and anticipation.

3. You can specify your preference of movies from the perspective of movie emotions in the following panel. Please adjust the emotion strength indicators bellow so we could fine-tune the recommendations for you.

3

Your taste on movie emotions

	Low	High	Ignore
Joy			✓
Trust		✓	
Fear			✓
Surprise	✓		
Sadness			✓
Disgust			✓
Anger			✓
Anticipation			✓

Reset

Enter

Movies you may like


1. First Knight (1995)


2. Dead Man Walking (1995)


3. Father of the Bride Part II (1995)


4. Natural Born Killers (1994)


5. It Could Happen to You (1994)


6. The Truth About Cats & Dogs (1996)


7. Murder in the First (1995)


8. Toy Story (1995)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10. Lawnmower Man 2: Beyond Cyberspace (1996)

First Knight

Lancelot falls in love with Guinevere, who is due to be married to King Arthur. Meanwhile, a violent warlord tries to seize power from Arthur and his Knights of the Round

Emotions

Next

Design

1. Among the movies in your system, we predict that you will like these 7 movies the best based on your ratings.

2. You can hover over movies to see a preview of the poster, a short synopsis, and a radar graph depicting the movie's emotional feature in 8 emotions: joy, trust, fear, surprise, sadness, disgust, anger, and anticipation.

3. You can specify your preference of movies from the perspective of movie emotions in the following panel. Please adjust the emotion strength indicators bellow so we could fine-tune the recommendations for you.

3

Your taste on movie emotions

	Low	High	Ignore
Joy			✓
Trust		✓	
Fear			✓
Surprise	✓		
Sadness			✓
Disgust			✓
Anger			✓
Anticipation			✓

Reset Enter

1

Movies you may like


1. First Knight (1995)


2. Dead Man Walking (1995)


3. Father of the Bride Part II (1995)


4. Natural Born Killers (1994)


5. It Could Happen to You (1994)


6. The Truth About Cats & Dogs (1996)


7. Murder in the First (1995)


8. Toy Story (1995)


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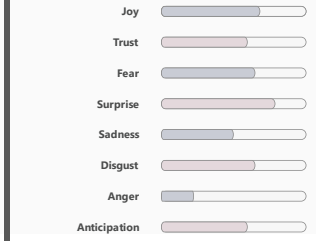
10. Lawnmower Man 2: Beyond Cyberspace (1996)

First Knight

Lancelot falls in love with Guinevere, who is due to be married to King Arthur. Meanwhile, a violent warlord tries to seize power from Arthur and his Knights of the Round

2

Emotions



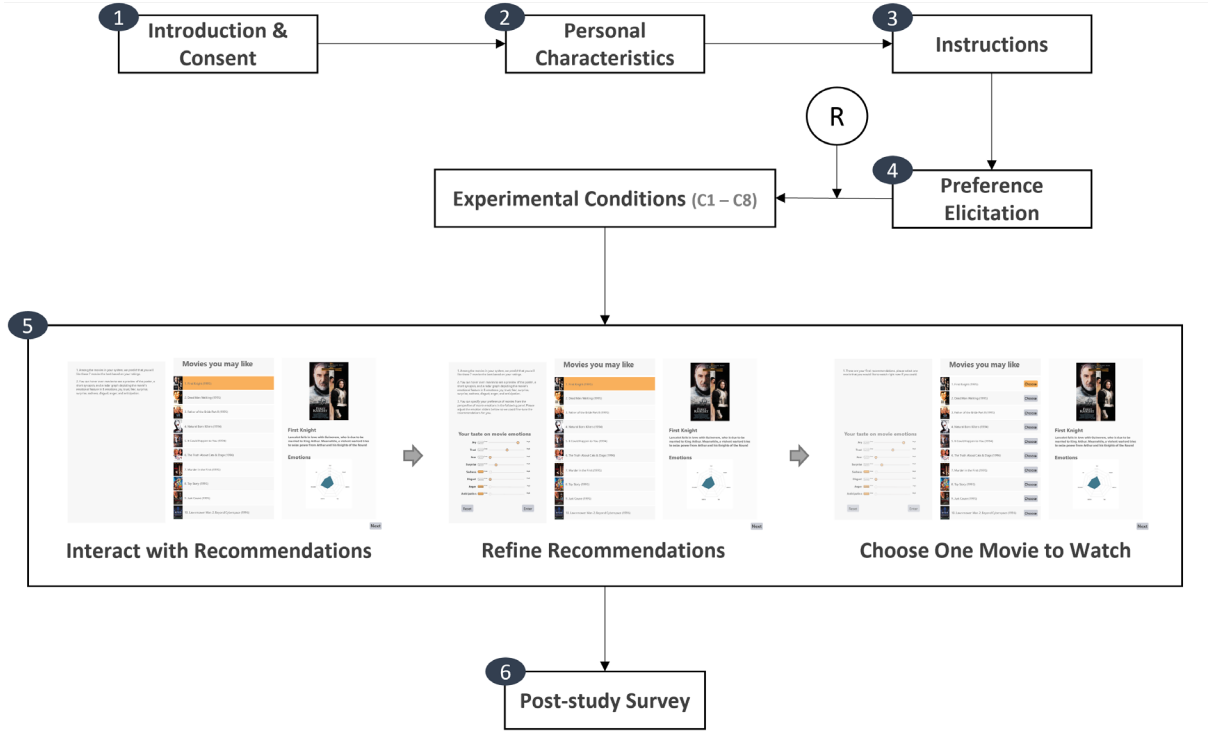
Next

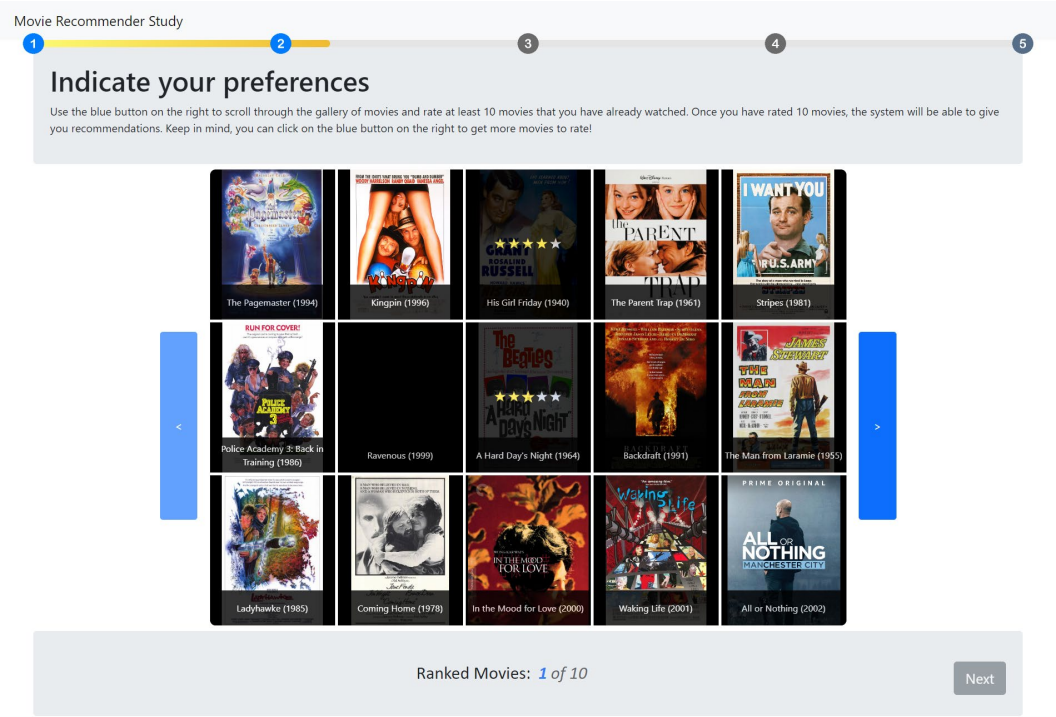
Algorithms

- 4 different versions of the algorithm

	Top N	Diverse N
No Inputs	Traditional top-N recommendations with Matrix Factorization algorithm (Koren et al., 2009)	Diversification algorithm (Willemsen et al., 2016) on emotions
User Inputs	Diversify the top-200 items on the **user-specified** emotions	Sort the top-200 items by similarity to the user-specified emotions; Diversified the above sorted items by the user-unspecified emotions

Procedure


1
Introduction & Consent
2
Personal Characteristics
3
Instructions
R
4
Preference Elicitation
Experimental Conditions (C1 – C8)
5
Movies you may like
Interact with Recommendations
Refine Recommendations
Choose One Movie to Watch
6
Post-study Survey


Movie Recommender Study
1
2
3
4
5
Indicate your preferences
Use the blue button on the right to scroll through the gallery of movies and rate at least 10 movies that you have already watched. Once you have rated 10 movies, the system will be able to give you recommendations. Keep in mind, you can click on the blue button on the right to get more movies to rate!
The Pagemaster (1994)
Kingpin (1996)
His Girl Friday (1940)
The Parent Trap (1961)
Stripes (1981)
Police Academy 3: Back in Training (1986)
Ravenous (1999)
A Hard Day's Night (1964)
Backdraft (1991)
The Man from Laramie (1955)
Ladyhawke (1985)
Coming Home (1978)
In the Mood for Love (2000)
Waking Life (2001)
All or Nothing (2002)
Ranked Movies: 1 of 10
Next

Please hang on while we find the recommendations for you.

1. Among the movies in your system, we recommend these 7 diverse movies for you (we predict movies based on your ratings and diverse them in terms of the following emotions: joy, trust, fear, surprise, surprise, sadness, disgust, anger, and anticipation.)

2. You can hover over movies to see a preview of the poster, a short synopsis, and a radar graph depicting the movie's emotional feature in 8 emotions.

3. You can specify your preference of movies from the perspective of movie emotions in the following panel. Please adjust the emotion strength indicators bellow so we could fine-tune the recommendations for you.

Your taste on movie emotions

	Low	High	Diverse
Joy			■
Trust		■	
Fear			
Surprise	■		
Sadness			
Disgust			
Anger			
Anticipation			

Reset Enter

Diverse movies


1. First Knight (1995)


2. Dead Man Walking (1995)


3. Father of the Bride Part II (1995)


4. Natural Born Killers (1994)


5. It Could Happen to You (1994)


6. The Truth About Cats & Dogs (1996)


7. Murder in the First (1995)


8. Toy Story (1995)


9. Just Cause (1995)


10. Lawnmower Man 2: Beyond Cyberspace (1996)

First Knight

Lancelot falls in love with Guinevere, who is due to be married to King Arthur. Meanwhile, a violent warlord tries to seize power from Arthur and his Knights of the Round

Emotions

Joy	■
Trust	■
Fear	■
Surprise	■
Sadness	■
Disgust	■
Anger	■
Anticipation	■

Next

1. Among the movies in your system, we recommend these 7 diverse movies for you (we predict movies based on your ratings and diverse them in terms of the following emotions: joy, trust, fear, surprise, surprise, sadness, disgust, anger, and anticipation.)

2. You can hover over movies to see a preview of the poster, a short synopsis, and a radar graph depicting the movie's emotional feature in 8 emotions.

3. You can specify your preference of movies from the perspective of movie emotions in the following panel. Please adjust the emotion strength indicators bellow so we could fine-tune the recommendations for you.

Your taste on movie emotions

	Low	High	Diverse
Joy			●
Trust		●	
Fear			●
Surprise	●		
Sadness			●
Disgust			●
Anger			●
Anticipation			●

Reset

Enter

Diverse movies


1. First Knight (1995)


2. Dead Man Walking (1995)


3. Father of the Bride Part II (1995)


4. Natural Born Killers (1994)


5. It Could Happen to You (1994)


6. The Truth About Cats & Dogs (1996)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8. Toy Story (1995)


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First Knight

Lancelot falls in love with Guinevere, who is due to be married to King Arthur. Meanwhile, a violent warlord tries to seize power from Arthur and his Knights of the Round

Emotions

Next

1. Among the movies in your system, we recommend these 7 diverse movies for you (we predict movies based on your ratings and diverse them in terms of the following emotions: joy, trust, fear, surprise, surprise, sadness, disgust, anger, and anticipation.)

2. You can hover over movies to see a preview of the poster, a short synopsis, and a radar graph depicting the movie's emotional feature in 8 emotions.

3. You can specify your preference of movies from the perspective of movie emotions in the following panel. Please adjust the emotion strength indicators bellow so we could fine-tune the recommendations for you.

Your taste on movie emotions

	Low	High	Diverse
Joy			■
Trust		■	
Fear			
Surprise	■		
Sadness			
Disgust			
Anger			
Anticipation			

Reset

Enter

Diverse movies


1. First Knight (1995)


2. Dead Man Walking (1995)


3. Father of the Bride Part II (1995)


4. Natural Born Killers (1994)


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First Knight

Lancelot falls in love with Guinevere, who is due to be married to King Arthur. Meanwhile, a violent warlord tries to seize power from Arthur and his Knights of the Round

Emotions

Joy	■
Trust	■
Fear	■
Surprise	■
Sadness	■
Disgust	■
Anger	■
Anticipation	■

Next

1. These are your final recommendations, please select one movie that you would like to watch right now if you could.

Your taste on movie emotions

	Low	High	Diverse
Joy			●
Trust		●	
Fear			
Surprise	●		
Sadness			
Disgust			
Anger			
Anticipation			

Reset Enter

Diverse movies

	1. First Knight (1995)	Choose
	2. Dead Man Walking (1995)	Choose
	3. Father of the Bride Part II (1995)	Choose
	4. Natural Born Killers (1994)	Choose
	5. It Could Happen to You (1994)	Choose
	6. The Truth About Cats & Dogs (1996)	Choose
	7. Murder in the First (1995)	Choose
	8. Toy Story (1995)	Choose
	9. Just Cause (1995)	Choose
	10. Lawnmower Man 2: Beyond Cyberspace (1996)	Choose

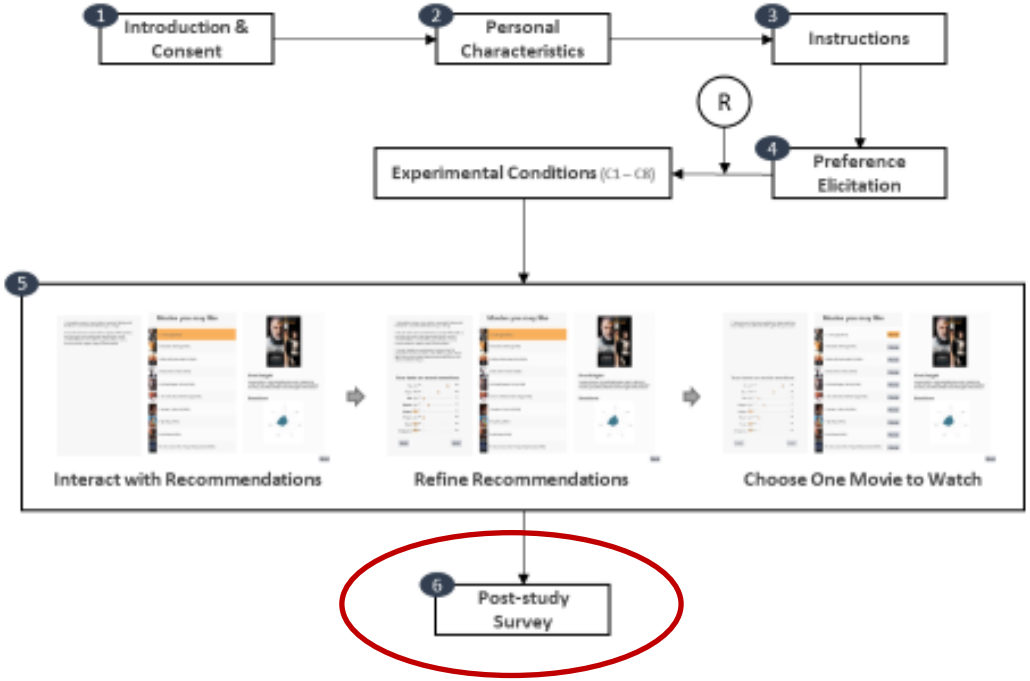
First Knight

Lancelot falls in love with Guinevere, who is due to be married to King Arthur. Meanwhile, a violent warlord tries to seize power from Arthur and his Knights of the Round

Emotions

Joy	●
Trust	●
Fear	●
Surprise	●
Sadness	●
Disgust	●
Anger	●
Anticipation	●

Next


1
Introduction & Consent
2
Personal Characteristics
3
Instructions
R
4
Preference Elicitation
Experimental Conditions (C1 – C8)
5
Interact with Recommendations
Refine Recommendations
Choose One Movie to Watch
6
Post-study Survey

Participants

- 400 participants
- 15 minutes

Measurement Scales

Pre-study survey:

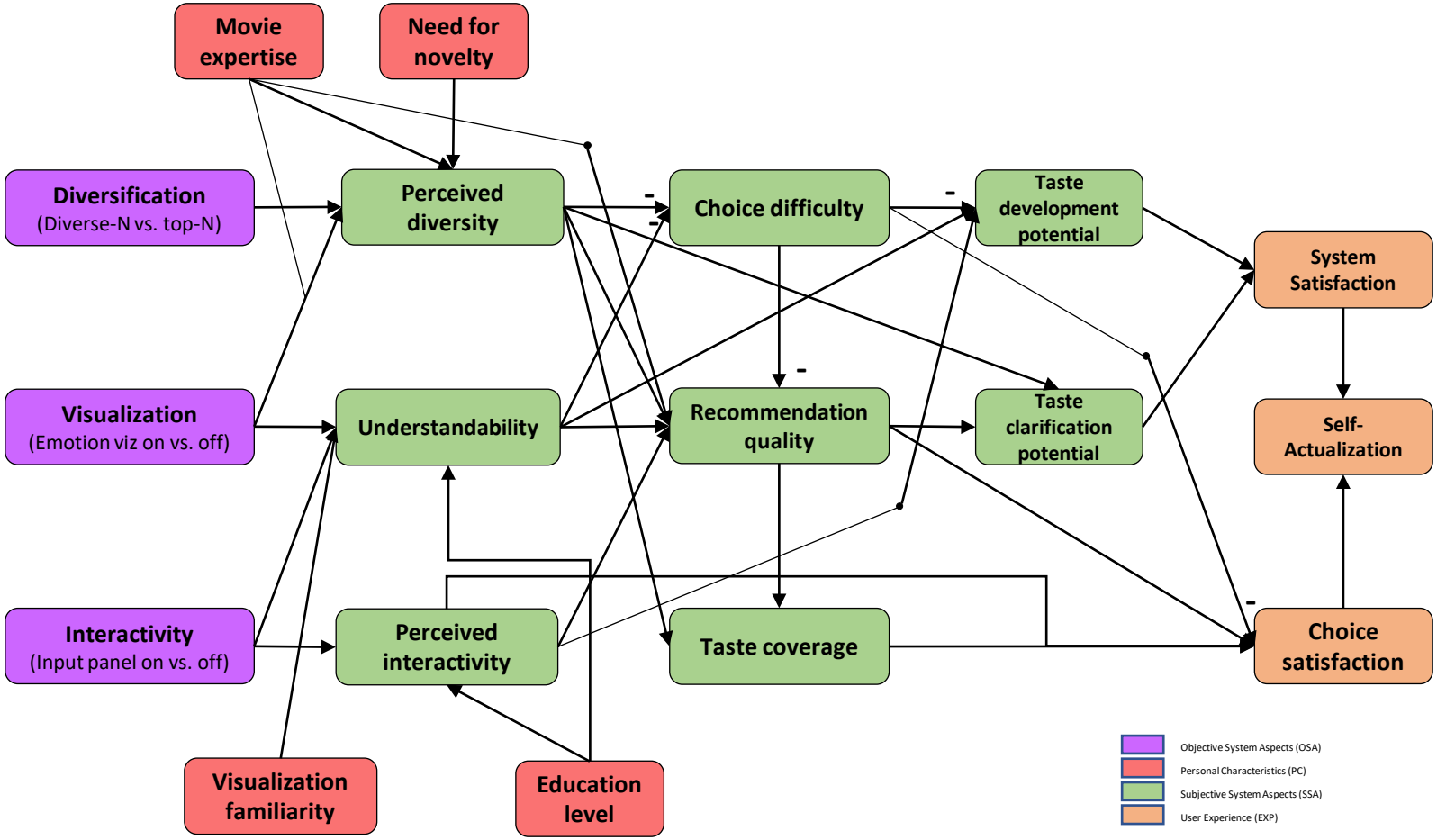
- Movie expertise (4)
- Need for novelty (6)
- Visualization familiarity (6)
- Education level

Post-study survey:

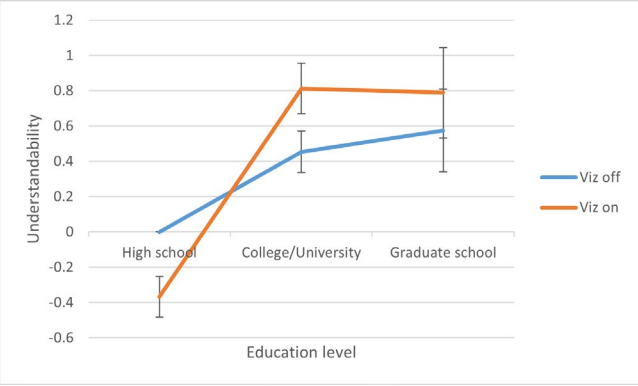
- Perceived diversity (6)
- Understandability (5)
- Perceived interactivity (6)
- Choice difficulty (5)
- Recommendation quality (6)
- Taste coverage (7)

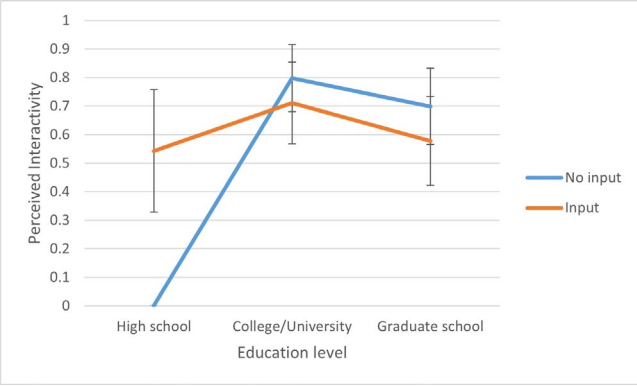
Post-study survey:

- Taste development potential (6)
- Taste clarification potential (5)
- Choice satisfaction (7)
- System satisfaction (7)
- Self-Actualization (5)

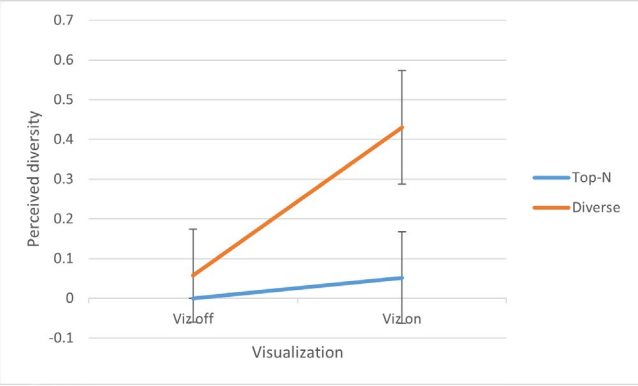

Movie expertise
Need for novelty
Diversification (Diverse-N vs. top-N)
Perceived diversity
Choice difficulty
Taste development potential
System Satisfaction
Visualization (Emotion viz on vs. off)
Understandability
Recommendation quality
Taste clarification potential
Self-Actualization
Interactivity (Input panel on vs. off)
Perceived interactivity
Taste coverage
Choice satisfaction
Visualization familiarity
Education level
Objective System Aspects (OSA)
Personal Characteristics (PC)
Subjective System Aspects (SSA)
User Experience (EXP)

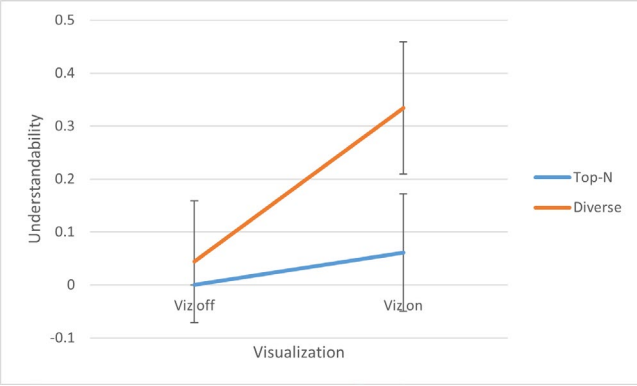
Anticipated Interaction Effects



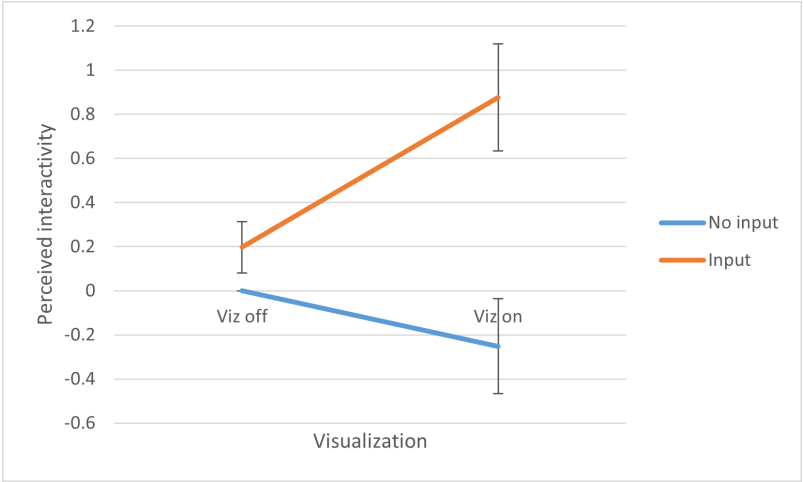


Anticipated Interaction Effects

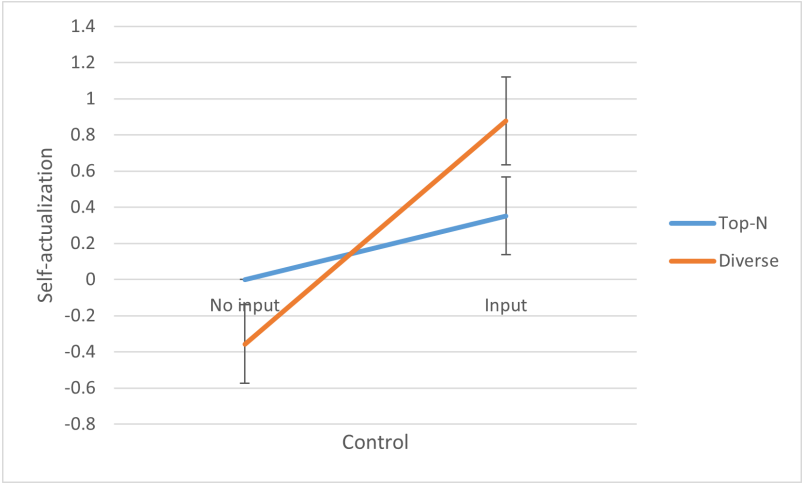




Anticipated Interaction Effects



Anticipated Interaction Effects



Novelty of the Proposed Work

- Combine diversification, justification, and interactivity
- Supporting them in exploring and understanding their unique personal taste
- A potential solution to the “filter bubble” problem