MAI4CAREU

Master programmes in Artificial Intelligence 4 Careers in Europe

University of Cyprus

HUMAN-CENTERED INTELLIGENT USER INTERFACES - MAI648

Marios Belk

2022

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CONTENT 5

Affective Computing

CONTENTS

- Introduction to Affective Computing
- Human Emotions
- Theories of Human Emotions
- Sentiment Analysis
- How to Elicit Human Emotions

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Learning Outcomes

- Understand the main principles of affective computing
- Know the underlying theories of human emotions
- List the characteristics of models in affective computing

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- *“if we want our computers to be really smart, to adapt to us as users, and to interact of course with us, then they must develop the ability to recognize and express emotions, to have empathy, and have what is called ‘emotional intelligence’ ” (Picard 2000)*

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- Norman (2004) argued that in order for media to communicate better with people they need to be able to understand our emotions and in order to do that they need to have emotions as well

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What is Affective Computing?

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What is Affective Computing

- *“Affective computing is the study and development of systems and devices that can recognize, interpret, process, and simulate human affects. It is an interdisciplinary field spanning computer science, psychology, and cognitive science.” - Wikipedia*

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What is Affective Computing

- *“Modern branch of computer science originated with Rosalind Picard’s 1995 paper on affective computing and her book Affective Computing published by MIT Press. One of the motivations for the research is the ability to give machines emotional intelligence, including to simulate empathy. The machine should interpret the emotional state of humans and adapt its behavior to them, giving an appropriate response to those emotions.” - Wikipedia*

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What is Affect?

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What is Affect in Affective Computing

“affect” refers to **emotion** and **“related phenomena”**:

- Emotions (e.g., angry, sad, joyful, fearful)
- Moods (e.g., cheerful, irritable, depressed)
- Interpersonal stances (e.g., distant, cold, warm, supportive)
- Preferences/Attitudes/Sentiment (e.g., liking, loving, hating)
- Personality (e.g., nervous, anxious, reckless, morose)
- Culture (e.g., Individualistic, Collectivist)

Notes from Jonathan Gratch, University of Southern California

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Why study emotions in computing?

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Growing interest in applying emotions in computing?

- **Behaviorism** (1850 - 1960)
  - Adaptation; Conditioning; Habits; Reinforcement; Extinction
- **Cognitivism** (1950 -)
  - Attention; Decision-making; Language; Memory; Perception
- **Affectivism** (2000 -)
  - Emotion; Empathy; Motivation; Stress; Well-being

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Relevant reading: Dukes et al., Rise of Affectivism, Nature Human Behavior vol 5, 2021

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Interest from the research community

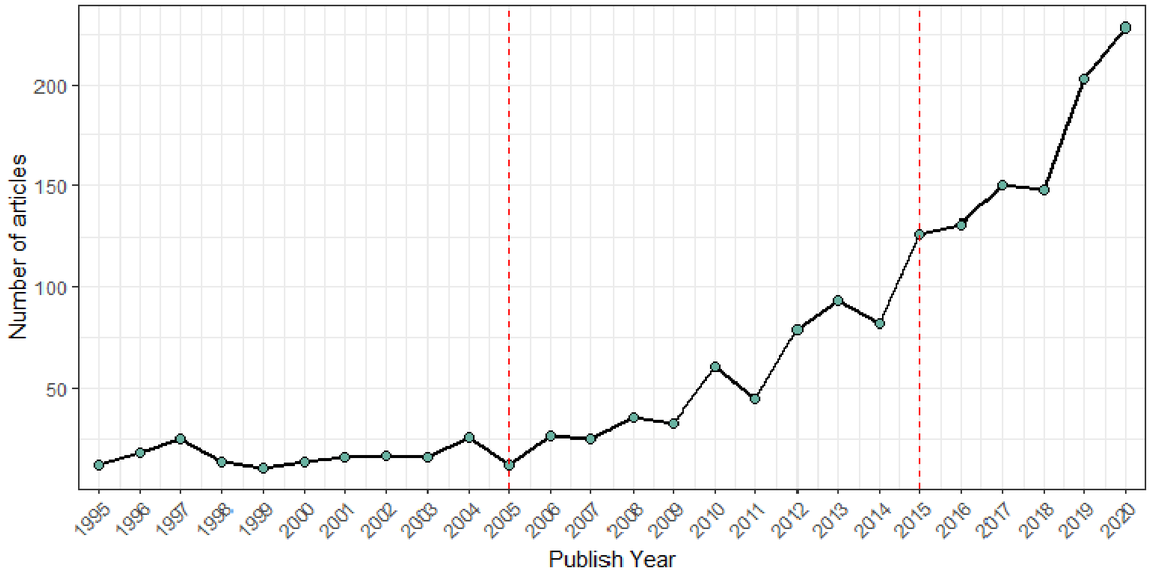

Figure 1: Annual scientific production on "affective computing", 1995-2020 (Source: Web of Science)

Source: Manh-Tung Ho et al. Affective computing at the edge: A bibliometric analysis of the period 1995-2020 - https://www.researchgate.net/publication/350409400_Affective_computing_at_the_edge_A_bibliometric_analysis_of_the_period_1995-2020

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Affective Computing Journal

Source:
https://ieeexplore.ieee.org/xpl/RecentIssue.jsp?punumber=5165369

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Interest from the industry

- *"The global affective computing market size was valued at USD 20.23 billion in 2019 and is expected to grow at a **compound annual growth rate (CAGR) of 33.0% from 2020 to 2027**"* [Grand View Research]
- *"The global affective computing market size in the post-COVID-19 scenario is projected to grow from USD 28.6 billion in 2020 to **USD 140.0 billion by 2025**, at a CAGR of 37.4% during the forecast period"* [Markets and Markets]

Sources
https://www.grandviewresearch.com/industry-analysis/affective-computing-market
https://www.marketsandmarkets.com/Market-Reports/affective-computing-market-130730395.html

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Interest from the industry

Source: Secondary Research, Expert Interviews, and MarketsandMarkets Analysis

Sources
https://www.marketsandmarkets.com/Market-Reports/affective-computing-market-130730395.html

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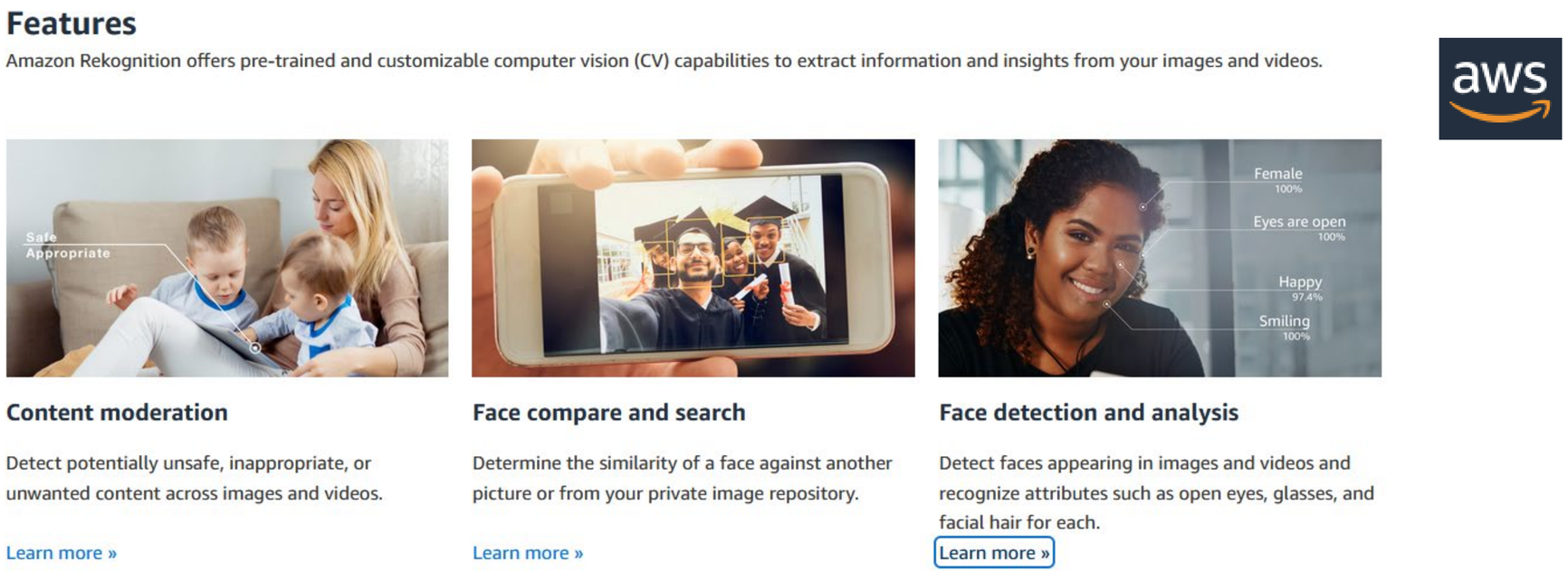
Interest from the industry



https://aws.amazon.com/rekognition

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World's Largest Companies in the Affective Computing Market: by Revenue

- Apple, Inc.
- Microsoft Corporation
- IBM
- Qualcomm
- Atos
- Palantir Technologies
- Affectiva
- CrowdEmotion
- Beyond Verbal
- Kairos AR

Source: https://www.emergenresearch.com/blog/top-10-leading-companies-operating-in-affective-computing-market

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Human Emotions

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Human Emotions

- States of feeling that affect human behavior

- Emotions can influence the rational processing
  - Preconceptions that are related to previous emotional experiences facilitate the efficient processing of knowledge and reasoning

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Human Emotions

- Research has shown that human cognitive factors affect the way individuals control their emotions
  - Humans with high working memory capacity control their emotions more naturally [Schmeichel and Demaree, 2010]
  - Emotion regulation indicates how individuals manage and experience unpleasant emotions

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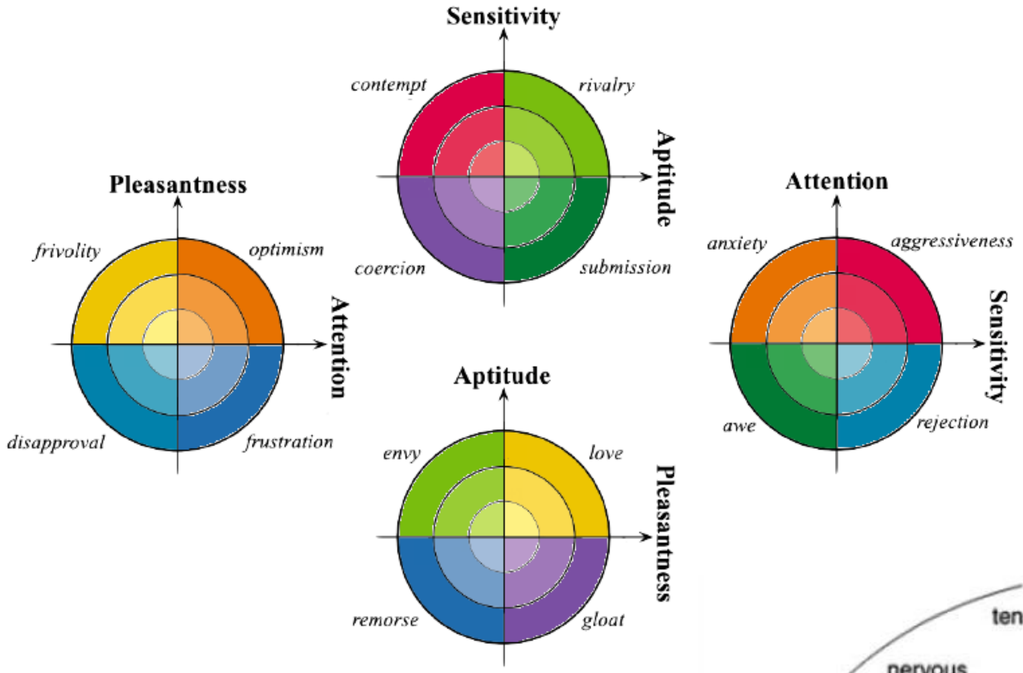
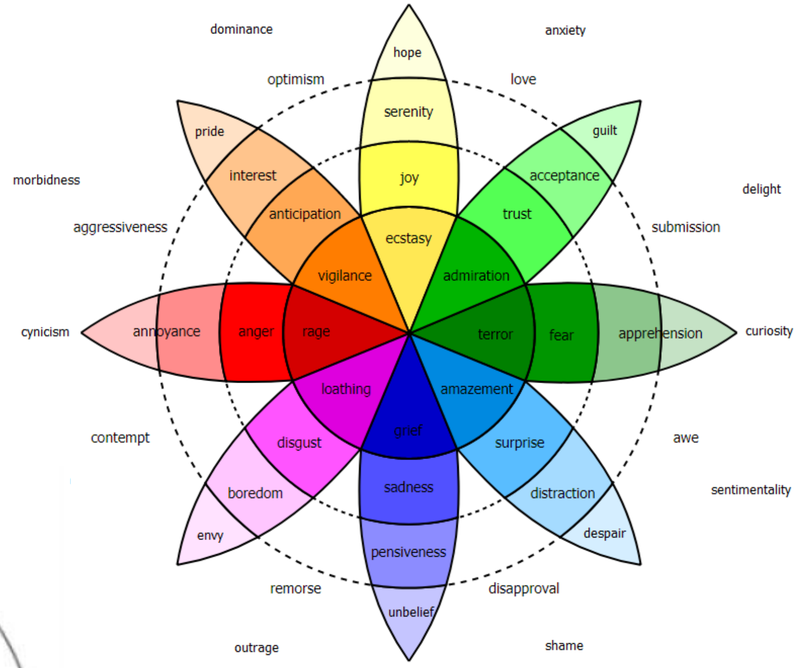
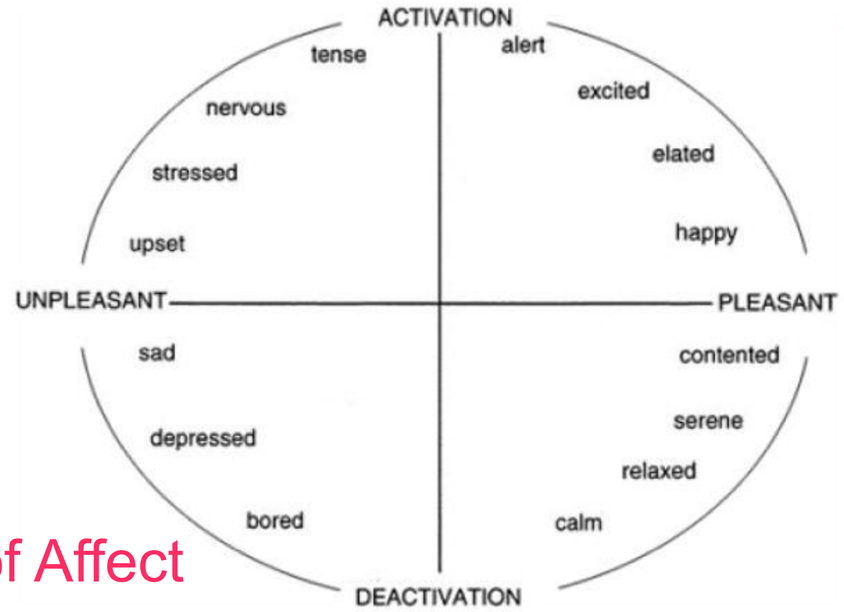
The Hourglass of Emotions





Plutchik's Wheel of Emotions



Circumplex Model of Affect

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No widely accepted theory on emotions

- Why?
- Differences of theories on components involved in emotion and process
- **Components of emotion:** Emphasize that emotion impacts various aspects
- **Phases of emotion:** Emphasizes that emotions have “stages”

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Components of emotion

- **Cognitive:** influences or influenced by thinking
- **Physiological:** related to hormones, heart beats, sweating
- **Expressive:** relates to facial expressions, posture, vocal features
- **Motivation:** relates to goals and drives
- **Feeling:** relates to conscious awareness being in an emotional state

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Phases of emotion

- **Low-level:** automatic reflexes
- **Hi-level:** deliberate, conscious evaluation
- Goal (re)prioritization
- Action evaluation / decision-making
- Behavior preparation
- Behavior execution / observable manifestation
- Communication with other

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Differences in emotion theories

- Theories emphasize on different aspects:
  - **Appraisal theories** emphasize cognitive antecedents of emotion
  - **Discrete emotion** theories emphasize physiological and expressive consequences of emotion
- In affective computing
  - emotion recognition techniques often draw upon discrete emotion theory and avoid appraisal models

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Emotional Processing

- How individuals process and control their emotions
- ***Emotion regulation:*** the way in which individuals perceive and control their emotions
- ***Emotional arousal:*** the capacity of a human being to sense and experience specific emotional situations
- By combining the levels of anxiety with the moderating role of emotion regulation, it is possible to examine how affectional responses hamper or promote human-computer interactions

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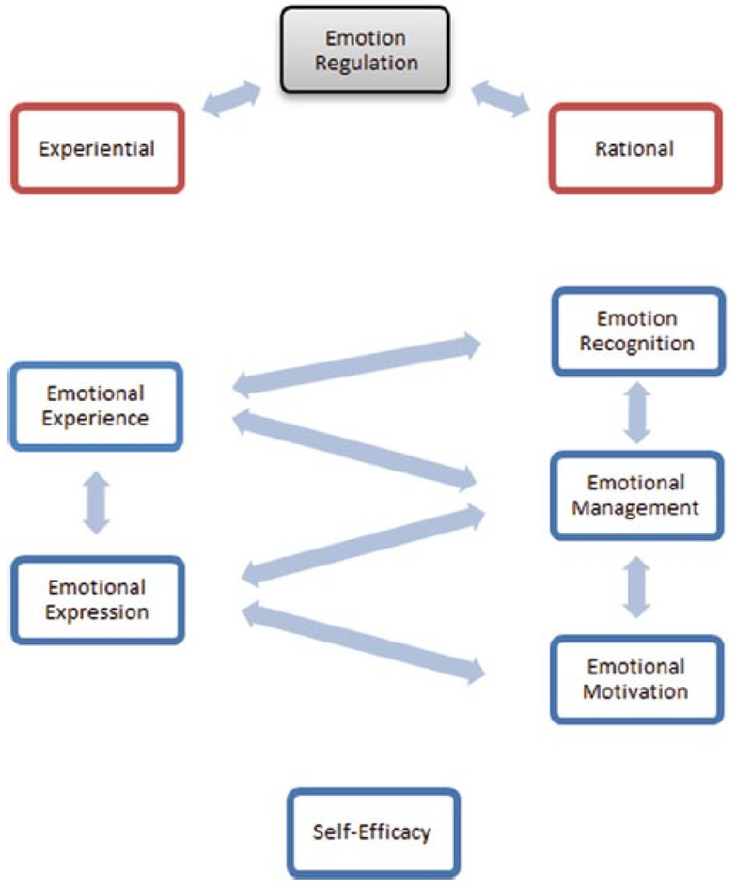
Emotion Regulation



The emotion regulation model (Lekkas et al. 2011a)

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The Experiential Level

- The actual emotional experience and emotional expression of the individual
  - the capacity of a human being to sense, experience and express emotional situations
  - the covert emotional condition that a human is experiencing as a result of a stimulus, while emotional expression is the overt reaction of such a stimulus, the behavior that follows the experience
- Emotional experience points more towards a stimulus event, and expression more towards the behavioral response

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The Experiential Level

- Studies date back to the 1870's (Darwin 1872)
  - Emotional experience, emotional expression and emotional arousal have been conceptualized as three primary components of emotion, with emotional reflection as a secondary component, involving thoughts about the three primary components

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The Experiential Level

- Expressive confidence involves the skillful production of situation-appropriate emotional expressions
  - Individuals high in expressive confidence have been found to be in good control of their emotions, as well as experiencing and expressing positive emotions with family and peers
  - Individuals high in negative expression are more likely to experience and express negative emotions, possibly with the consequence that they are less well liked

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Emotion Regulation

- Emotion regulation is not so much concerned about whether emotional expression is right or wrong but more with what mechanisms underlies successful and unsuccessful processing
- Failure to express emotions may be integrally related to failure to properly process an emotional event
- However, this is only one important part within a more complex process, as emotion regulation is regarded as the overall concept within which, emotional expression simply constitutes the final stage

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The Rational Level

- The multiple ways with which the individual recognizes and manages emotions
  - Emotion recognition
  - Emotional management
  - Emotional motivation
- Three (out of five) scales that comprise the emotional intelligence construct which has been introduced based on the research conducted by Goleman (1995)
  - the ability to recognize our own emotions and those of others, to motivate ourselves and to properly manage our emotions in our relations
  - the ability to assess, manage and express our emotions (and those of others) and the ability to make use of them

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Emotional Intelligence

- Emotional intelligence is believed by many to be a personality trait that is related to performance (Lyons and Schneider; Newsome et al. 2000; Day and Carroll 2004)

- People with high emotional intelligence, perform better both at work (e.g., interviews, management, academic issues, to groups and cognitive tasks) and in the various activities of daily living

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Interaction between Experiential and Rational

- If someone during the stage of emotion recognition realizes intuitively that the emotion that is about to be triggered will have a negative and unpleasant emotional experience as an outcome, then it will be implicitly transformed to a different emotion so that it will be easily manageable in the next stage
- The human brain prioritizes based on the principles of self-regulation and not on the search of objectivity and truthfulness
- Self-efficacy: People's beliefs about their capabilities to produce and perform (Bandura 1997). These beliefs determine how people feel, think, motivate themselves and behave

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Emotional Arousal

- The capacity of a human being to sense and experience specific emotional situations
- Russell's Circumplex Model of Affect (Russell 1980): all affective states arise from two fundamental neurophysiological systems
  - Valence: a pleasure–displeasure continuum
  - Arousal: physiological and psychological state of being awoken

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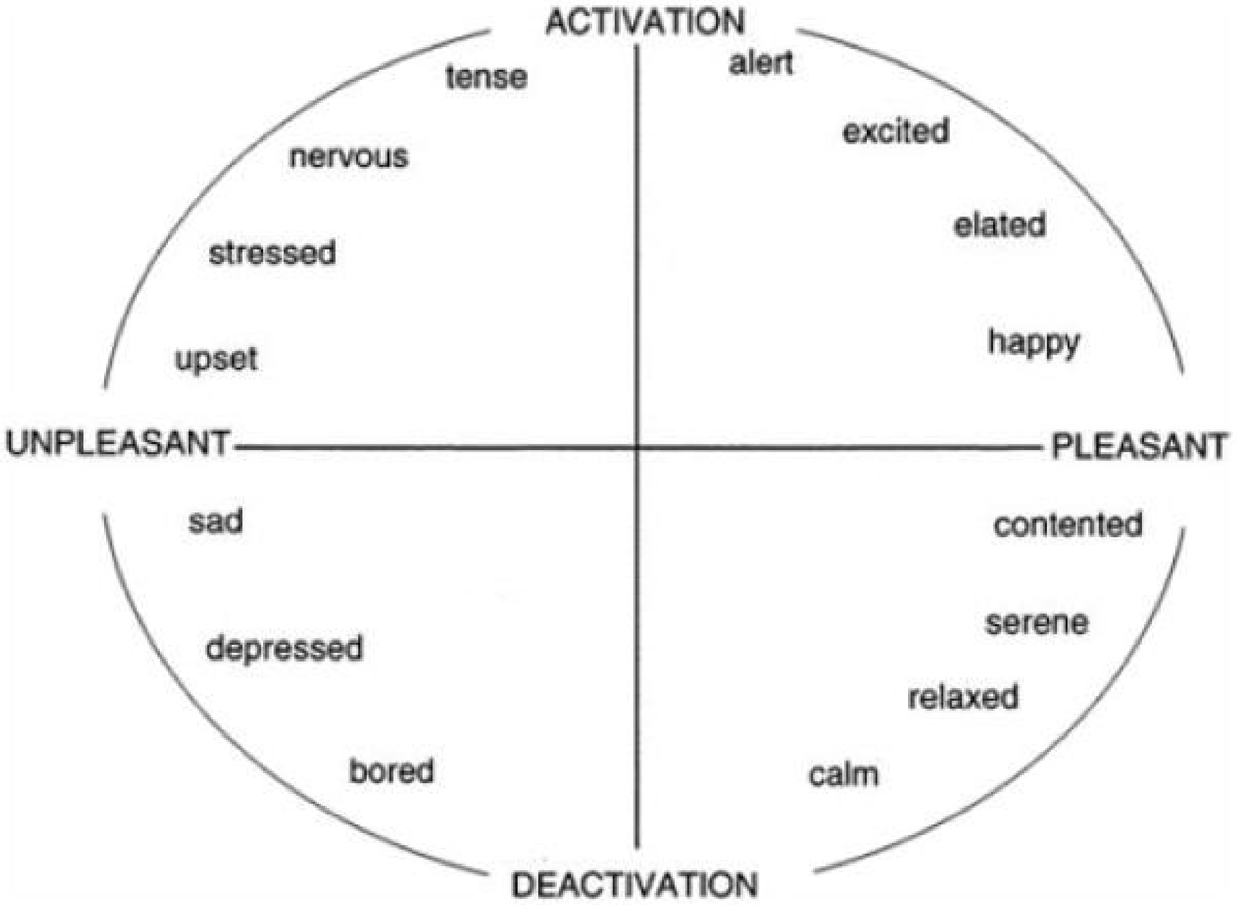
Circumplex Model of Affect



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Dual Process theories of emotion

- *In Thinking, Fast and Slow, a 2011 book by Daniel Kahneman*

- **Emotion** (System 1)
  - Parallel
  - Associative
  - Intuitive
- **Cognition** (System 2)
  - Sequential
  - Rule-based
  - Rational
- People have 2 modes of thinking
  - “Rational”
  - “Emotional”

Notes from Jonathan Gratch, University of Southern California

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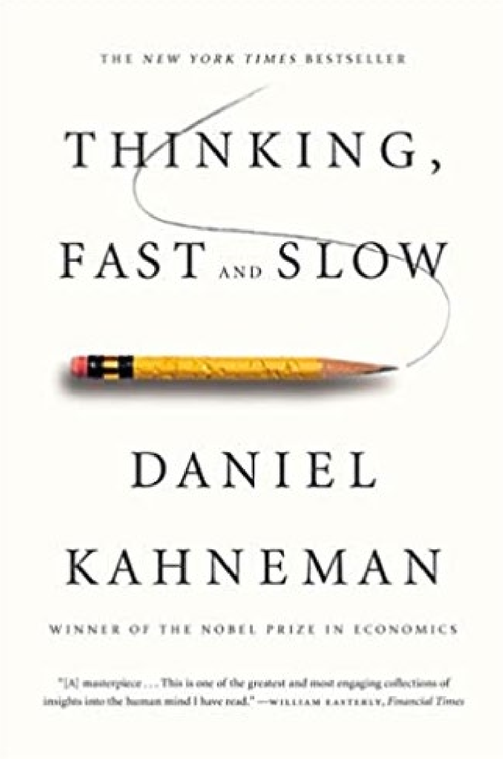
Thinking, Fast and Slow

- *The book's main thesis is that of a dichotomy between two modes of thought: "System 1" is fast, instinctive and emotional; "System 2" is slower, more deliberative, and more logical. - Wikipedia*



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Persuasive Technologies

- Technologies that are designed to influence the behavior of users

- Popular examples include persuasive technologies
  - personalize the care of patients [Elton, 2007]
  - motivate healthier life styles [Consolvo et al., 2009]
  - encourage social interaction [Vargheese et al., 2016]
  - promote safe driving behavior [Bergmans and Shahid, 2012]
  - promote global peace [Stanford Persuasive Tech Lab, 2017]

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Scenario

- **User:** Depressed and reluctant to take his daily walk outside in the park
- **Cognitive Assistant:**
  - Cold Cognition: Suggests to take a walk based on the medical needs of the user
  - Hot Cognition: Considering the emotional state of the user (depression), the system would suggest to stay indoors and carry on watching TV

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Scenario

- What is a good decision for the user?
  - To encourage him to go for a walk? or
  - To let him calm down thus missing the walk
- Which decision can be more persuasive?
  - not only quality but persuasive as well
- Possible arguments for persuasion
  - Go for a walk: "Staying in, you will miss your chance to meet your friends in the park“
  - Stay home: "Staying in will help you relax and you will be able to see your friends later in the night"

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Sentiment Analysis

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What is Sentiment Analysis?

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Sentiment Analysis

- *"Sentiment analysis (also known as **opinion mining** or **emotion AI**) is the use of natural language processing, text analysis, computational linguistics, and biometrics to systematically identify, extract, quantify, and study affective states and subjective information"* - Wikipedia

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Extract the option of people on a certain subject

- Movie ratings
- Voting
- Product reviews

- *“This movie was great!”*
- *“This TV series stars Cillian Murphy”*

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Why sentiment analysis?

- The Internet includes a huge amount of data that can be analyzed
- Extract knowledge on sentiment
- Helps automatically generating reviews, opinions of people on products, services, etc.

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Core fields in sentiment analysis

- Cognitive Sciences
- Artificial Intelligence, Machine Learning
- Natural Language Processing

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Main approaches for sentiment analysis

- Lexicon-based
- Machine learning
- Both

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Is sentiment analysis a text classification problem?

- *I really **liked** the movie!*
- *The movie is **unpredictable***
- When a drive the motorbike, its steering is **unpredictable**

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Challenges in sentiment analysis

- Sarcasm
- Negations
- Word ambiguity
- Multipolarity

Rudolf Eremyan. Four Pitfalls of Sentiment Analysis Accuracy
https://www.toptal.com/deep-learning/4-sentiment-analysis-accuracy-traps

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Sarcasm

- Sarcasm (noun): *"a sharp and often satirical or ironic utterance designed to cut or give pain"* - *https://www.merriam-webster.com/dictionary/sarcasm*
- Expressing **negative sentiments** using **positive words**
- Seen in social media comments, Facebook, Twitter
- Need to know the **context**

Rudolf Eremyan. Four Pitfalls of Sentiment Analysis Accuracy
https://www.toptal.com/deep-learning/4-sentiment-analysis-accuracy-traps

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Types of sarcasm

- **Propositional:** Sarcasm appears to be a non-sentiment proposition but has an implicit sentiment involved
- **Embedded:** Sarcasm has an embedded sentiment incongruity in the form of words and phrases themselves
- **Like-prefixed:** A like-phrase provides an implied denial of the argument being made
- **Illocutionary:** Non-speech acts (body language, gestures) contributing to the sarcasm

Elisabeth Camp (2011). Sarcasm, Pretense, and The Semantics/Pragmatics Distinction - https://doi.org/10.1111/j.1468-0068.2010.00822.x
Rudolf Eremyan. Four Pitfalls of Sentiment Analysis Accuracy https://www.toptal.com/deep-learning/4-sentiment-analysis-accuracy-traps

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Numeric sarcasm

- *This phone has an awesome battery back-up of 38 hours. (Non-sarcastic)*
- *This phone has an awesome battery back-up of 2 hours. (Sarcastic)*
- *This phone has a terrible battery back-up of 2 hours (Non-sarcastic)*

Lakshya Kumar, Arpan Somani, Pushpak Bhattacharyya (2017). "Having 2 hours to write a paper is fun!": Detecting Sarcasm in Numerical Portions of Text - https://arxiv.org/abs/1709.01950?context=cs

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CONTENT 5

Approaches to detect sarcasm

- Rule-based
- Statistical
- Machine learning
- Deep learning

Rudolf Eremyan. Four Pitfalls of Sentiment Analysis Accuracy
https://www.toptal.com/deep-learning/4-sentiment-analysis-accuracy-traps

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CONTENT 5

Negation

- Reversing the polarity of words, phrases, and sentences
- *“I did **not like** the movie” – negation word*
- *“I don’t really think this is a science fiction movie” – negation until the end of the sentence*

Rudolf Eremyan. Four Pitfalls of Sentiment Analysis Accuracy
https://www.toptal.com/deep-learning/4-sentiment-analysis-accuracy-traps

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CONTENT 5

Types of negation

- **Morphological:** denoted by a prefix (“dis-”, “non-”) or a suffix (“-less”)
- **Implicit:** Carrying a negative sentiment without using negative words
- **Explicit:** *“I did not like the movie”*

Maral Dadvar Claudia Hauff, Franciska de Jong Scope of Negation Detection in Sentiment Analysis
https://ris.utwente.nl/ws/files/5513521/DIR_Edited_version_27.pdf

Rudolf Eremyan. Four Pitfalls of Sentiment Analysis Accuracy
https://www.toptal.com/deep-learning/4-sentiment-analysis-accuracy-traps

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CONTENT 5

Detecting negation in sentences with AI

- Recurrent neural networks (RNNs)
- Long short-term memory models (LSTM)

Rudolf Eremyan. Four Pitfalls of Sentiment Analysis Accuracy
https://www.toptal.com/deep-learning/4-sentiment-analysis-accuracy-traps

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CONTENT 5

Word Ambiguity

- *The movie is **unpredictable***
- When a drive the motorbike, its steering is **unpredictable**

- Context is important

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CONTENT 5

Word Ambiguity

- Lexicon-based sentiment analysis approaches
- Opinion lexicon includes opinion words with polarity value
- Examples of public opinion lexicons:
  - SentiWordNet
  - General Inquirer
  - SenticNet
- Word polarity varies in different domains

Rudolf Eremyan. Four Pitfalls of Sentiment Analysis Accuracy
https://www.toptal.com/deep-learning/4-sentiment-analysis-accuracy-traps

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CONTENT 5

Multipolarity

- Multiple sentiments in a sentence
- Extract sentiment for each aspect/object in the sentence

- *“The movie was awesome, but I didn’t like the actor XYZ”*

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CONTENT 5

Lexicon-based approaches

- Most basic approach for sentiment analysis
- Using a dictionary or thesaurus
  - e.g., SentiWordNet lexicon

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CONTENT 5

SentiWordNet

- *"SentiWordNet is a lexical resource for **opinion mining**. SentiWordNet assigns to each synset of **WordNet** three sentiment scores: positivity, negativity, objectivity" - https://github.com/aesuli/SentiWordNet*

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CONTENT 5

WordNet

- *WordNet is a lexical database of semantic relations between words in more than 200 languages - Wikipedia*
- Semantic relations are know as ***synsets***
- Developed initially by the Cognitive Science Laboratory at Princeton University
  - https://wordnet.princeton.edu/
- Free to use
- Thesaurus, semantically accurate storing synonyms of words in ***contexts***

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CONTENT 5

SentiWordNet

- Every *synset s* is associated with
  - *Pos(s)*: positivity value (range between [0,1])
  - *Neg(s):* negativity value (range between [0,1])
  - *Obj(s):* objectivity (neutrality) value (range between [0,1])

- Pos(s) + Neg(s) + Obj(s) = 1

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CONTENT 5

SentiWordNet algorithm

- **Step 1.** Data preprocessing (remove stopwords, punctuation marks
- **Step 2.** Extract *parts of speech* for each word in the dictionaries
  - Parts of speech: Noun (n) Verb (v) Adjective (a) Adverb Preposition Conjunction Pronoun Interjection
- **Step 3.** Find polarity of each word using SentiWordNet functions
  - *pos_score(), neg_score(), obj_score()*

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CONTENT 5

Example

- *I disliked the movie* – a negative sentiment

With SentiWordNet:

- “Dislike” (verb): negativity score 0.5
- “I”, “the”: filtered out during preprocessing
- “Movie”: objectivity score is 1.0
- Sentiment is negative

Srishti Sharma. Sentiment Analysis Using the SentiWordNet Lexicon - https://srish6.medium.com/sentiment-analysis-using-the-sentiwordnet-lexicon-1a3d8d856a10

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CONTENT 5

Eliciting Human Emotions

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CONTENT 5

Methods of Extracting Emotions and Anxiety

- Physiological measurements for identifying users' emotional state by employing biometric sensors
- EEG analysis
- Facial expression analysis
- User interaction analysis
- Psychometric questionnaires

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CONTENT 5

Physiological Responses

- Galvanic skin response (also referred as skin conductance or electrodermal activity)
- Heart rate
- Heart rate variability: variation in the beat-to-beat interval
- Blood volume pulse

- Trending markets
  - Emotion Sensor and Mental Health Advisors: Recognize and track emotions, while providing real-time coaching to help you achieve your mental well-being goals

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CONTENT 5

Physiological Responses

MyFeel

https://www.myfeel.co

https://www.empatica.com

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CONTENT 5

Electroencephalography

- **Performance Metrics** – Elicitation of different cognitive states in real time – Excitement (Arousal), Interest (Valence), Stress (Frustration), Engagement/Boredom, Attention (Focus) and Meditation (Relaxation)

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CONTENT 5

Electroencephalography

Emotiv

https://www.emotiv.com

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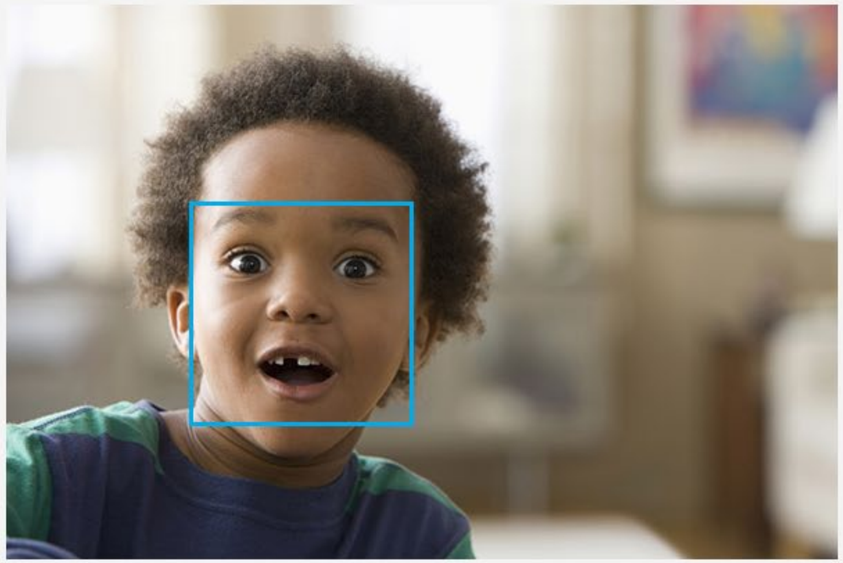
CONTENT 5

Facial Expression




```
Detection result:
1 faces detected

 JSON:
 [
  {
    "faceRectangle": {
      "top": 141,
      "left": 130,
      "width": 162,
      "height": 162
    },
    "scores": {
      "anger": 9.29041E-06,
      "contempt": 0.000118981574,
      "disgust": 3.15619363E-05,
      "fear": 0.000589638,
      "happiness": 0.06630674,
      "neutral": 0.00555004273,
      "sadness": 7.44669524E-06,
      "surprise": 0.9273863
    }
  }
]
```


https://azure.microsoft.com/en-us/services/cognitive-services/#overview

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CONTENT 5

User Interaction Analysis

- Elicit human emotions through user interaction with a system

- Examples include
  - Key-stroke analysis
  - Pressure-sensing mouse
  - Computer mouse movement efficiency

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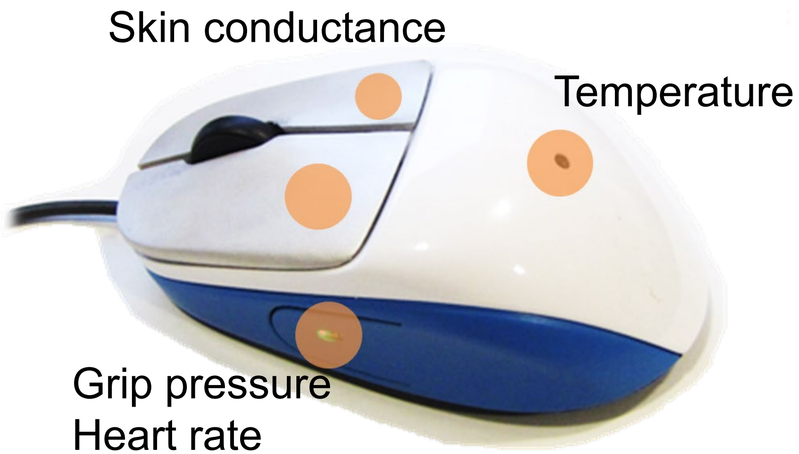
CONTENT 5

User Interaction Analysis

- CogniWin – Intelligent Mouse
  - An in-house developed intelligent computer mouse to extract human emotions based on real-time computer mouse movement analysis and physiological sensors embedded in the mouse



CogniWin – Cognitive Support for Older Adults at Work. Funded by the EU Active and Assisted Living Programme

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CONTENT 5

Questionnaires

- Beck Anxiety Inventory: an accredited anxiety inventory with a focus on somatic symptoms of anxiety, aiming to elicit symptoms such as nervousness, dizziness, inability to relax, etc.
- Depression Anxiety and Stress Scale: a 42-item self-report questionnaire which measures the negative emotional states of depression, anxiety and stress

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CONTENT 5

Questionnaires

- Geriatric Anxiety Inventory: a validated instrument for anxiety that is specifically targeted on older adults
- Stait-Trait Anxiety Inventory: an accredited and widely used anxiety inventory
  - current state of anxiety, asking how respondents feel “right now”
  - anxiety proneness

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CONTENT 5

Sources and further readings

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- Rudolf Eremyan. Four Pitfalls of Sentiment Analysis Accuracy https://www.toptal.com/deep-learning/4-sentiment-analysis-accuracy-traps
- Germanakos, P., Belk, M. (2016). Human-Centred Web Adaptation and Personalization - From Theory to Practice. Human-Computer Interaction Series, Springer, doi: 10.1007/978-3-319-28050-9

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CONTENT 5

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- Srishti Sharma. Sentiment Analysis Using the SentiWordNet Lexicon - https://srish6.medium.com/sentiment-analysis-using-the-sentiwordnet-lexicon-1a3d8d856a10
- Jonathan Gratch, University of Southern California

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Thank you.

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