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### Experiments on the Neurocognition of Creativity

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## Neurocognitive Responses Related to Divergent Thinking

Creative production is often correlated to divergent thinking to produce many different ideas; hence, for the engineering education domain, design learning presents opportunities to enhance divergent thinking.

- New experimental approaches need to be designed and developed to better understand cognitive and neural mechanisms associated with different aspects of divergent thinking and creative ideation more generally.

*We hypothesize that our students' divergent thinking and creative processing outcomes can be enhanced by investigating the impacts of carefully selected methods and tools enabled by developments in the robust analysis of engineering ideation performance, and neurocognitive responses to creativity.*

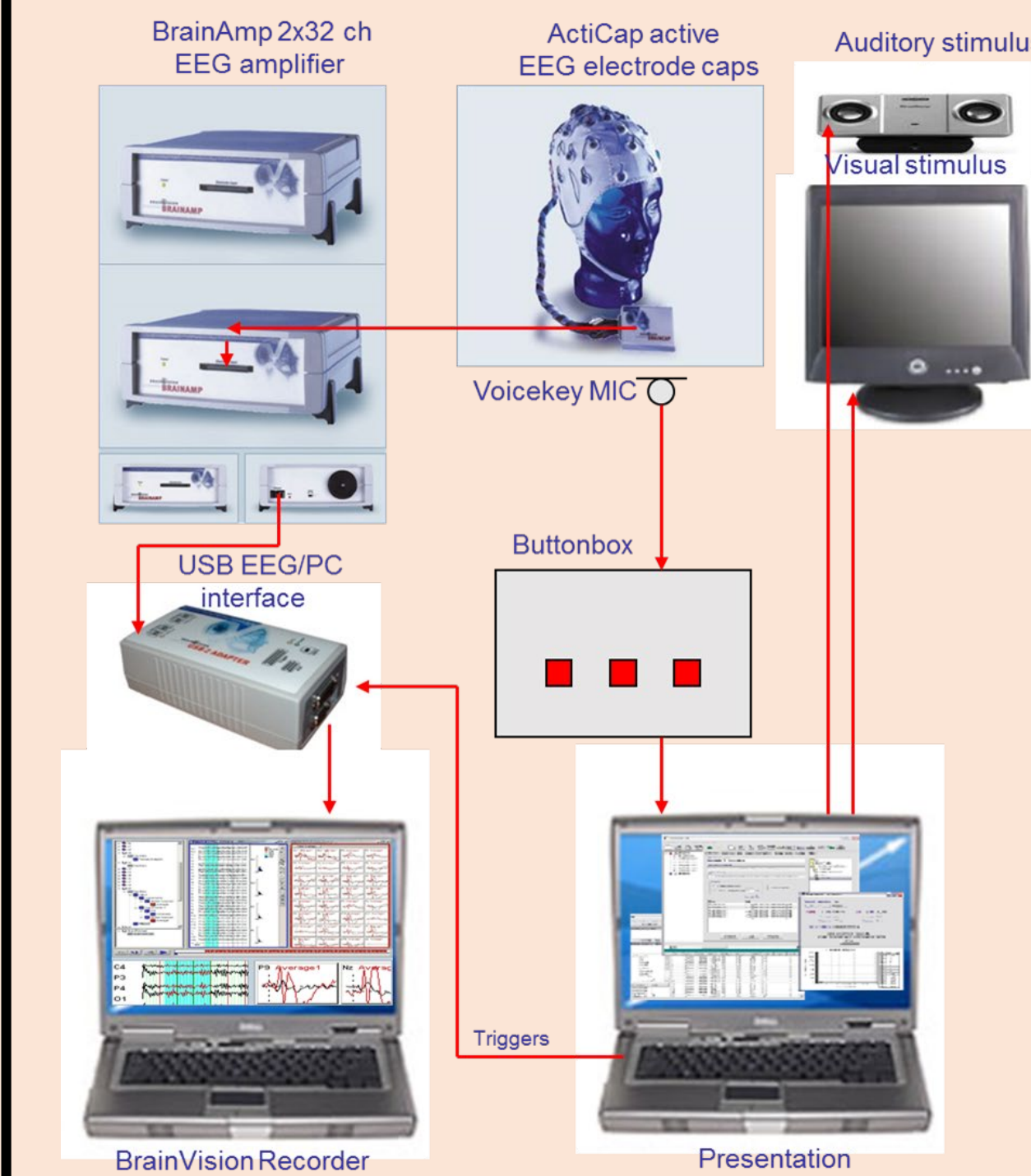
## Specific Research Questions

- Research Question #1:** Does prior engineering knowledge impact processing of novel metaphors containing engineering or non-engineering terms?
- Research Question #2:** Does creativity training modulate the cognitive effort associated with novel metaphor processing? If so, what is the effect of TRIZ and sketching training?
- Research Question #3:** Does stereotype threat or feedback from authority figures have an impact on creative idea generation?

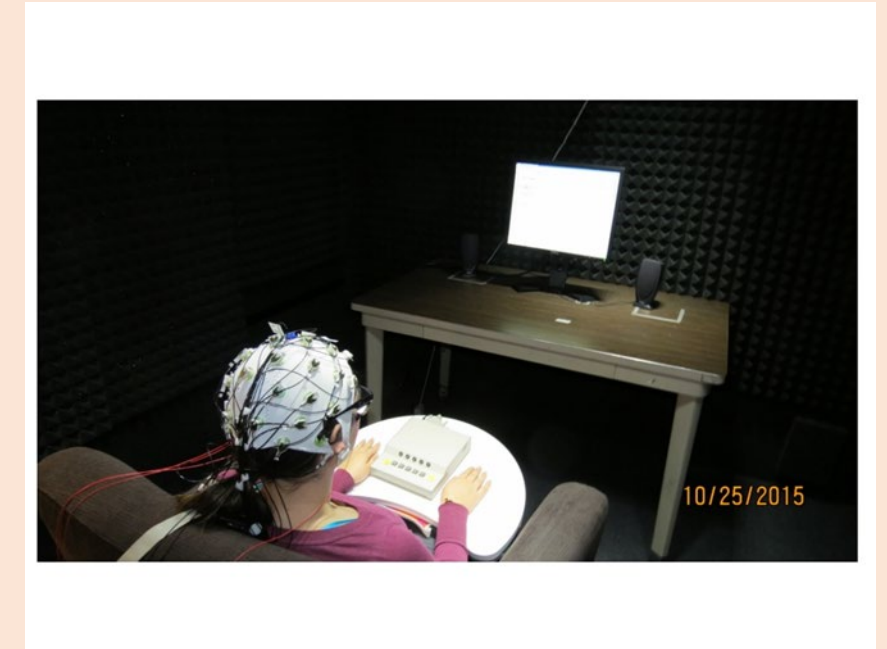
### Procedures:

- Participants were introduced to the research team, screened for eligibility criteria and consent was obtained.
- Participants were next taken to the experimental booth in which participants were prepared for the EEG recording.
- Participants were familiarized with the task.

## EEG Equipment



We present an experiment using the **Event-Related brain Potentials (ERP)** technique and **creative language use**. ERPs provide a millisecond-by-millisecond record of the brain's electrical activity during mental processing, and can be used to index ongoing cognitive processes as they unfold over time.



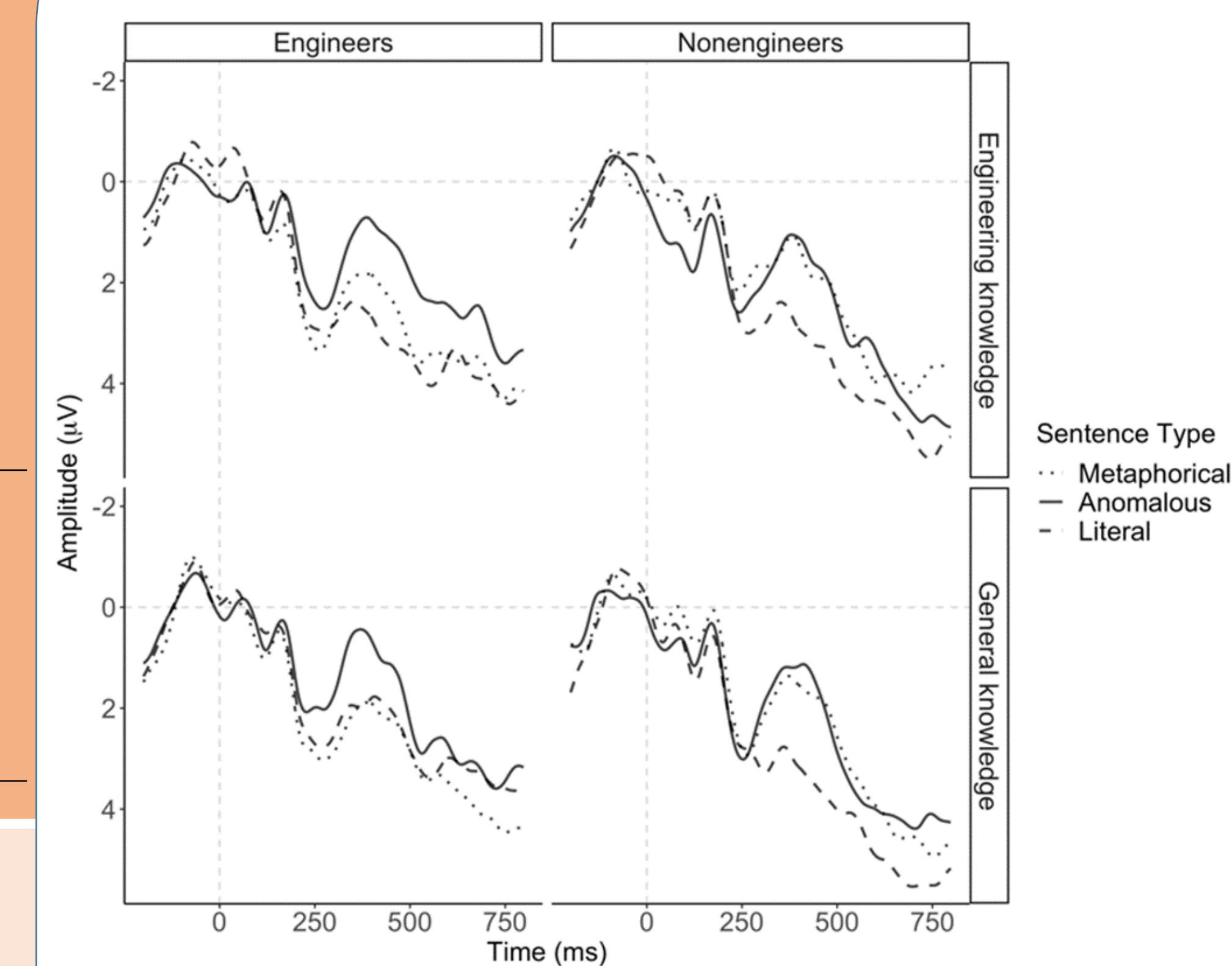
## Select Experimental Details

- Experiment corresponding to RQ1 builds on Rutter et al.'s [1] study, and extends our current understanding on how the creative potential may be dependent on an individual's prior knowledge, with a specific focus on engineering knowledge.
- We asked engineering 22 engineers (11♀, 11♂) and nonengineering 21 (13♀, 8♂) students to make yes/no judgments about originality and appropriateness of literal, novel metaphorical, and anomalous sentences referring to engineering and nonengineering concepts while their EEG was recorded.

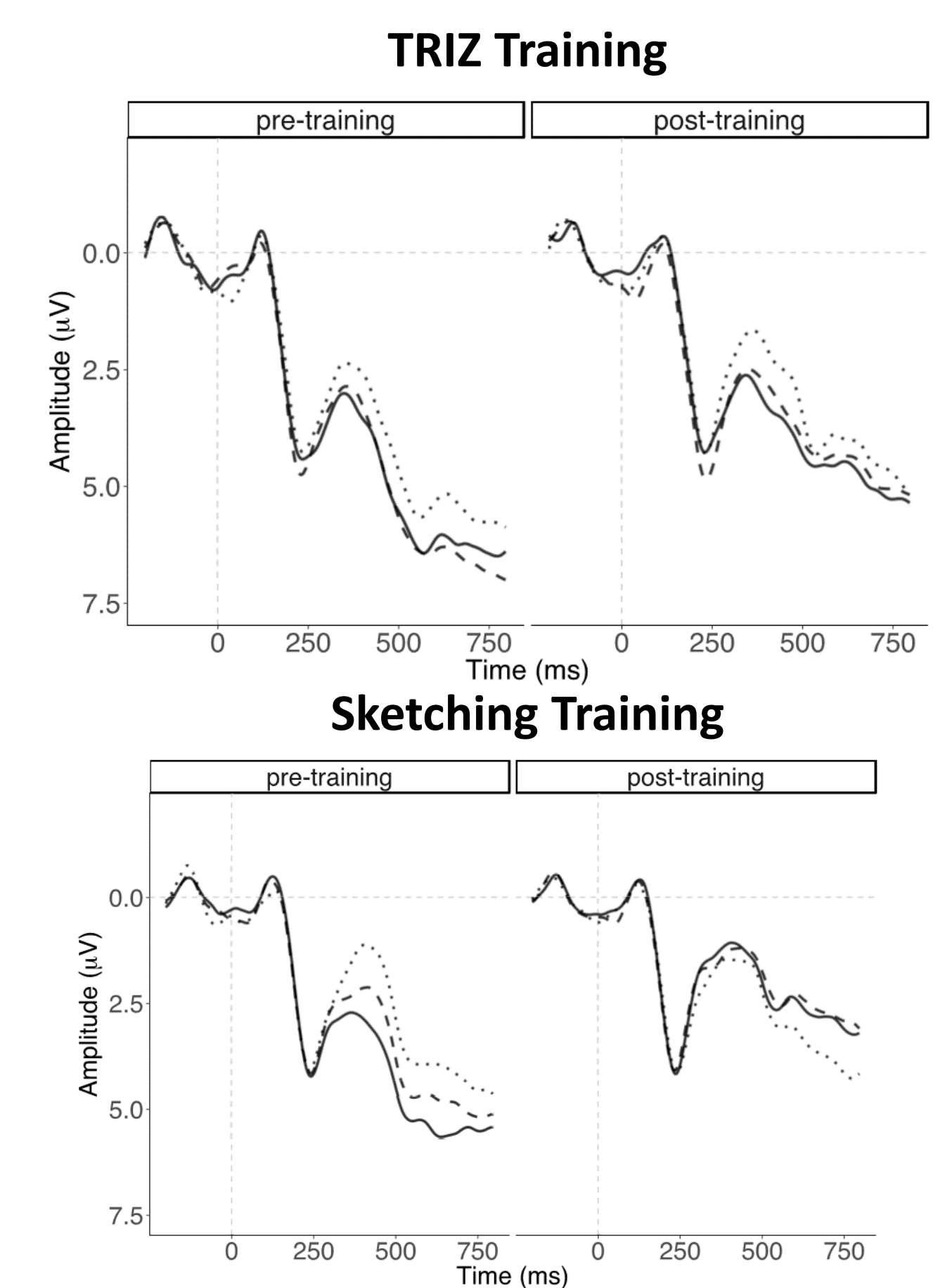
- Experiment corresponding to RQ2 extends behavioral experiments from co-PI Kremer's earlier work, and compares the influence of TRIZ and sketching. We used 38 TRIZ and 38 non-TRIZ stimuli. Participants were 17 (3♀, 14♂; Mage= 19.6) for the TRIZ group, and 17 (10♀, 7♂; Mage= 19.2) for the sketching group.
- Experiment corresponding to RQ3 included 25 female engineering students (final sample) (Mage= 19.1; SDage=.89). The experiment featured a mid-experiment stereotype threat.

No	Type	Engineering items	General knowledge items
38	LIT	The wind <i>moved</i> the <u>turbine</u> .	The waves <i>flooded</i> the <u>beach</u> .
38	MET	The wind <i>tickled</i> the <u>turbine</u> .	The waves <i>drowned</i> the <u>beach</u> .
38	ANO	The wind <i>ate</i> the <u>turbine</u> .	The waves <i>excused</i> the <u>beach</u> .

### Results: RQ #1



### Results: RQ #2



## Data Analysis and Results

Electrophysiological responses were time-locked to the verb (mid-sentence position) and the last word (final sentence position) in a sentence, to obtain brain signatures of sentence processing.

- Between group comparisons revealed differences in the way engineers and nonengineers processed the sentences.
  - In the engineering students, N400 amplitudes to novel metaphorical sentences patterned with the literal sentences
  - In the nonengineering students N400 amplitudes to novel metaphorical sentences patterned with the anomalous sentences.
- Experimental results showed that both training options increased the effectiveness as less effort was observed. However, sketching enabled more efficient semantic re-analysis and re-integration of novel metaphors as indexed by significantly reduced P600 amplitudes.
- Although our analysis for the stereotype threat intervention is not complete, preliminary results suggest that unsupportive feedback seems to positively impact the performance metric for females.

- Engineering students had at their disposal knowledge and experiences related to engineering as well as general knowledge about the world –resulted in quicker semantic access and resolution of ambiguity created by novel metaphorical experiences
- Nonengineering students, with little to no experience in engineering, found it more difficult to resolve the ambiguity of unexpected metaphor endings, which could have also affected the resolution of ambiguities in the case of sentences relating to general knowledge.

### Results: RQ #3

