

Perceptions of Strength

Can People Accurately Assess the Strength of Planar Structures?

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Introduction

The human brain is a volatile tool capable of making judgments without the need for conscious reasoning through the power of intuition. In this study, I sought to determine whether that human intuition was a qualified tool for assessing the strength of simple, planar structures.

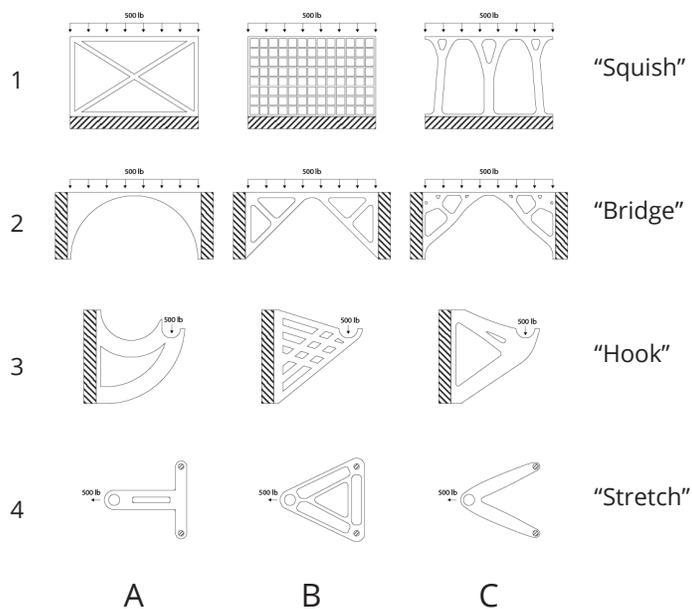
Motivation

It doesn't matter how strong a structure is if its intended user does not trust it enough to use it. Thus, I wanted to begin to try and understand the human ability to evaluate what is and isn't strong - and with it, what is and isn't safe.

Methods

For each of four simple cases in which there was a force being applied to a fixed body, I designed three structures, each of which weighed approximately the same and took the same forces and had the same fixed joints. For each case, one structure was designed using Fusion 360's topological optimization tool to find an optimal design. Then, two other structures were designed with intentional flaws and weaknesses that would yield a significantly lower safety factor.

Figure 1: Designs



As seen in Figure 1, three designs were generated for each case: "Squish", "Bridge", "Hook", and "Stretch". The cases are ordered here from least to most strong, labeled A to C.

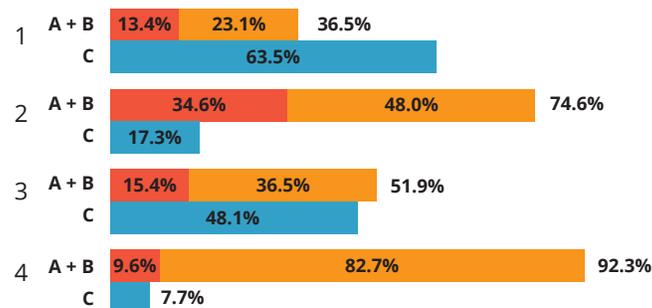
To assess perceptions of strength, survey participants were shown the three structures within each case and asked to select the one they believed to be the least likely to break.

Survey respondents were solicited through social media. Due to this, the respondents were all ages 18-30.

Data Analysis

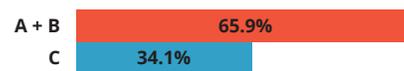
The survey yielded 52 unique responses. For each question, the answers were pre-randomized. Below, they have been sorted from least to most strong, A-C.

Strength Assessment Accuracy



Though participants' abilities to correctly assess strength varied greatly from case to case, on average, they scored very close to a random sample.

Overall Strength Assessment Accuracy



Discussion

Though results varied greatly by case, in each group, participants chose answer A (the weakest) less than they chose answer B (the second weakest). Additionally, a weaker answer only held a supermajority in one case, case 4.

Additionally, respondents who indicated that they had no formal statics training chose the best option roughly the same amount as those who indicated that they had statics training at an undergrad level. Overall, respondents with no training chose the strongest answer 30.1% of the time, while those with undergraduate experience in statics chose the strongest answer 31.3% of the time.

Conclusion

Though the results of this study are promising, they are insufficient in their scale and specificity to allow any conclusion to be drawn. However, going through the process of collecting this data has elucidated a few key changes to the study that could yield much better results if repeated.

1. Consistency in Design

In this iteration of the study, the "less strong" designs for each case were generated manually, unlike the strongest designs, each of which were generated using topological optimization. Should this study be repeated, the less strong designs should be generated in a uniform way to ensure that they are all providing an apt alternative choice to the strongest model. This could be achieved by generating the weaker models the same way but with a coarser mesh size.

2. Less Choices

The choice to provide respondents with three potential models instead of two clouds the response data, as it is harder to pinpoint what exactly about each model could persuade the respondent to choose it.

3. Justification

The lack of an opportunity for respondents to justify their choices left the study without a way to determine reasoning behind correct and incorrect choices. Including the ability to give this feedback would help expand the implications of the study.