Analogies as the Workhorse of Multidisciplinary Creativity and Problem Solving

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The challenges of doing interdisciplinary teamwork

• How will we uncover better ideas? (group think)

• How will we figure out which one is best? (confirmation bias)
My thesis:

Analogies provide support for divergence & convergence
What is analogy?

Analogy = accessing and transferring elements from familiar categories

1. Can be within or outside domain of problem
2. Factor in success of multidisciplinary teams (Dunbar, 1993)
3. Cognitive process (not just the source)
4. Creates inferences

Example in the context of engineering:
Analogy raised in designing an unsupported tube to transport liquid:
“the stuff you make Venetian blinds of for example... they can be bent.”
The Cognitive Science *In Vivo* approach to studying team problem solving

Science + Engineering Team video

Qualitative

Sampled, Transcribed, Coded line-by-line

Quantitative

Time-lagged, Hierarchical, (Poisson) statistical models

To address this question, a time-lagged logistic regression was employed; time lagged, because this analysis would estimate the change in concept generation probability at time $t$ and $t+1$ based on patterns of FAR ANALOGY use at time $t$, and logistic because the outcome variable was binary (i.e., did a designer generate a concept or not). This analysis assumed that (a) there was some baseline probability of a concept being generated in a given time slice and (b) a decrease in this probability as a function of the presence of a FAR ANALOGY in the current or previous time slice would suggest that the far analogies were reducing fluency of concept generation.

3.2. Methods

3.2.1. Creating blocks

The first step in the analysis was to segment the transcript into blocks for the time-lagged analysis. As similar trends were seen with block sizes of 10 and 5 lines in Study 1, and concepts were less rare than analogies, we selected a block size of five lines for this analysis to achieve a more favorable tradeoff between time window precision (estimating more immediate effects of FAR ANALOGY) and noise due to attrition (smaller time window leads to more attrition of measured phenomena). Sets of five consecutive lines were chunked to create separate blocks. When a coherent cluster of analogy utterances occurred that contained at least one far concept-generating analogy (here, as with Study 1, this included both concept generation and function-finding analogies), it was marked as its own block, beginning from the start to the end of the analogy cluster. Subsequent sets of five consecutive lines continued to be clustered into separate blocks, until the next cluster of FAR ANALOGY utterances began (see Fig. 2 for a visual summary of the block creation strategy). Analogy onsets and offsets were used as boundary markers for blocks because the focus is on estimating the effects of analogy, which should be most directly shown when closely time locked to analogies. Because of...
Part 1: Analogies in Divergent Processes

Knowledge → Analogies → Ideas
Analogies in Brainstorming

• Examined analogies & ideas produced during an engineering team’s brainstorming sessions (DTRS7)

• Analogies served many purposes:
  – solution generating
  – problem identifying
  – function finding
  – explanation

Analogies produce more ideas

Analogies produce more of similar ideas

Figure 1. Percentage of concepts at 5 distance from just prior cut-off points, presented for baseline and far analogy concepts, defined at the 5-line window.

The powerful effects of fixation

**Task:** Design a spill-proof coffee mug

![Diagram showing examples of plastic top and coffee](image)

Jansson & Smith (1991)
Even expert designers fixate

• Task: design low cost peanut sheller for Africa that uses no electricity
• Subjects: PhD engineers
• Conditions:
  — Control (just problem)
  — Fixation (mediocre gas-powered example)

Even expert designers fixate

Solutions from fixated person

Even expert designers fixate

But analogies can de-fixate!

De-fixation condition: Same example + Analogies

Hull, shuck, husk, clean a deer, clean a fish, soak, heat, roast, dissolve, pod, pitt, burr, ream, bark, skin, pare apples, deplume, peel

Part 2: Analogies in Convergent Processes

Uncertainty → Analogies → Conflict
Mars Exploration Rovers

- Highly novel and very successful science mission
- 2 solar powered rovers
- Daily commanding on Mars time
  - Mars day = Sol = 24hrs 39min
- Mission lifetime:
  - Nominal mission = 90 sols
The Mars Exploration Rover Case

- Large multidisciplinary science team: > 100 scientists, professors, graduate students

- Five “theme” groups:
  - Geology
  - Geochemistry
  - Soils
  - Atmospheres
  - Long Term Planning

Captured ~800 hours of video; sampled and coded ~10 hrs
• Within-domain
  – “That looks like everything we’ve been seeing so far in transition.”
  – “Yeah, it’s probably not going to look like these little spheroids, it’s going to look different.”

• Within-discipline
  – “You see now how they jump here across the rock, and all these, I don’t know if you’ve ever seen, like in caves or places where you get scalloping by water or something.”

• Outside discipline
  – “[brushing two spots] shouldn’t be a problem. Well, it’s just a question of it’s a chess game. What order do you do your move.”
Coding Uncertainty

– Search for hedge words (e.g., “I guess” “I think” “possibly” “maybe” “I believe”)
– Verify that meant as uncertainty using context
– Exhaustively double-coded (Kappa=.75)

– “Yea, well I mean, I don’t think that we can rule out that this isn’t some kind of desert varnish, although I don’t understand how desert varnish forms”
Analogies as a tool for resolving uncertainty in teams

Temporal Flow

Dosage Effects


Coding Conflict

– Task
  – Task planning conflict
    • “No, no, no, no. If you want to do the integration on the RAT, you’re going to do some additional brushing because you don’t want crap in the brushing in the gravel.”

  – Task science conflict
    • S2: “That’s the deepest granite.” S1: “no, this is the granite right there…”

– Process conflict
  • S2: “...It’s not a big deal to have some overlap.” S1: “Well, it is to Science... they want us to cite each others’ papers.”

– Relationship conflict: non-existent (on tape)
Analogy as a way of producing conflict in teams

Type of Analogies that produced Conflict

Analogy as a way of producing conflict in teams

Type of Conflict produced by Within-Discipline Analogies

Summary

Knowledge → Analogies → Ideas

Uncertainty → Analogies → Conflict
How we influence analogizing (moderately concrete inputs)

- Studied award-winning product development team in medical plastics
- Videotaped 7 product development meetings (conceptual design)

% of utterances with analogy

### Fewer Analogies with Prototypes

- **Idea**: 5%
- **Sketch**: 4%
- **Prototype**: 3%

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