# HOW DO STUDENTS UNDERSTAND CONFIDENCE INTERVALS? IDENTIFYING COMPETING INTUITIONS THROUGH SEMI-STRUCTURED INTERVIEWS

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## Abstract

How do students think about confidence intervals (CIs)? We interviewed 24 students to explore. Do students think all points within a CI are equally likely to be the population mean (μ) being estimated? OR do they think likelihood varies as a smooth curve (Figure 1)?
We identified several misconceptions in students' thinking about CIs.
We also explored if seeing and discussing the cat's eye picture of a CI (Figure 1) helps reduce CI misconceptions.

## Introduction

In a judgement task, 101 postgraduate and final year undergraduate students' subjective likelihood distributions (SLDs) were classified as above. In addition, a quarter (25% of 101) indicated that as the Confidence Level (CL) of a CI decreases the width of a CI increases.
**But what conceptions and misconceptions go with those shapes?...**

## Method

Twenty four postgraduate students (PhD, Professional Masters, Professional Doctorate) who had previously completed our survey about SLD participated in a 45+ minute semi structured interview. The first part of the interview explored CI concepts such as distribution, width, and confidence level. The second focused on Cat's eye confidence intervals to see how this new teaching tool affects student reasoning.

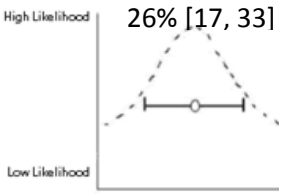
## Example of student misconception

Interviewing students gave us insight into why students might think a CI has a square likelihood distribution

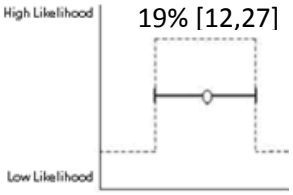
**Everything inside the CI is equally likely:** "My reasoning was CI just tells you that I'm 95% confident that the mean falls within this range but it doesn't mean that [if a point] is closer to the mean, it doesn't tell you that it's more likely to happen." (#100)

## How Do Students think about CIs ?

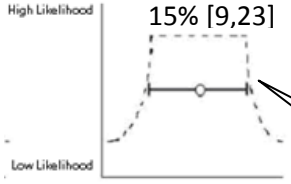
**Bell curve?**



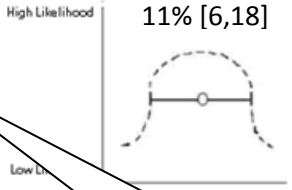

**Square?**



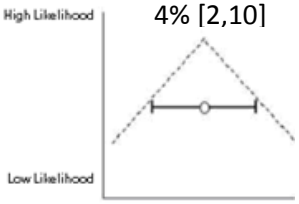

**Mesa?**




**Semi Circle?**




**Triangle?**




These are all possible shapes for students' Subjective Likelihood Distribution (SLD). 26%were classified as *other*

## Cat's Eye Confidence Intervals (CECI)

The CECI was particularly helpful at reducing the relational misconception about confidence level and confidence width. Approximately one third (32%, 8 of 24) of the interviewed students initially believed that a 95%CI would be shorter than a 50%CI, given the same data. After seeing the CECI *all* of these students were able to identify this as a misconception. Here is an example of a students' initial belief:

> "The larger the CI, the less confident we are of the [results]. The smaller the CI, the more power a study would have, the more confident we are of the results" (#48)

Here is an example of the same student gaining insight through the CECI:

> "So changing the confidence level is changing the amount of the distribution that you are looking at. So 95 is 95% of the distribution and 50 is 50%...so hang on… it gets shorter." (#48)

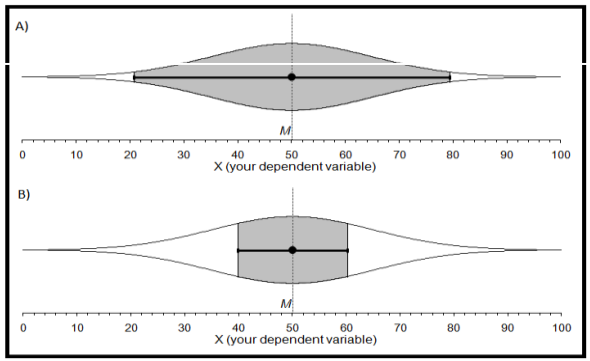



*Figure 1.* The CECI makes explicit the normal distribution underlying the CI. The amount of shading reflects the confidence level and so the relationship between confidence level and area is also explicit. Because the display is interactive, students can discover the effect changing *n* has on CI width.

## Conclusion

Interviewing participants provided us with evidence for new CI misconceptions. CECIs can mitigate CI misconceptions. A very minimal intervention can produce reasonably dramatic results. We are not suggesting that CECIs should be the way CIs are presented all the time, but they are a useful conceptual tool for students to encounter and discuss. CECIs would also be useful to keep in mind as a guide for thinking about and interpreting CIs.