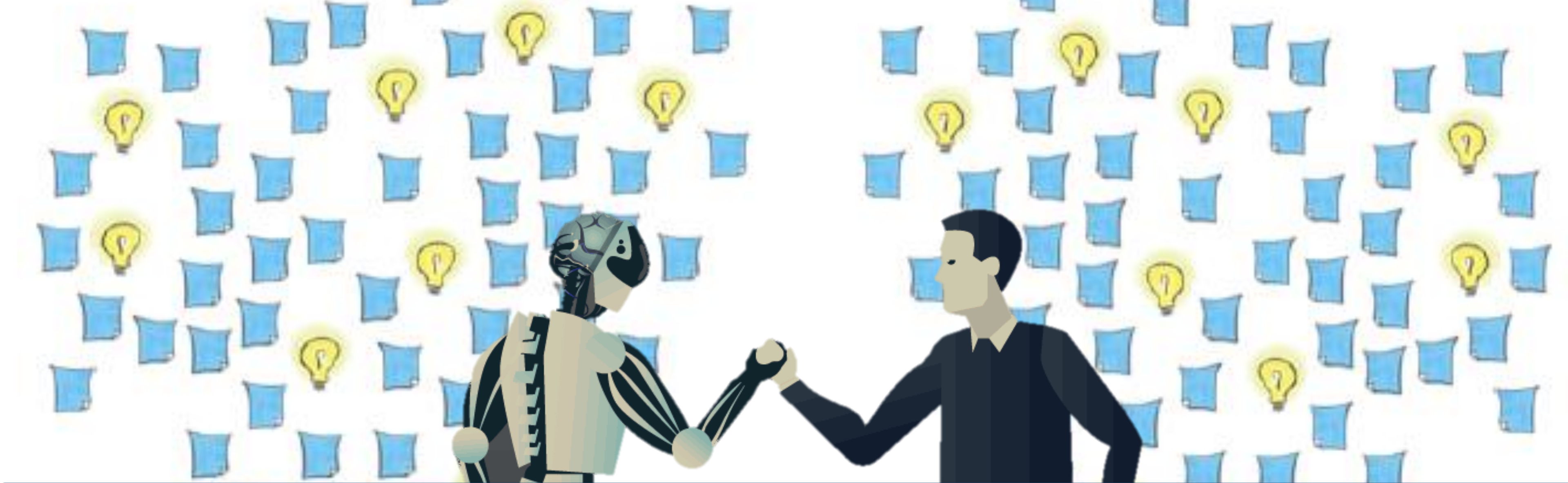

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SHPE

Deep Learning Generative Models in the Product Development Process:

Exploring Designers' Bias

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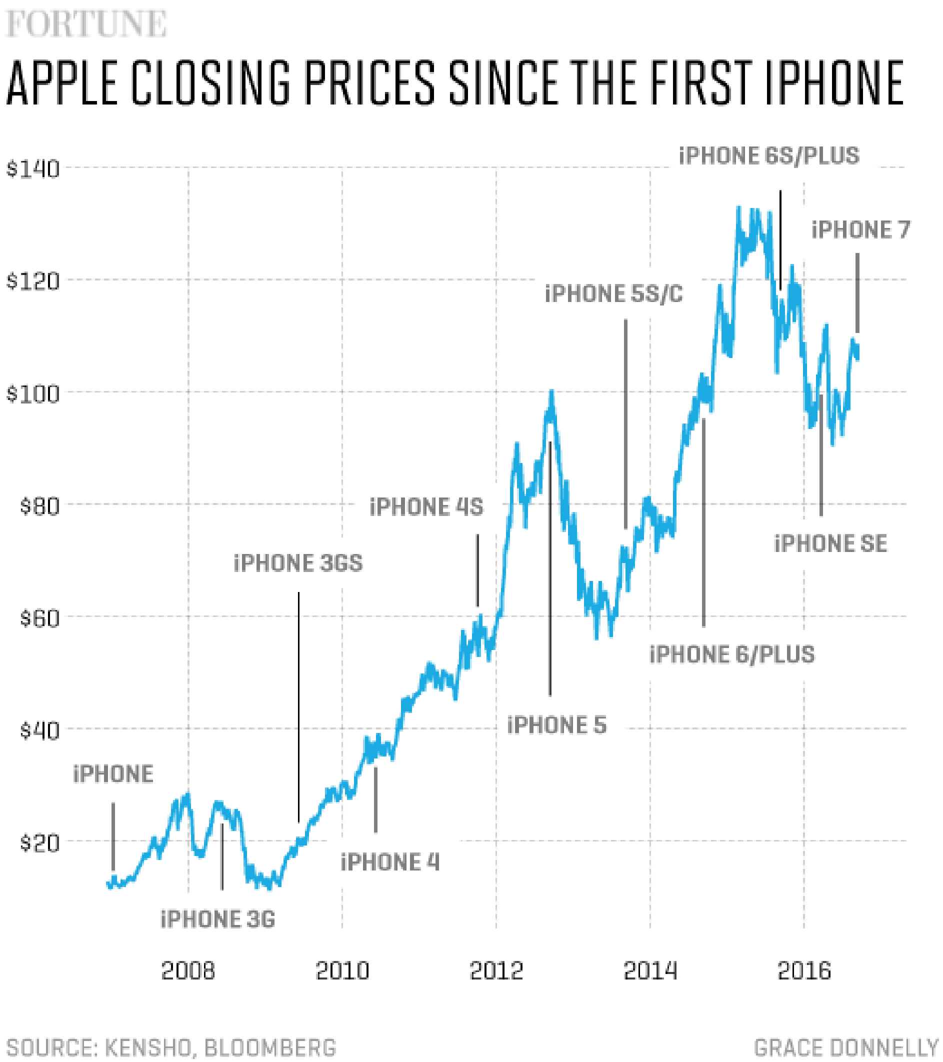
The Pennsylvania State University, University Park

"Creativity is an integral part of engineering design… without creativity there is no potential for innovation"

[Howard, Culley & Dekoninck, 2008]



*fortune.com/2016/04/01/apple-favorite-products/

Designers are benefiting from integrating computational tools into the design process

As these computational tools become more efficient, they will foster designers' creativity. [Liapis *et al.*, 2016]

AUTODESK

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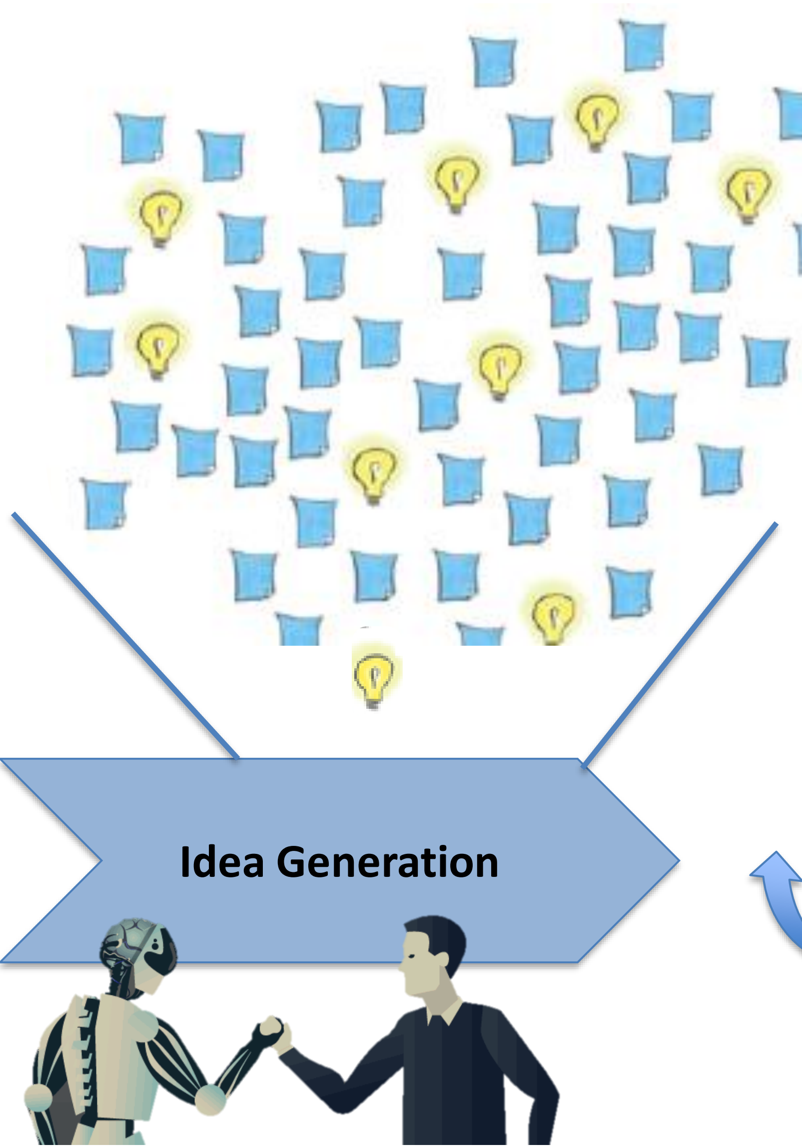
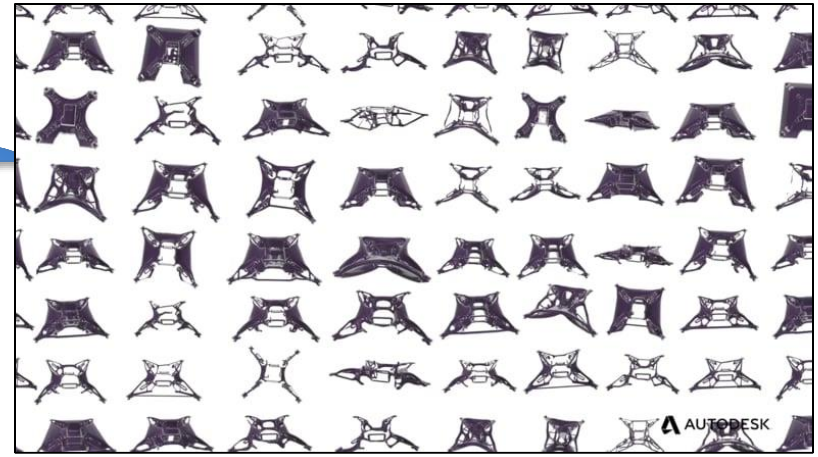
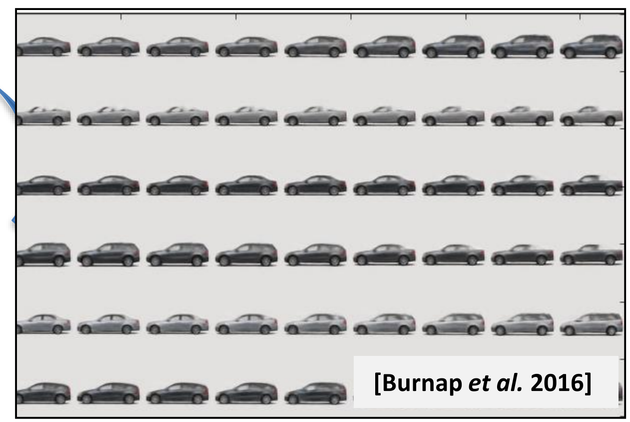
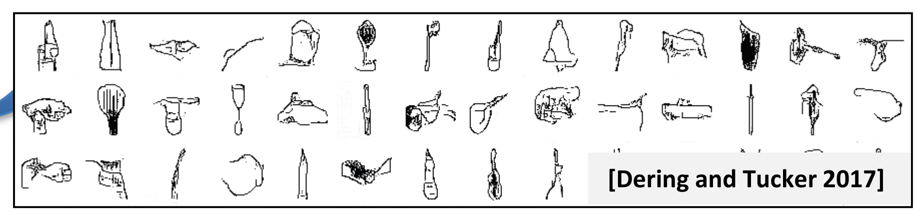
Generative design algorithms are helping designers explore the design space






[Burnap *et al.* 2016]


[Dering and Tucker 2017]

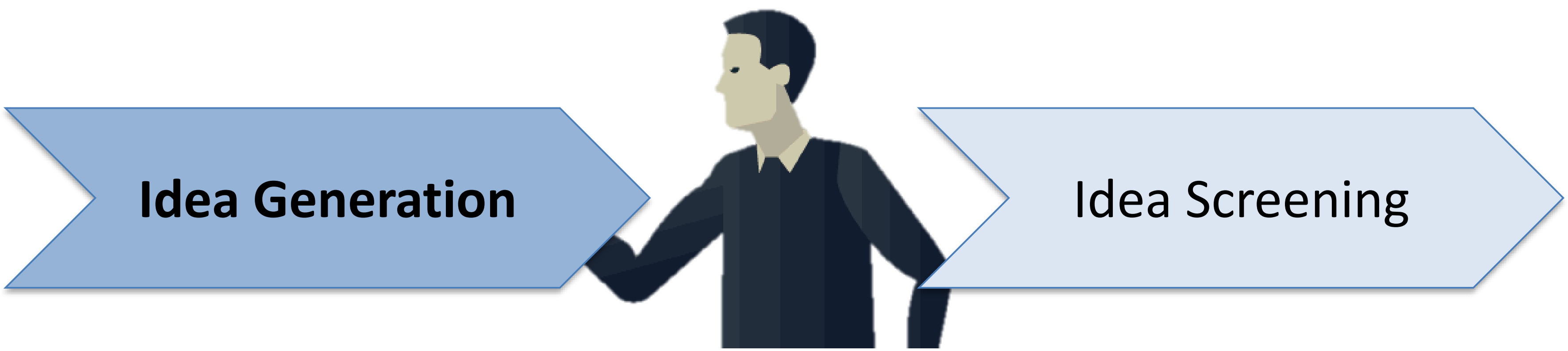
Novel ideas also have to meet their intended functionality and be useful to be considered creative

Mass-Collaborative Product Development take advantage of crowdsourcing

*kkstudio.gr

"… the availability of creative ideas is a necessary but insufficient condition for innovation."

[Reitzchel *et al.*, 2006]



1) **Compare the perceived functionality of human vs computer generated sketches**

2) **Explore individuals' bias towards human and computer generated sketches**

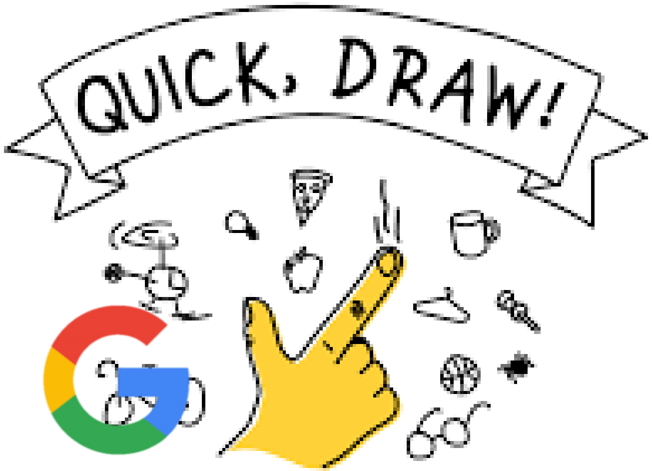
3) **Explore individuals' capability to distinguish between human and computer generated sketches**

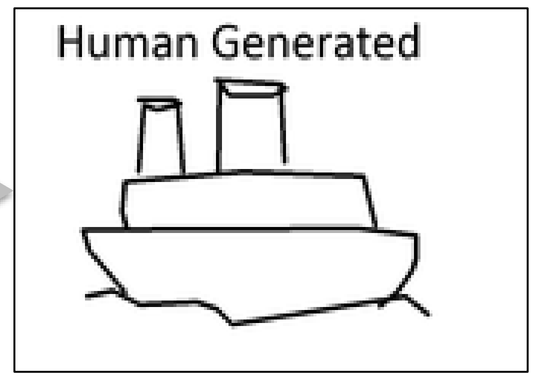
4) **Explore the correlation between individuals' subjective and computer simulation objective functionality evaluation**

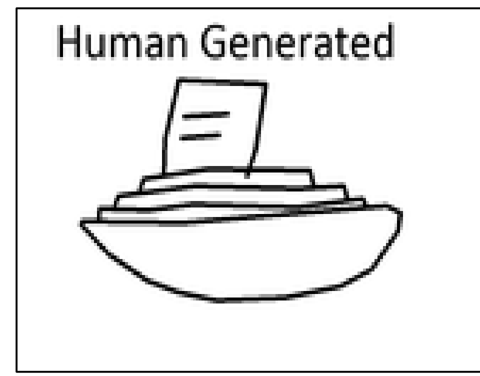
Low-fidelity, rough 2D sketches are the primary communication source of ideas in early design phases

[Kazi et al. (2017)]

CASE STUDY: Boat sketches

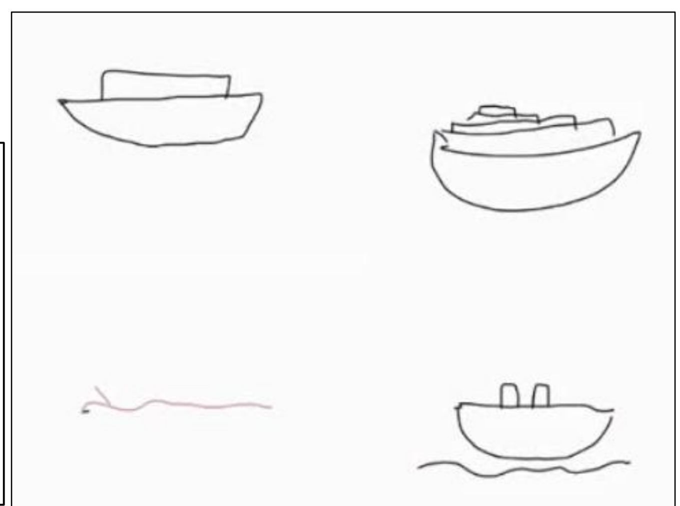


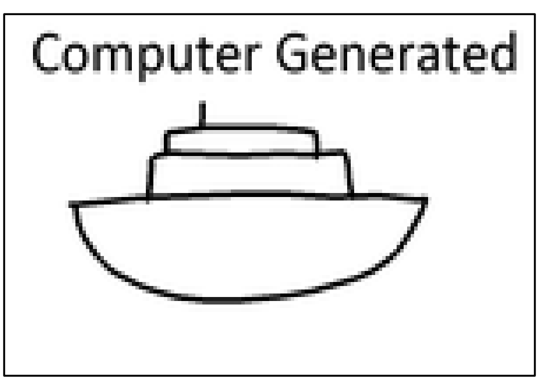




Sketch-RNN

Ha and Eck (2017)





Questionnaire and Participants

amazon mechanical turk beta

1,187 Raters

(90% satisfaction rate)

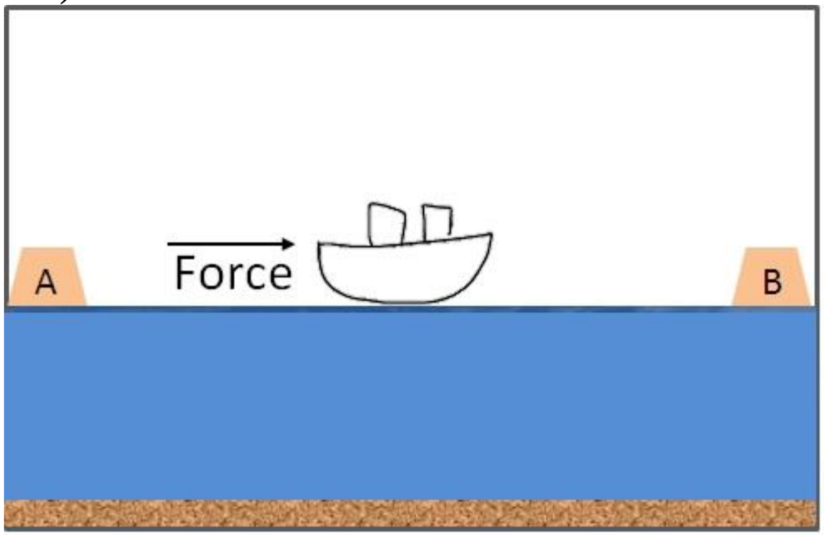
Benefits*:

(i) Low cost

(ii) Large rater pool access

(iii) Large rater pool diversity

In this section, you will be shown 2D boat sketches and asked to evaluate them from 1 to 7 based on how well they will **float** in a 2D environment as the one shown below. Additionally, you will be asked to evaluate them based how well they will **move** from point A to point B when a force is applied in the same direction, as shown below (like the force from a motor that results in a boat being propelled forward).



>>

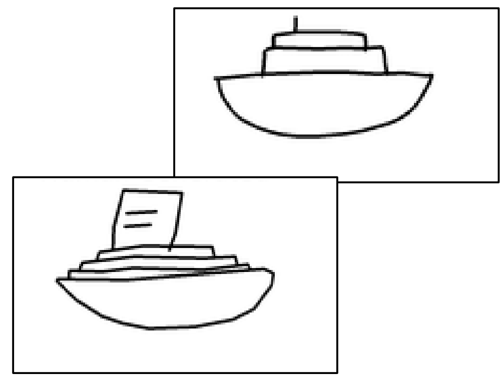
*[Mason et al. (2012), Paolacci et al. (2010)]

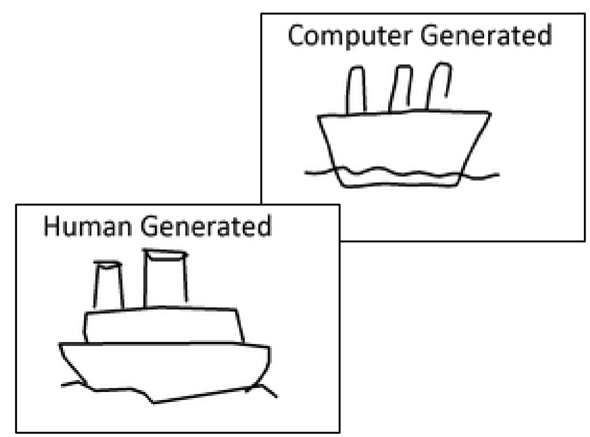
Questionnaire and Participants

Between-subject experiment:

- Total of 50 computer and 50 human generated sketches
- 2 sets of 4 sketches per participant

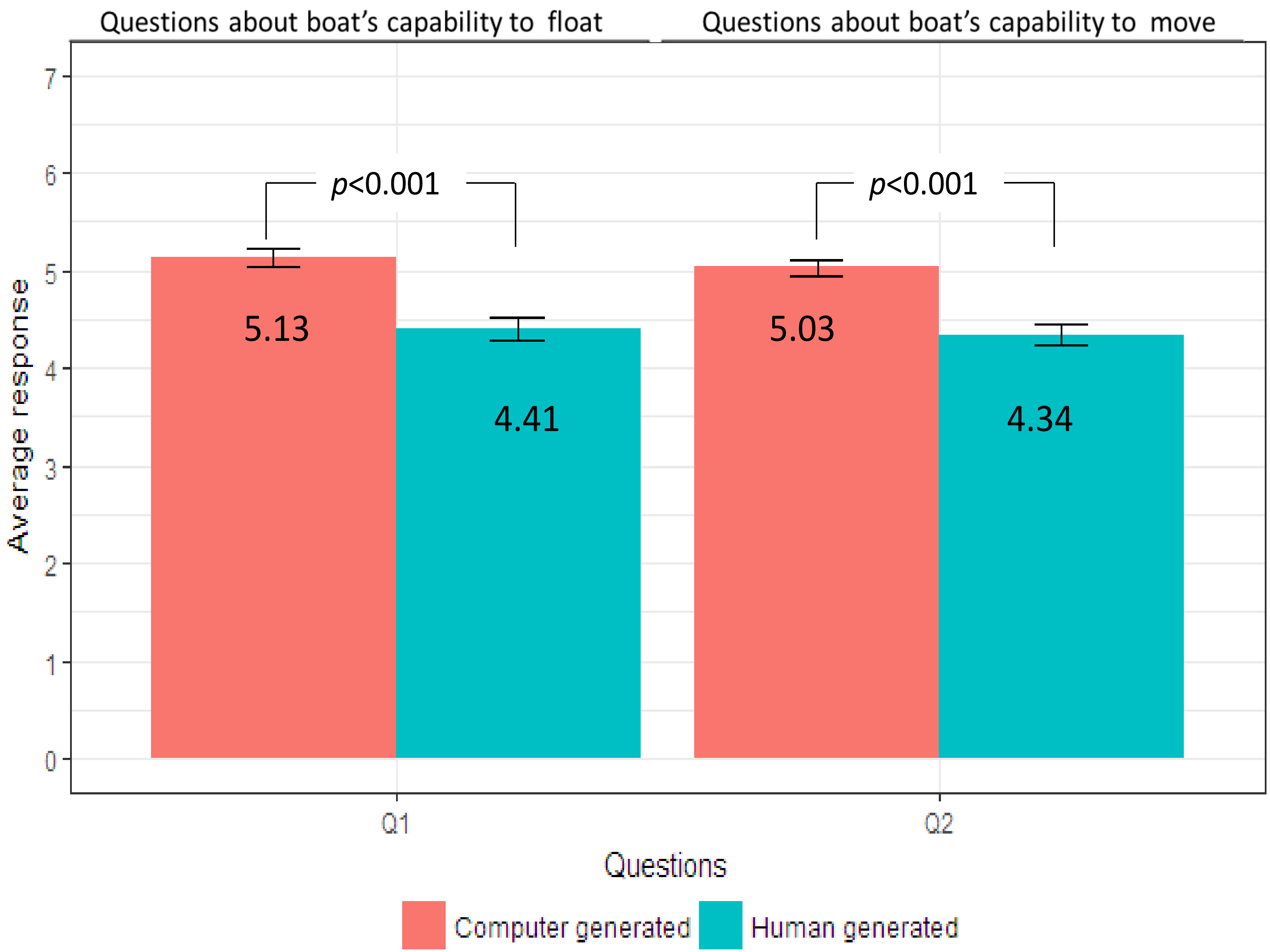
Q1: Please evaluate the following boat sketches based on how well they will **float** in the 2D environment shown below.
Q2: Please evaluate the following boat sketches based on how well they will **move** from point A (left) to point B (right) when a force is applied in the 2D environment as shown below.
Q3: Please classify the following sketches as *human-generated* (drawn by a person) or *computer-generated* (drawn by a computer).
Q4: Please evaluate the following computer and human generated boat sketches based on how well they will **float** in the 2D environment shown below.
Q5: Please evaluate the following computer and human generated boat sketches based on how well they will **move** from point A (left) to point B (right) when a force is applied in the 2D environment as shown below.





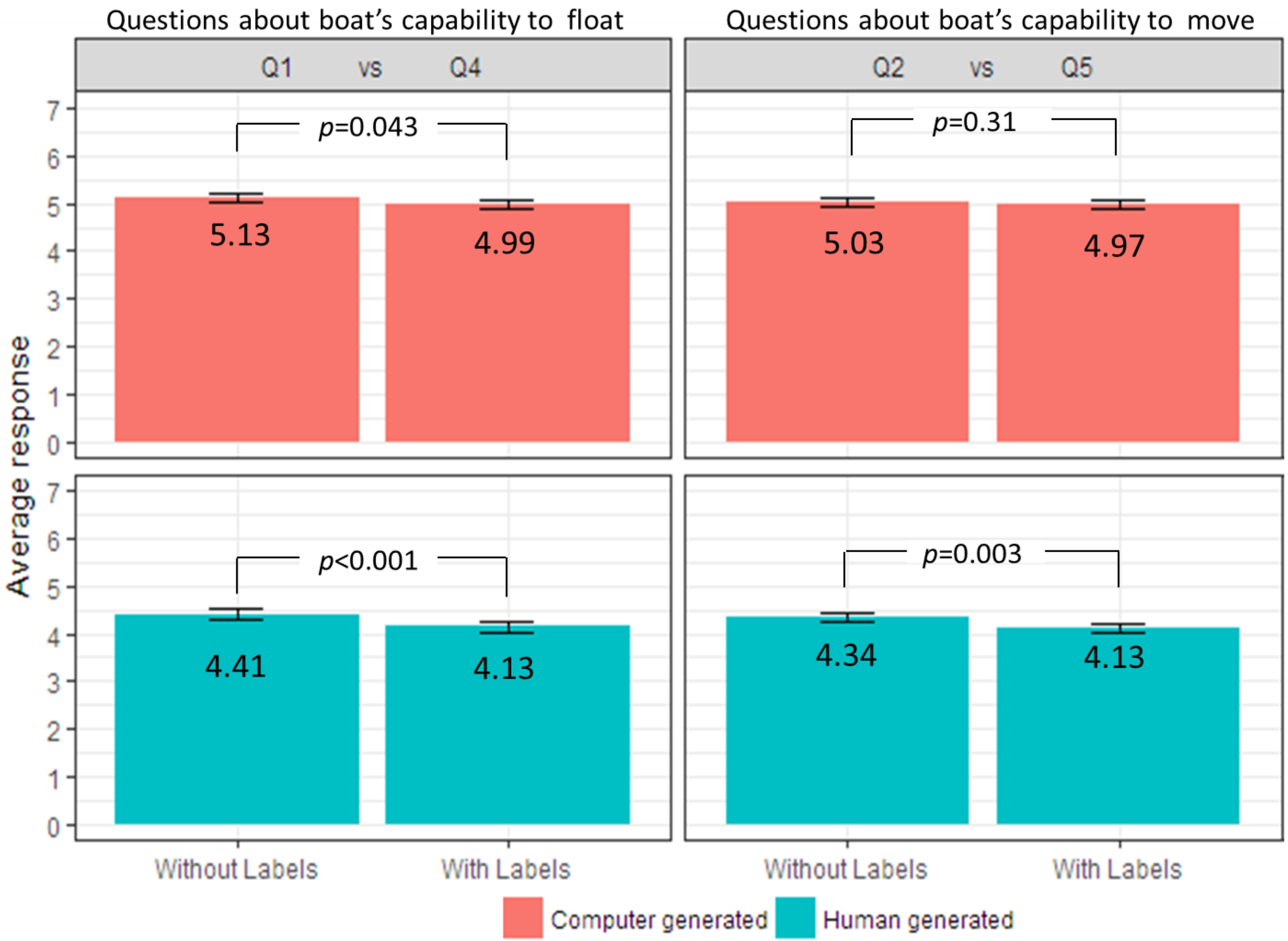
7-point Likert scale

Computer generated sketches were perceived as more likely to float and move



RQ1

Participants' functionality perception of human created sketches was biased



RQ2

Individuals cannot accurately distinguish between human and computer generated sketches

ACCURACY

49.8%

95% CI: [47.81%-51.79%]

CONFUSION MATRIX OF SKETCHES CLASSIFICATION

Ground truth

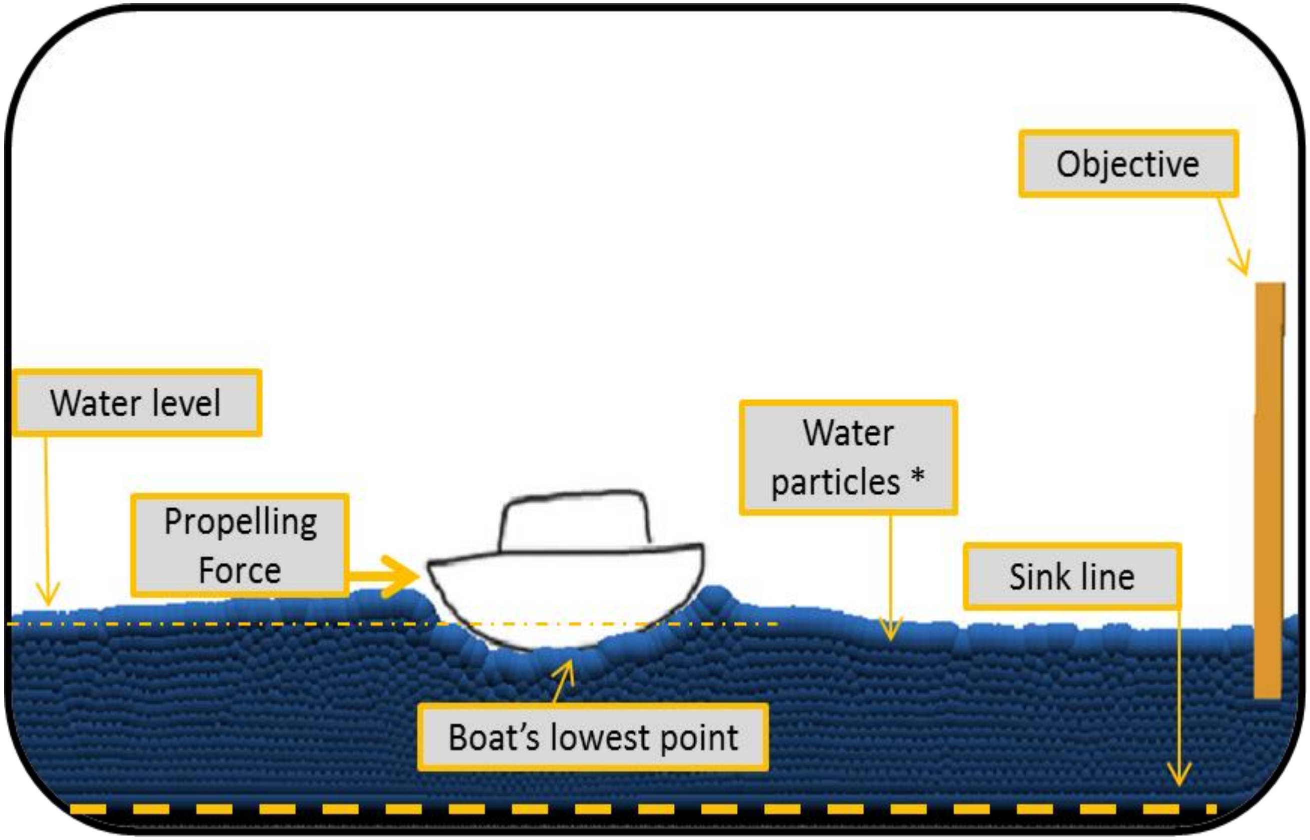
Prediction	*Computer*	*Human*	**Total**
Computer	264	269	533 (22%)
Human	974	969	1943 (78%)
Total	1238 (50%)	1238 (50%)	**2476 (100%)**

RQ3

Validating raters' perceived functionality

Physics Computer Simulation

<u>Output Scores:</u>
-Float
-Speed



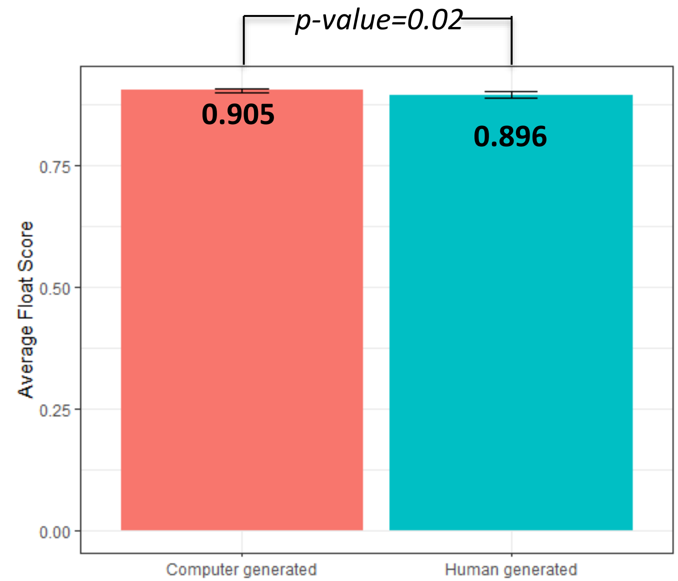
unity

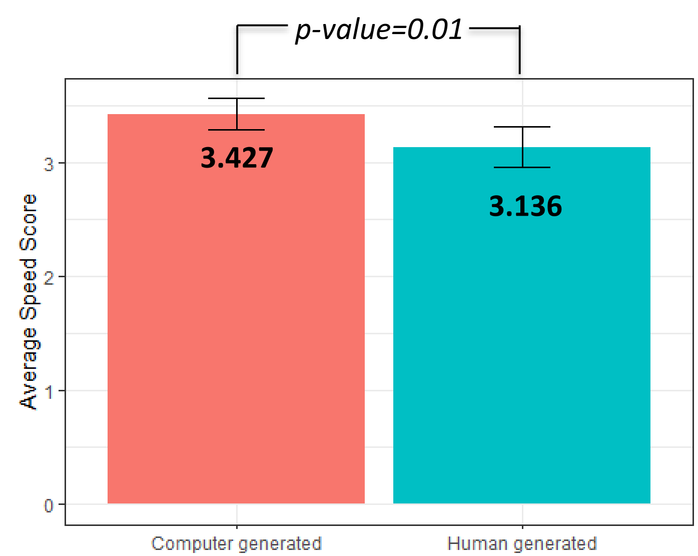
[Cunningham and Tucker (2018)]

Raters’ perceived functionality are in line with the Computer simulation evaluation

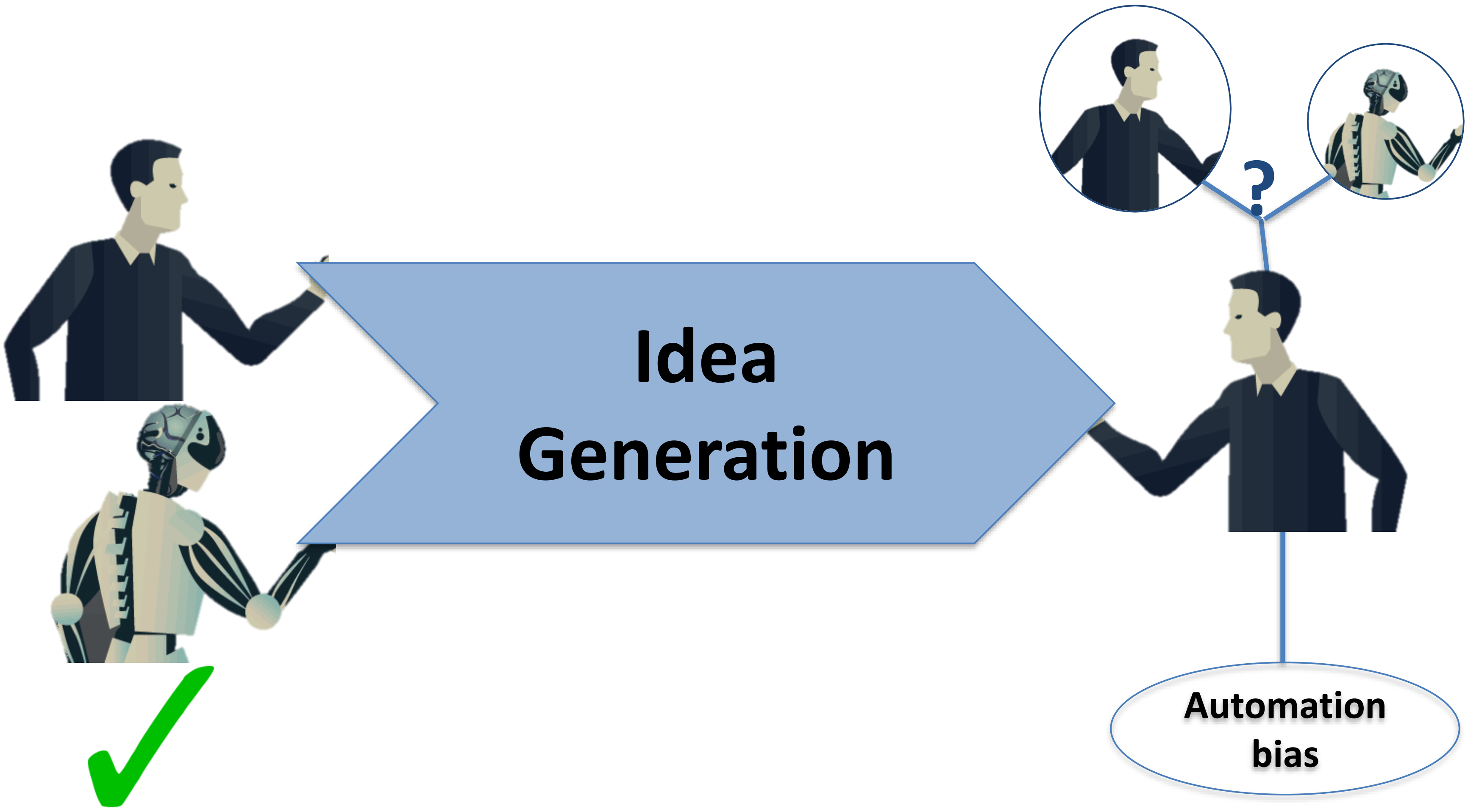
Variables		Pearson correlation (ρ)	p-value
Float Score	***Q1***	0.3	<0.01
Speed Score	***Q2***	0.5	<0.001

Computer generated Human generated

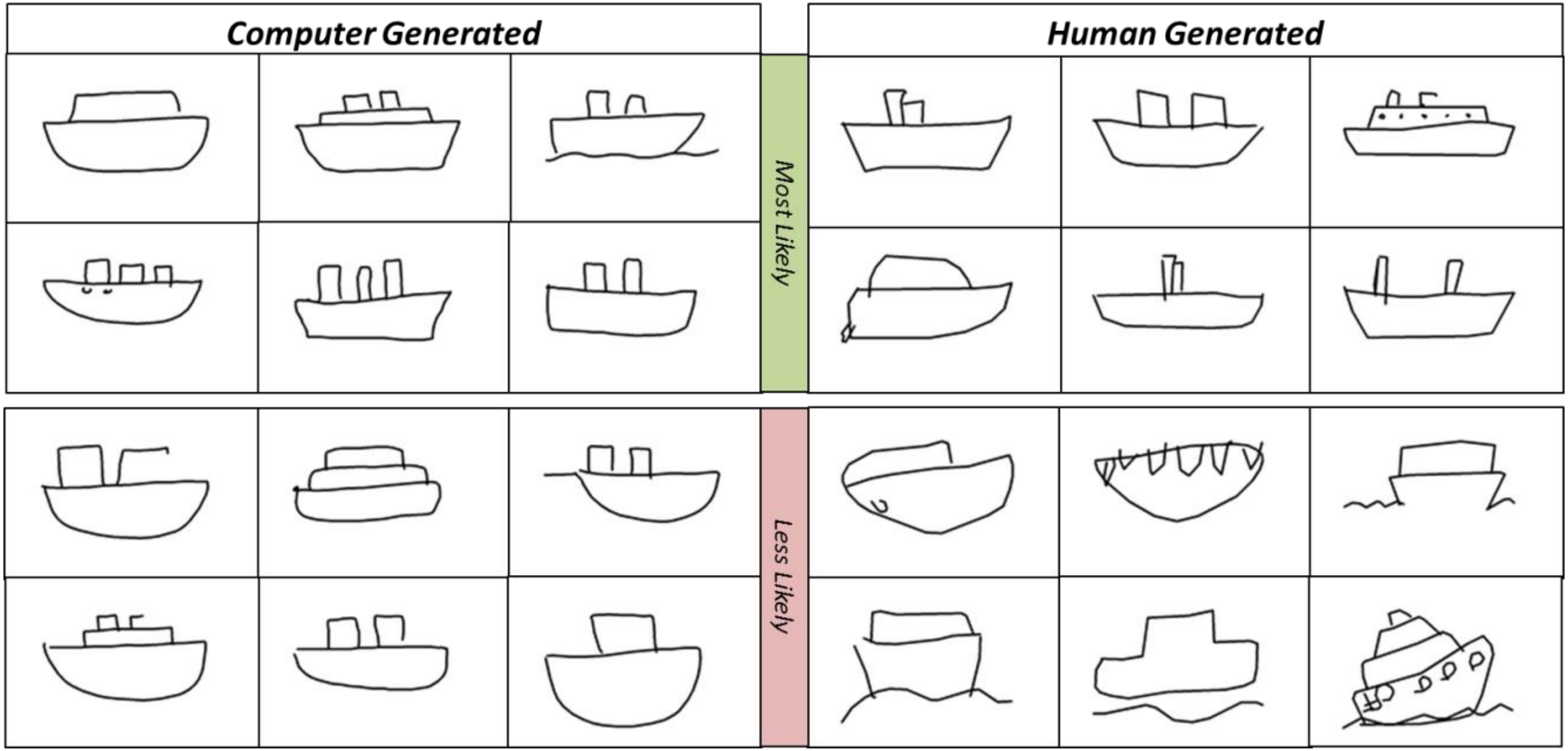




Results support the capability of deep generative models to generated new functional ideas

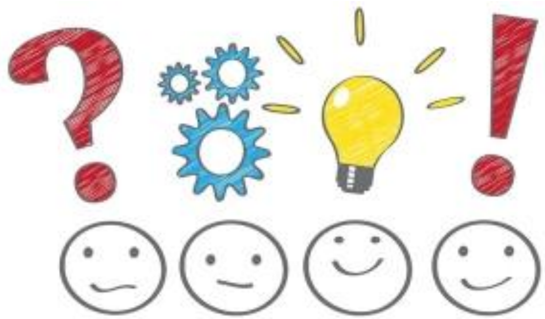


Future works: What are the visual features of sketches that make them functional?

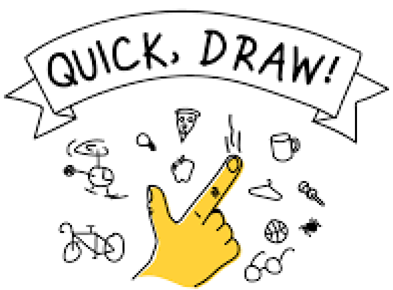


www.engr.psu.edu/datalab

Thank you!



sites.psu.edu/clopez



Quick, Draw!

Sketch-RNN - Magenta

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