A person is seated at a desk in a computer lab or office, working with multiple monitors. The person is wearing a light-colored long-sleeved shirt and is looking at the screens. The desk is cluttered with various pieces of technology, including keyboards, mice, and additional monitors. The background shows a typical office or classroom setting with a wall-mounted power outlet and some papers on the wall.

# Combining Gaze, Dialogue, and Action from a Collaborative Intelligent Tutoring System to Inform Student Learning Processes

Jennifer K. Olsen

# Adaptation and Personalization in Education

- Content
- Materials/Activities
- Feedback
- Difficulty

# Technology Platform: Intelligent Tutoring Systems (ITS)

Immediate feedback

On demand hints

Comparing Fractions

A **Let's compare fractions**

1 What is the least common denominator of the below fractions?

$\frac{3}{4}$   $\frac{5}{6}$   $\frac{1}{2}$   $\frac{2}{3}$   $\frac{3}{12}$

Hint

A common denominator for all the fractions is a number that can be divided by all the denominators.

← Previous Next →

# Multiple Social Levels in the Classroom



# Effective Support for Collaborative Learning

The image displays two side-by-side screenshots of a digital learning interface for 'Equivalent Fractions'. Both windows are titled 'Fraction Study Fall 2013 Collaborative Conceptual Student 1: Problem 1 of 1' and 'Student 2: Problem 1 of 1' respectively. The interface is light green with a blue header. The main content area contains a white box with the instruction: 'A Let's make some equivalent fractions.' Below this, there is a grey circle labeled 'This is the unit of the fractions.' and a purple circle divided into four quadrants, labeled 'The purple circle shows the fraction  $\frac{1}{4}$ '. A task instruction follows: '1 The fractions below are the same as the purple fraction. Make an equivalent fraction by cutting all of the sections into two equal pieces.' Below the instruction is a blue circle divided into four quadrants, with a red 'X' icon over the top-left quadrant. To the right of the main content is a yellow 'Hint' button with a question mark, and a white text input field with 'Previous' and 'Next' navigation buttons. The 'Student 1' window shows the 'Previous' button, while the 'Student 2' window shows both 'Previous' and 'Next' buttons.

Olsen, Belenky, Alevan, & Rummel, 2014; Olsen, Alevan, & Rummel, 2015; Olsen, Rummel, & Alevan, 2016

# Engaging with the system and each other



# What can eye-tracking tell us about collaboration?

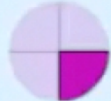
Home

Fraction Study 2013 Collaborative Conceptual Student 2: Problem 4 of 16

## Equivalent Fractions


**A** Let's compare fractions.

This is the unit of the fraction below.



The purple fraction shows  $\frac{1}{4}$

This is the unit of the fraction below.



The blue fraction shows  $\frac{1}{2}$

**B** Are the fractions equivalent?  
What do you think?

1 Please select the correct answer from each pair. Then discuss it with your partner based on both your answers and select a group answer.

- They have the same size parts.
- They have different size parts.
- They have the same numerators.
- They have different numerators.
- They have the same denominators.
- They have different denominators.
- They have the same unit.
- They have different units.
- They have the same amount.
- They have different amounts.

**?**  
Hint

← Previous      Next →

# What is the relation between eye gaze and other process data collected during the learning process?

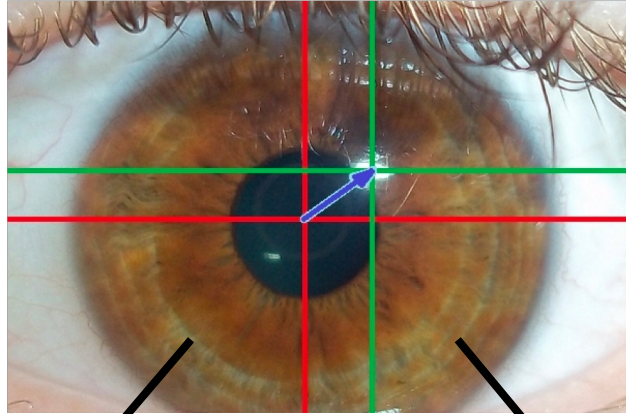
The screenshot shows an interactive learning interface titled "Equivalent Fractions". The main area contains three panels. The first panel shows a purple circle divided into four equal quadrants, with the fraction  $\frac{1}{4}$  next to it. The second panel shows a green circle divided into eight equal sectors, with the instruction "Make a fraction by cutting all of the sections into two equal pieces." and an "OK" button. The third panel shows a yellow circle divided into six equal sectors, with the instruction "Make a fraction by cutting all of the sections into three equal pieces." and an "OK" button. To the right of these panels is a yellow "Hint" button with a question mark icon. Below the hint button is a text input field with the question "How many total sections will there be if the total number of sections is tripled?". At the bottom of the interface are "Previous" and "Next" navigation buttons.

- 84 4<sup>th</sup> and 5<sup>th</sup> grade students, 26 collaborating pairs
- Students either worked on conceptually oriented problems or procedurally oriented problems, randomly assigned to condition
- Pull-out study
  - Sitting across the room communicating through Skype

Olsen, Sharma, Rummel, & Alevan, 2018



# Comparing Data Streams



Equivalent Fractions

A **Let's make some equivalent fractions.**

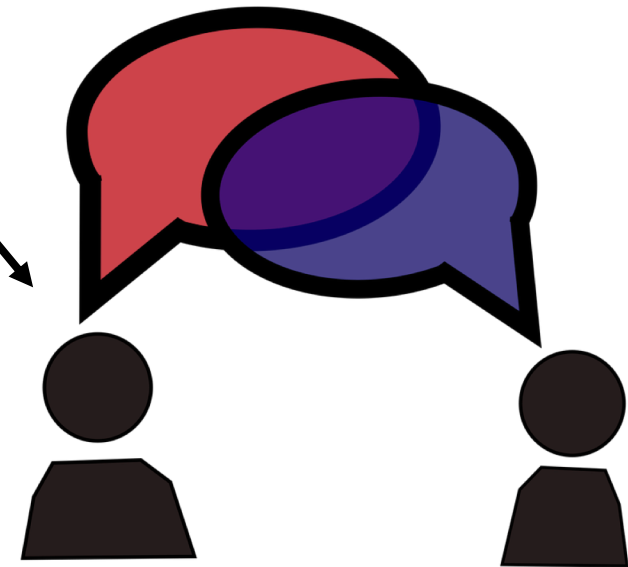
The purple circle shows the fraction:  $\frac{1}{4}$

Make a fraction by cutting all of the sections into two equal pieces.

Make a fraction by cutting all of the sections into three equal pieces.

**?**  
Hint

How many total sections will there be if the total number of sections is tripled?



# Dialogue

<b>Code</b>	<b>Description</b>
<b>Not Applicable</b>	The student engages in off-task behavior, converses with the experimenter, or vocalizations without any context.
<b>Acknowledgments</b>	The student acknowledges their partner, or they request acknowledgment or a repeat of what the partner has said.
<b>Read Out Loud</b>	The student is reading information provided within the problem and presented on the screen.
<b>Interface</b>	The student discusses actions that can be taken in the interface or engage in work coordination.
<b>Problem Solving</b>	The student is providing an answer to the problem or showing evidence of think aloud as they solve the problem.
<b>Concepts</b>	The student is adding information from outside of the problem or providing an explanation that goes beyond the required answer.
<b>Metacognitive</b>	The student verbally expressing their understanding of their current knowledge/problem solving state.


Kappa= 0.78

# Tutor Response


Equivalent Fractions

A **Let's make some equivalent fractions.**

The purple circle shows the fraction:



$$\frac{1}{4}$$

Make a fraction by cutting all of the sections into two equal pieces.



OK

Make a fraction by cutting all of the sections into three equal pieces.



OK

**?**  
Hint

How many total sections will there be if the total number of sections is tripled?

← Previous      Next →

Correct Feedback

Hint or Incorrect Feedback

Hints

# Eye Gaze: Focus (Individual)

Focus = inverse entropy

A	B	C	D	E
0.2	0.2	0.2	0.2	0.2
0	0	1	0	0

Focus = 0.14

Focus = 1



# Eye Gaze: Similarity (Collaborative)

Subject 1

A B C D E

0.4	0.2	0.1	0.1	0
-----	-----	-----	-----	---

Similarity = 1

Subject 2

A B C D E

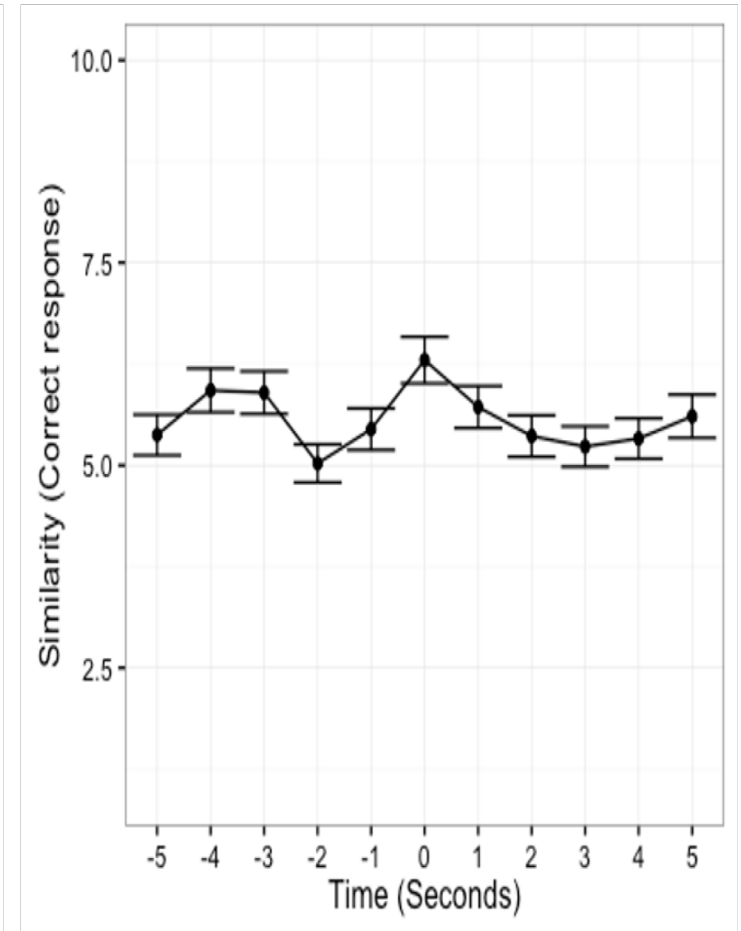
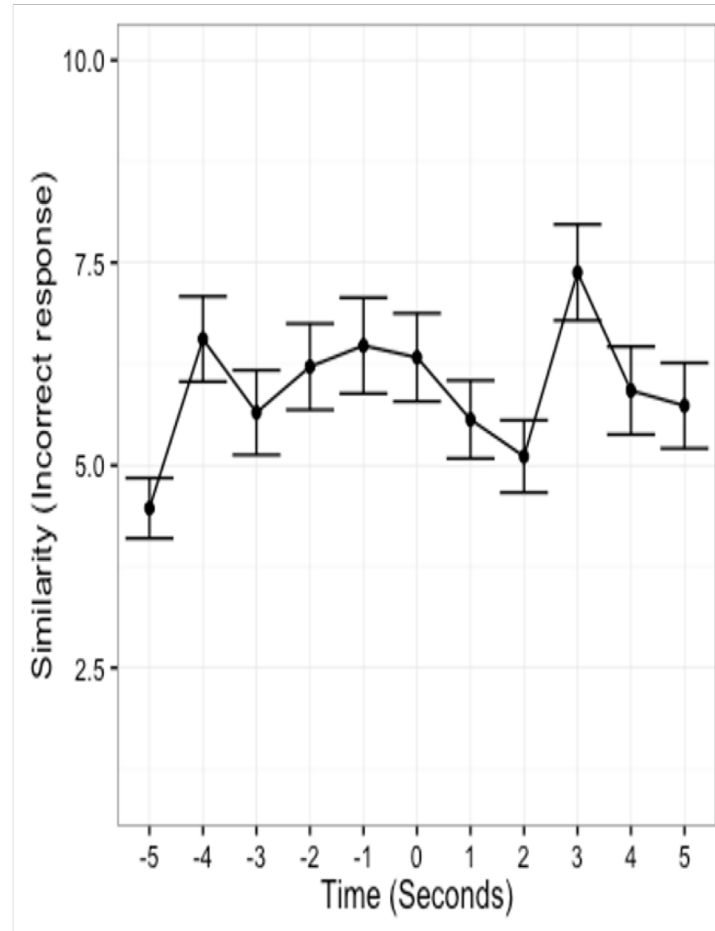
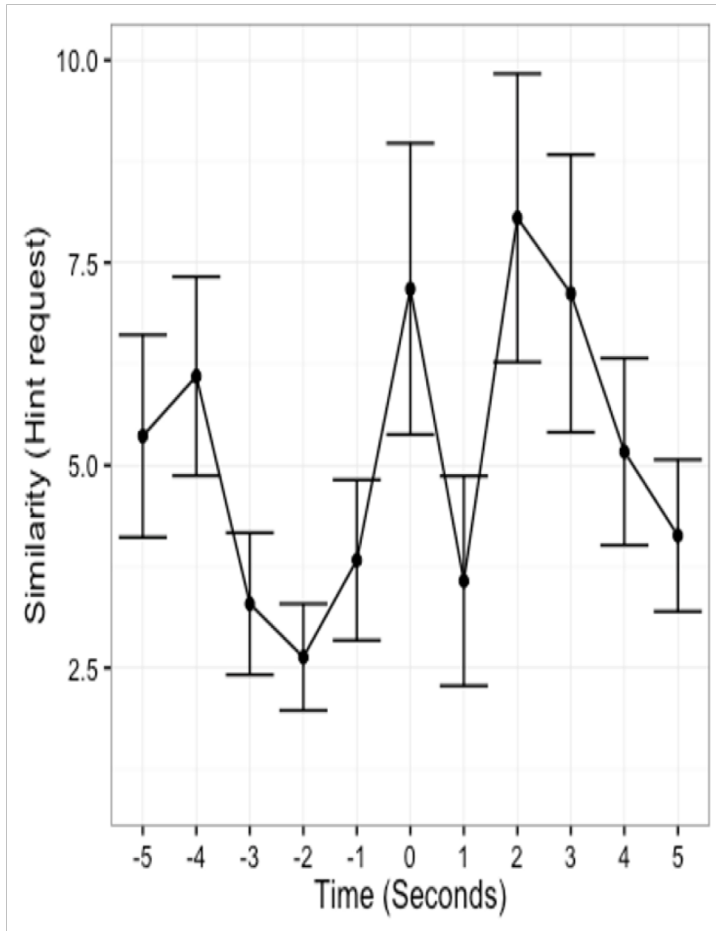
0.4	0.2	0.1	0.1	0
-----	-----	-----	-----	---

0.3	0	0.5	0	0.2
-----	---	-----	---	-----

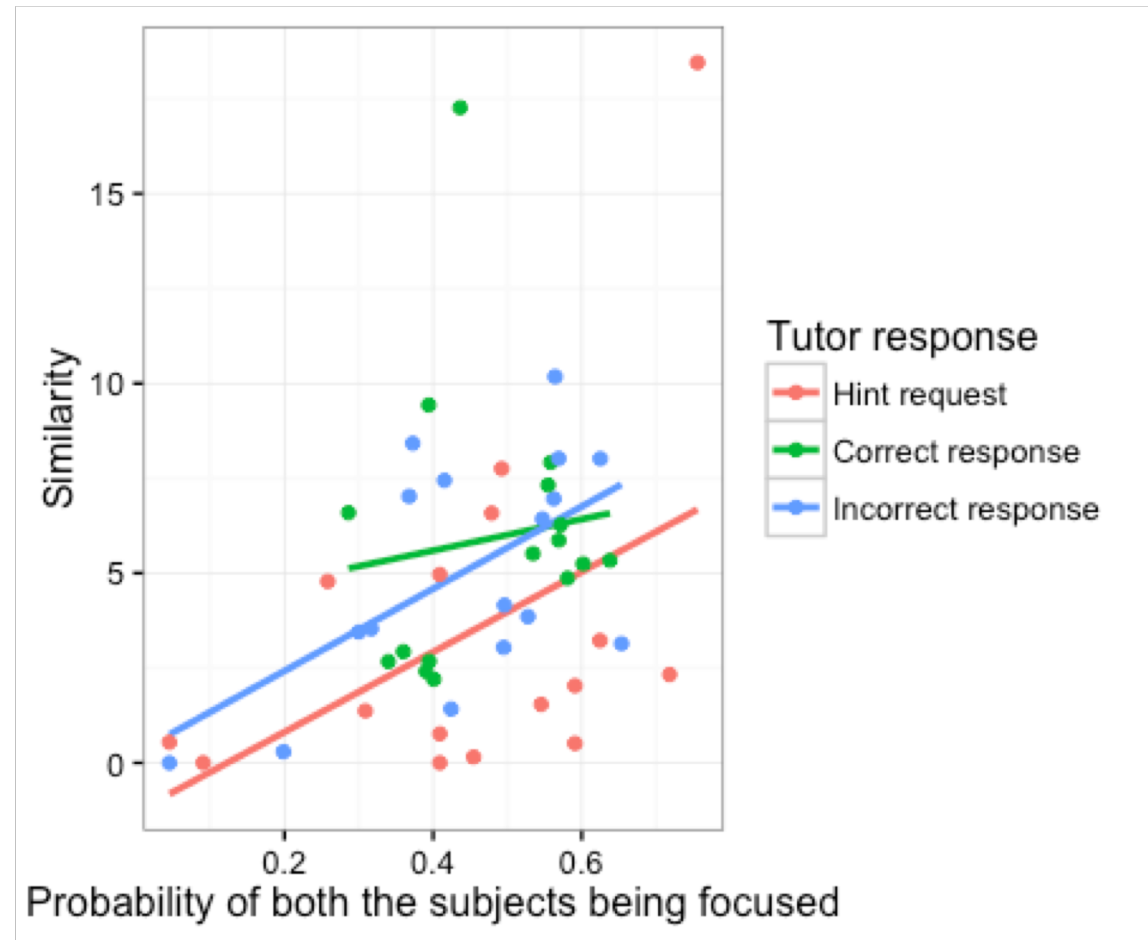
Similarity = 0

0	0.5	0	0.5	0
---	-----	---	-----	---

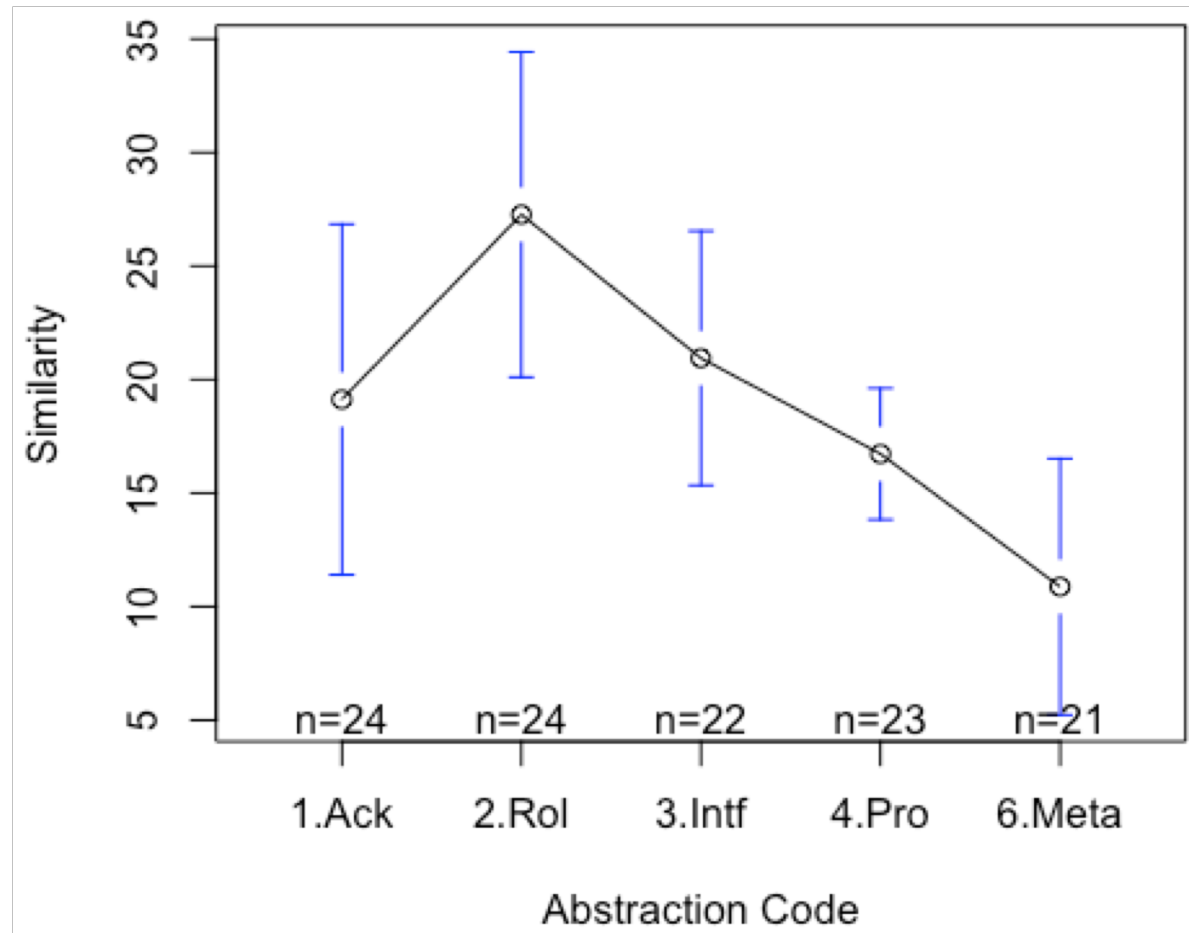
# Similarity and Tutor Actions



# Similarity and Focus Around Tutor Actions



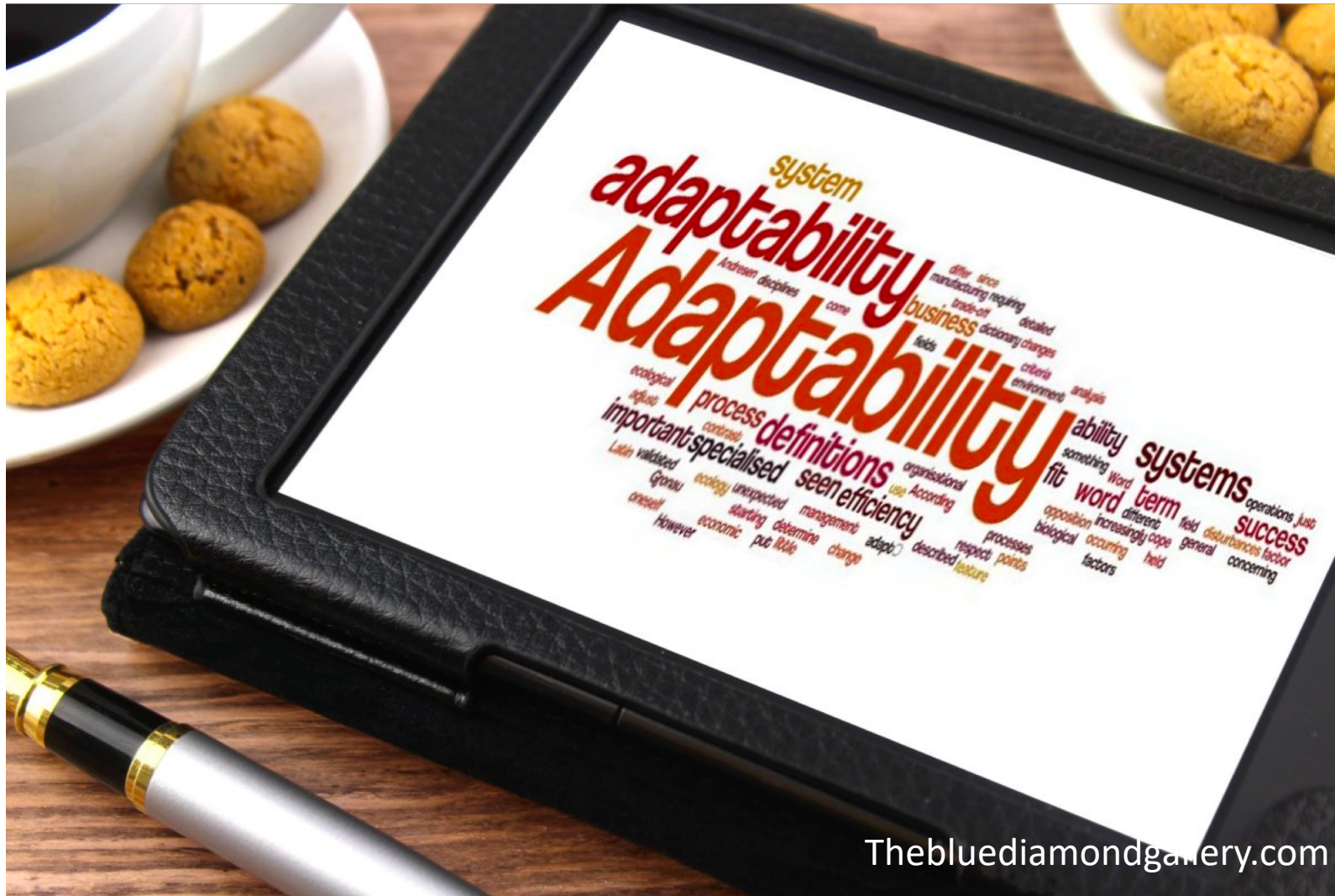
# Similarity and Abstraction



# Take-aways

- More gaze similarity after something has gone wrong
- More gaze similarity around more grounded speech
- Counting collaboration actions on their own may not be enough

# What do we do with this?



Thebluediamondgallery.com

# Thank you



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