The underlying cognitive process of complex problem solving
Online vs Offline

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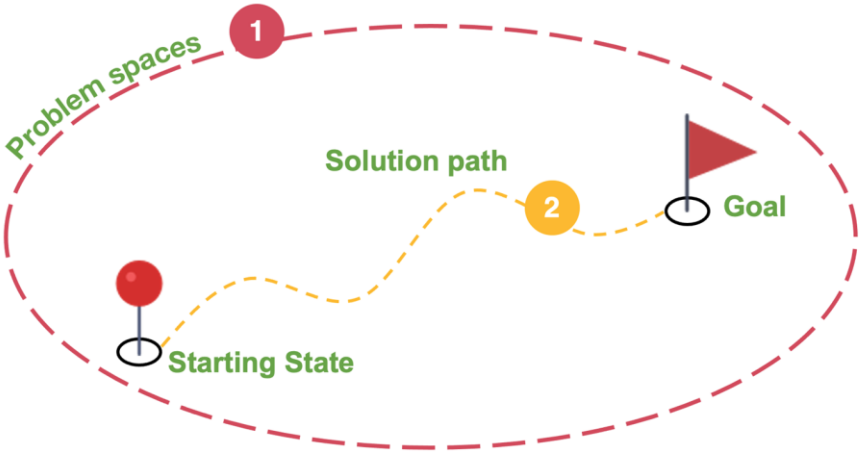
Introduction

Portrayal of Problem-solving

Newell and Simon (1972) proposed a framework for problem solving in which goals are achieved by movement through the **problem space**.

Within this framework different problem spaces are **mental representations** of different task environments.

- Interrelated components
- Decomposed into Subproblems
- Various cognitive operations



Wastes in Meetings

67000 hrs

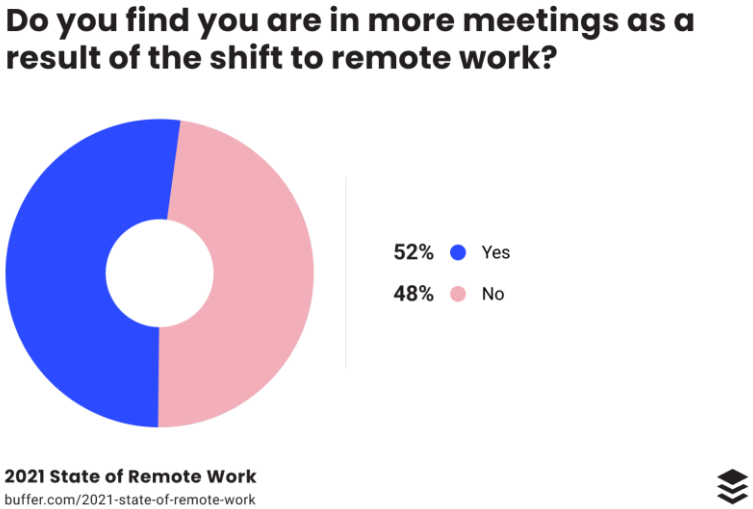
Of non effective meeting / year

50%

Caused by cognitive-related factors [1]

[1] Mosvick, R. K., & Nelson, R. B. (1987). We've got to start meeting like this: A guide to successful meeting management. Scott Foresman. https://books.google.co.jp/books?id=sDEUAQAAMAAJ

More meetings to avoid asynchronous communication



57.1% work remotely

For the companies in Tokyo [2]

[2] 東京都新型コロナウイルス感染症対策本部. (2021,January 22). テレワーク導入率調査結果（1501報）｜東京都. 東京都庁. https://www.metro.tokyo.lg.jp/tosei/hodohappyo/press/2021/01/22/17.html

Question about remote CPS discussion

Are the online problem-solving discussions the same as the ones offline?

Methodology

Type of Complex Problem

Time-related		
Time-dependent	Static	Dynamic
Decision making	Discrete	Continuous
Feedback interval	Delayed	Immediate

Participant-related		
Interaction type	Planning-based	Skill-based
Knowledge acquisition	Non Learning	Learning
Problem representation	Comprehension-based	Search-based

System behavior		
Information availability	Transparent	Opaque
Randomness	Deterministic	Stochastic

Problem features		
Variable values	Dichotomic	Continuous-value
Inter-correlation	Linear	Non Linear
Uniqueness	Well-defined	Ill-defined

Quesada, J., Kintsch, W., & Gomez, E. (2005). Complex problem-solving: A field in search of a definition? *Theoretical Issues in Ergonomics Science*, *6*(1), 5–33. https://doi.org/10.1080/14639220512331311553

Methodology

Overview

- Mixed method study
- Three questionnaires(n=63, 16, 16)
- Two experimental discussions
- Within-subjects design
- Experimental discussion in dyads

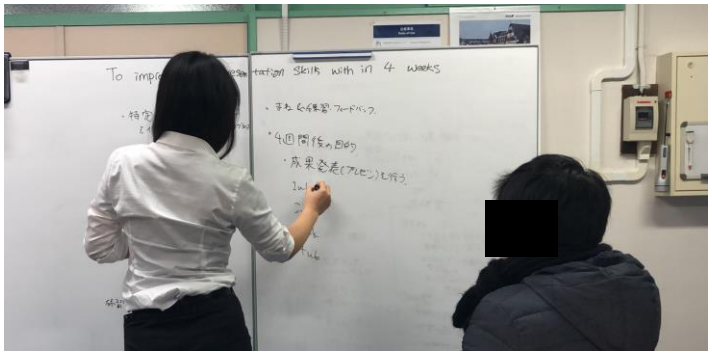
Participants

- 16 individuals
- Aged 20–32 years
- Chinese mandarin speakers (n=9), Taiwanese (n=3), Japanese (n=2), Malaysian (n=1), Norwegian (n=1)

Experimental discussion

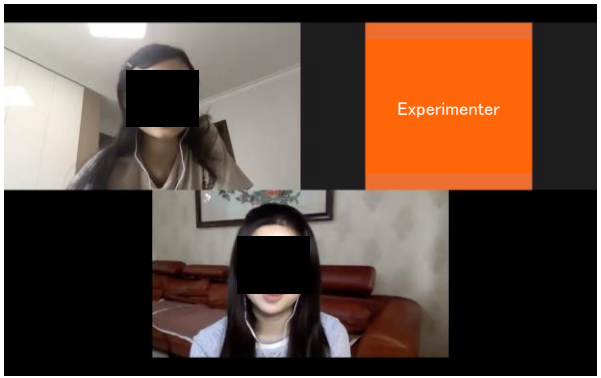
Offline settings

- Two-person group
- Native language
- 30-minute-duration
- Whiteboard to document information
- Experimenter presented in the same room



Online settings

- Two-person group
- Native language
- 30-minute-duration
- Google form to document information
- Experimenter presented in the same meeting with camera off



Coding Scheme

Source utterance

Memory

Episodic memory
Memory for 'temporally dated episodes or events, and the temporal-spatial relations.'

Semantic memory
A 'mental thesaurus" that provides "the memory necessary for the use of language'.

Cue

Self-directed cue
A cue, sometimes includes self-referent contents, tends to elicit information from the self.

Other-directed cue
A cue relies upon general, semantic, and gist-based information to elicit information from the discussion counterpart.

Other

Teamwork
Acknowledgment of the previous utterance.

Other
Off-topic conversation and non-lexical words.

Outcome utterance

Idea

Initial idea
An attempt of problem-solving at the finishing point of incubation.

Developed idea
An elaborated version based on the initial one.

Problem representation

Initial problem representation
A temporary cognitive structure that combines stable knowledge structures with short-term information.

Interpreter
A new encoding process that modifies the earlier problem representation:

- Elaboration
- Re-encoding
- Constraint relaxation

Information entropy per minute

In information theory, the entropy of a random variable is the average level of "information" inherent in the variable's possible outcomes.

Rare events are surprising and require more information to represent them than common events.

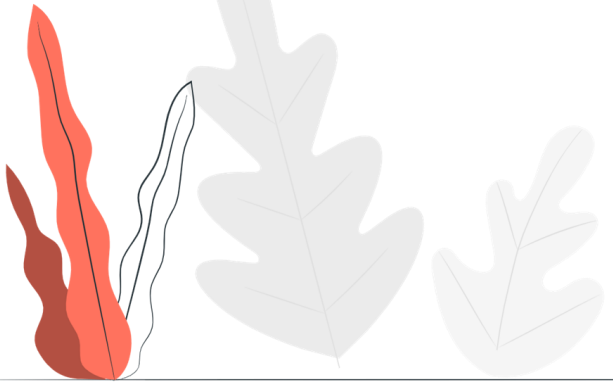
- **Low Probability Event (occurrence of an utterance)**: High Information (*surprising*).
- **High Probability Event (occurrence of an utterance)**: Low Information (*unsurprising*).

Entropy also represents the diversity of the contents.

$$\mathrm{H}(m) = -\sum_{i=1}^{n} P(u_i)\, log_e P(u_i)$$

Where,
H(m) = the information entropy per minute
ui = the i-th utterance type occurs in a minute

Results and discussion



Overview

15,866s

Audio sample duration

10s

Max. utterance duration

3.94s

Mean utterance duration

90%

Observer accuracy

2024

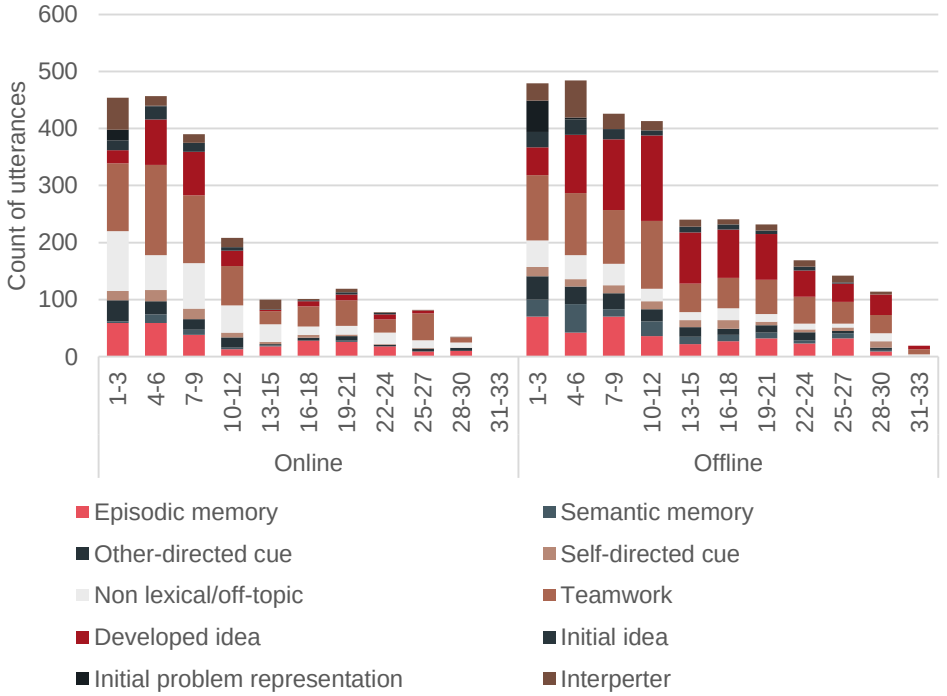
Online utterances

2959

Offline utterances

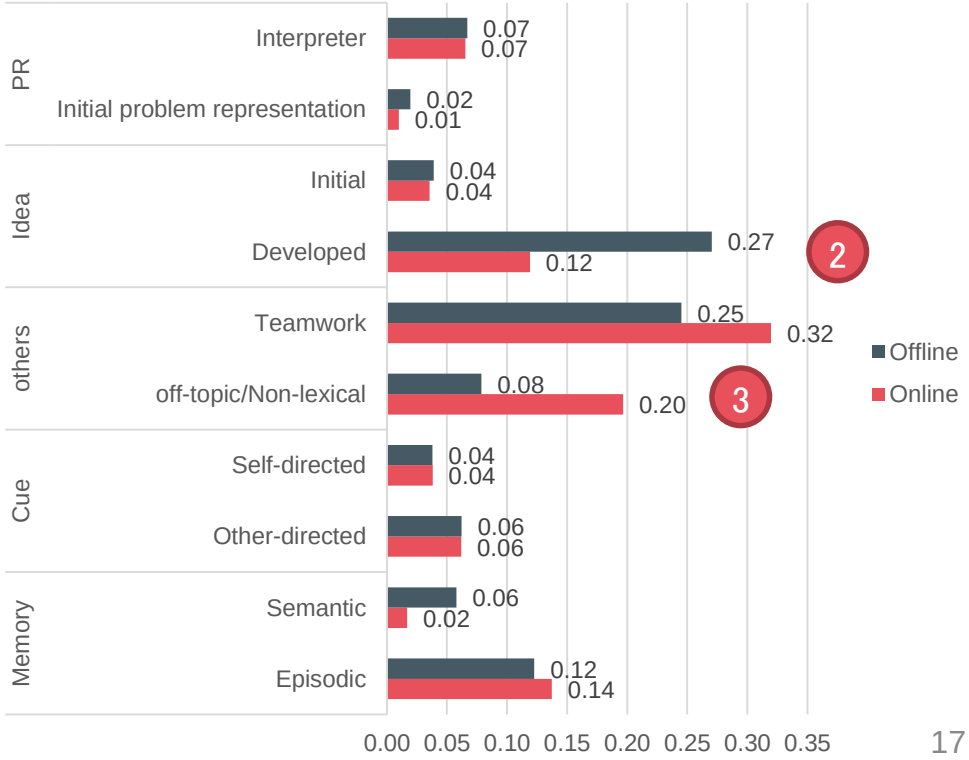
Count of utterance types per 3-minute

1. Participants talked less in online discussions
2. The amount of talking gradually reduced along discussions
3. Similar patterns were shown in both online and offline discussions



Ratio of utterance types

1. The discussion contents are dependent on meeting platforms (p-value: 3.13E-69)
2. More than twice as much of the speaking were used on idea development in offline meetings
3. There was 50% more off-topic utterances in the online discussions compared to the offline ones

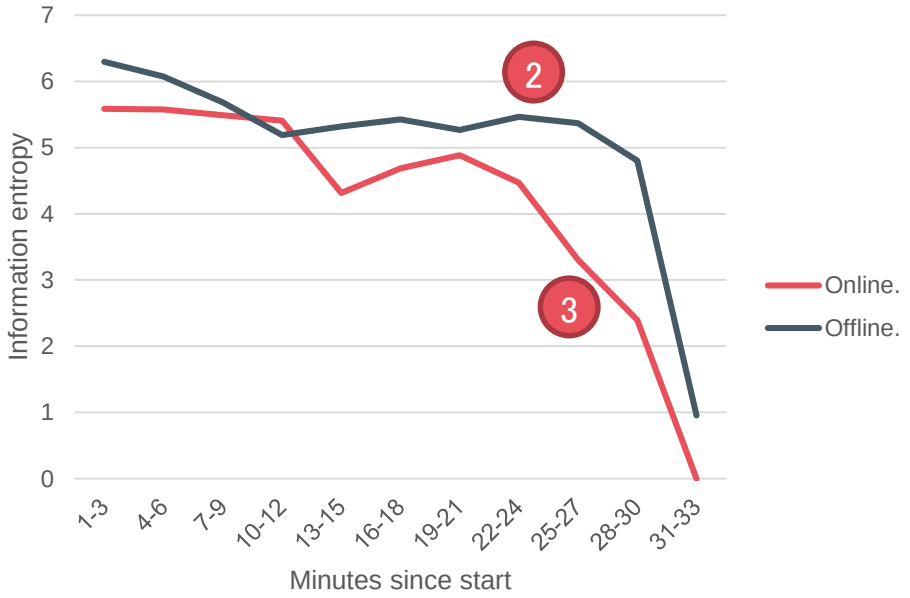


Information entropy per 3-minute

1. The online and offline information entropy had shown **similar trend** (correlation: .79, p-value: 5.91558E-08)

2. Online discussions generated less information compared to the ones offline

3. The contents in online discussions reduce faster than the ones offline



Conclusion

Conclusion

- To understand the differences in cognition between online and offline discussions
- The discussion contents are dependent on meeting platforms
- Participants talked less in online discussions
- The online and offline information entropy had shown similar trend
- Future research will focus on closing the gap between the two platforms

Thank you

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