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Human validation of computer vs human generated design sketches

Christian E. López[1], Dr. Scarlett R. Miller,[1,2] & Dr. Conrad S. Tucker[1,2]

[1] Department of Industrial and Manufacturing Engineering,

[2] School of Engineering Design Technology and Professional Programs

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]

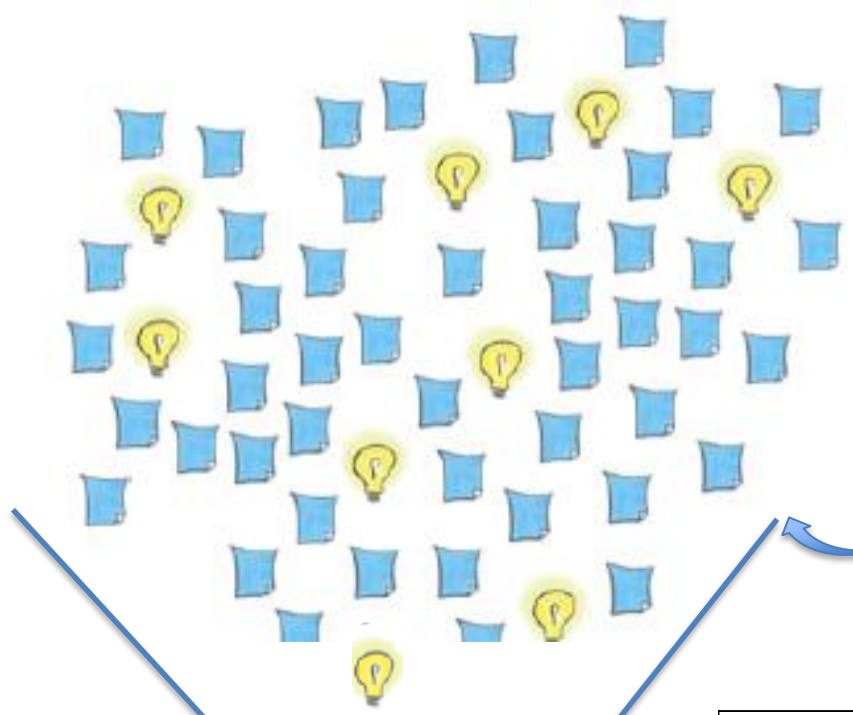
*fortune.com/2016/04/01/apple-favorite-products/

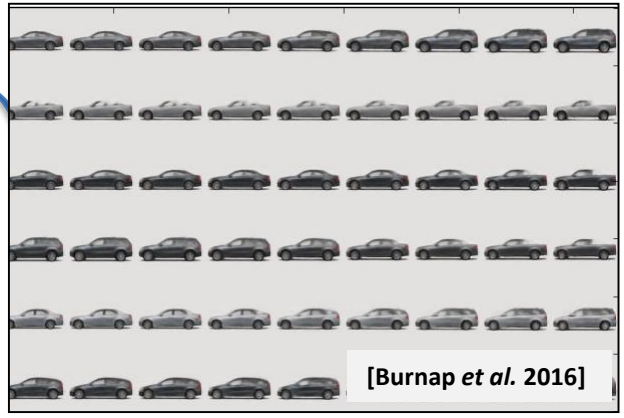
Designers are benefiting from integrating computational tools into the design process

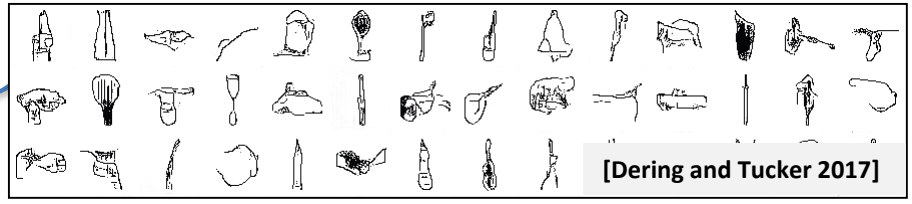
As these computational tools become more efficient, they will foster designers' creativity. [Liapis *et al.*, 2016]

AUTODESK

Generative design algorithms are helping designers explore the design space







Idea Generation

Reference	*Object Classification evaluation*	*Crowdsourcing method*
[Kazi et al. 2017][Dosovitskiy et al. 2017]	X	
[Burnap et al. 2016][Dering and Tucker 2017] [Chen et al. 2017][Ren et al. 2013]	X	X

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 ability of computational tools to produce not only novel but functional ideas, need to be explored

Reference	*Object Classification evaluation*	*Crowdsourcing method*	***Functionality evaluation***
[Kazi et al., 2017] [Dosovitskiy et al., 2017]	X		
[Burnap et al., 2016] [Dering and Tucker, 2017] [Chen et al., 2017][Ren et al., 2013]	X	X	
[Dering and Tucker 2017a] [Cunningham and Tucker 2018]			X

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

[Reitzchel *et al.*, 2006]

***RQ1*: How does the perceived functionality of 2D computer generated sketches compare to the functionality of human generated sketches?**

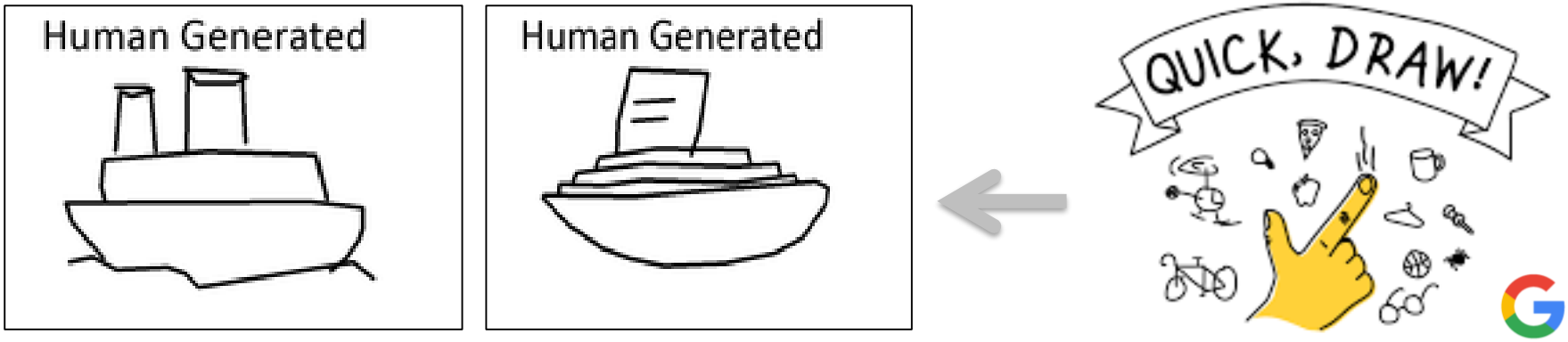
RQ2*: Are individuals' perceived functionality of 2D sketches biased towards computer generated sketches*?

***RQ3:* Are individuals capable of accurately distinguishing between 2D human generated sketches and computer generated sketches?**

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

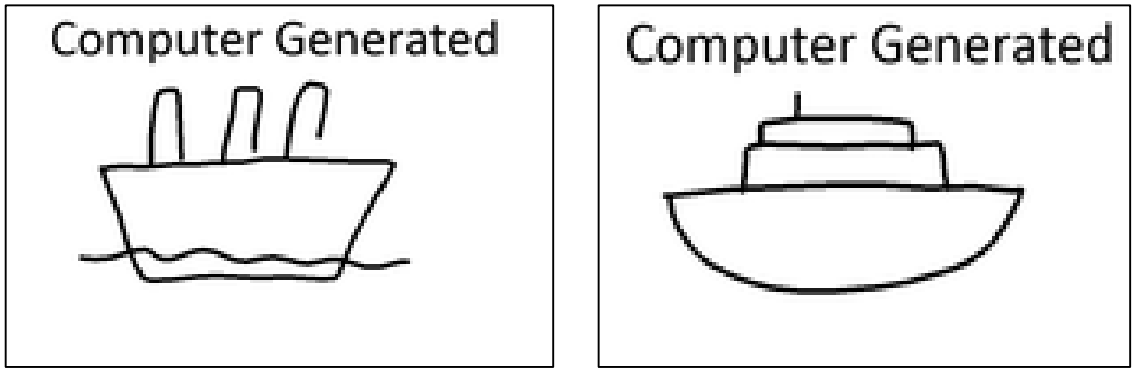
[Kazi et al. (2017)]

CASE STUDY: Boat sketches



Sketch-RNN

Ha and Eck (2017)



Questionnaire and Participants

amazon beta mechanical turk

983 Raters

(90% satisfaction rate)

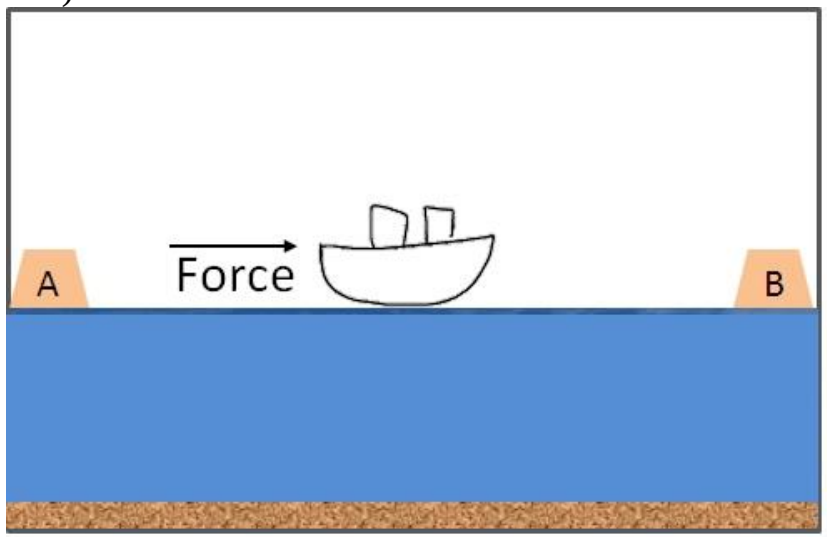
Benefits*:

(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).



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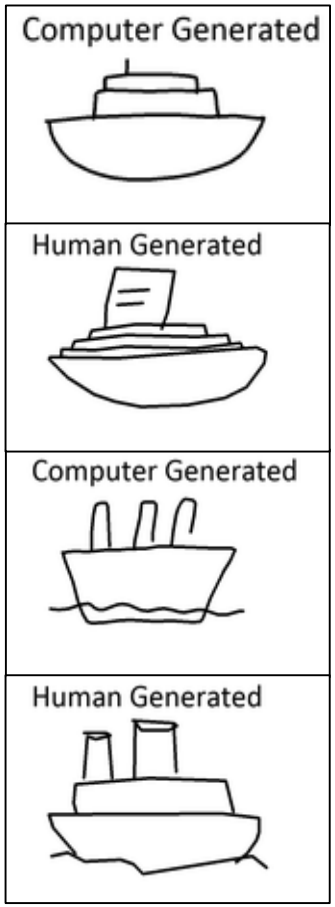
*[Mason et al. (2012), Paolacci et al. (2010)]

Questionnaire and Participants

Between-subject experiment:

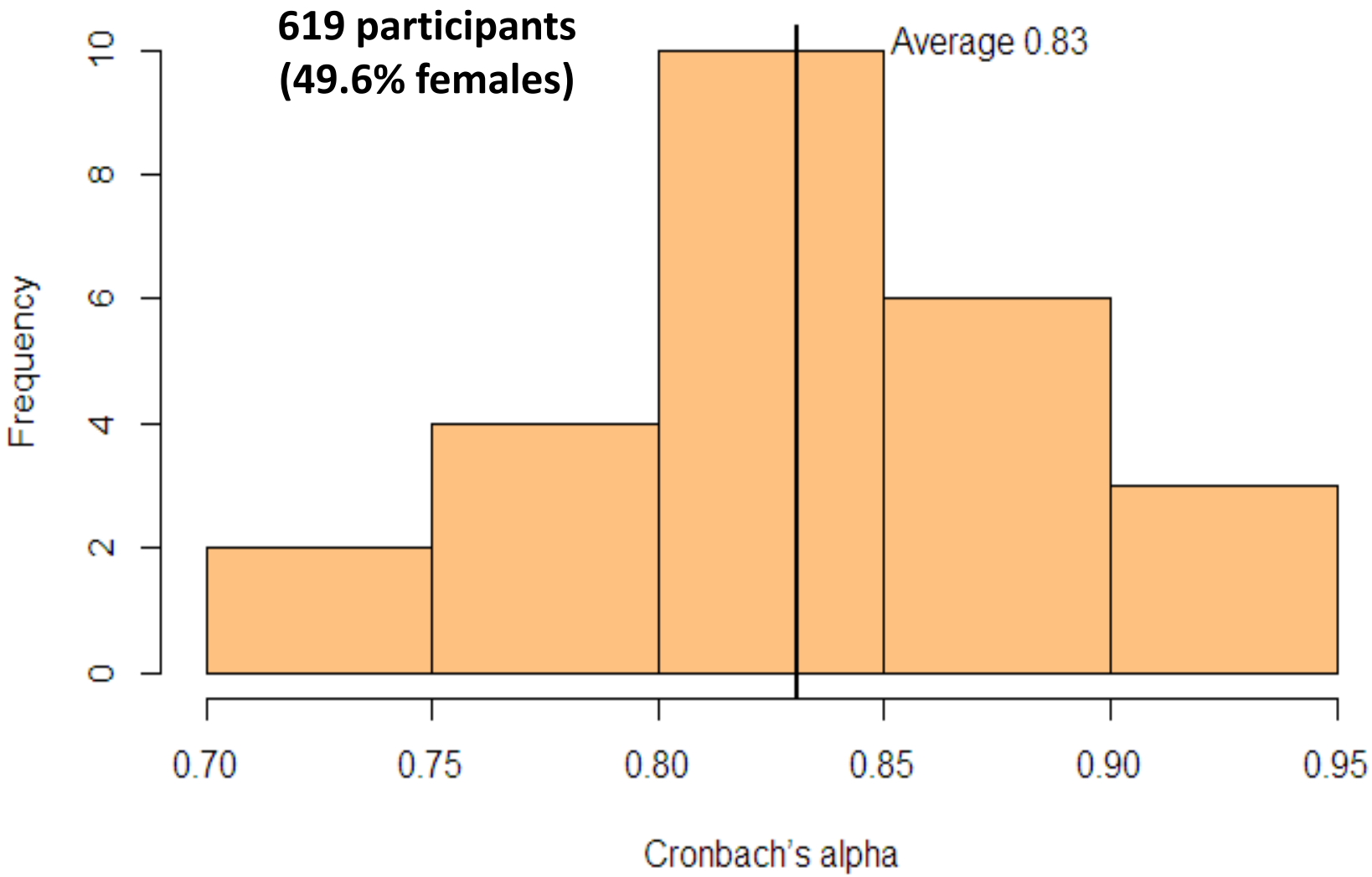
- Total of 50 computer and 50 human generated sketches
- 2 sets of 4 sketches per participant

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.

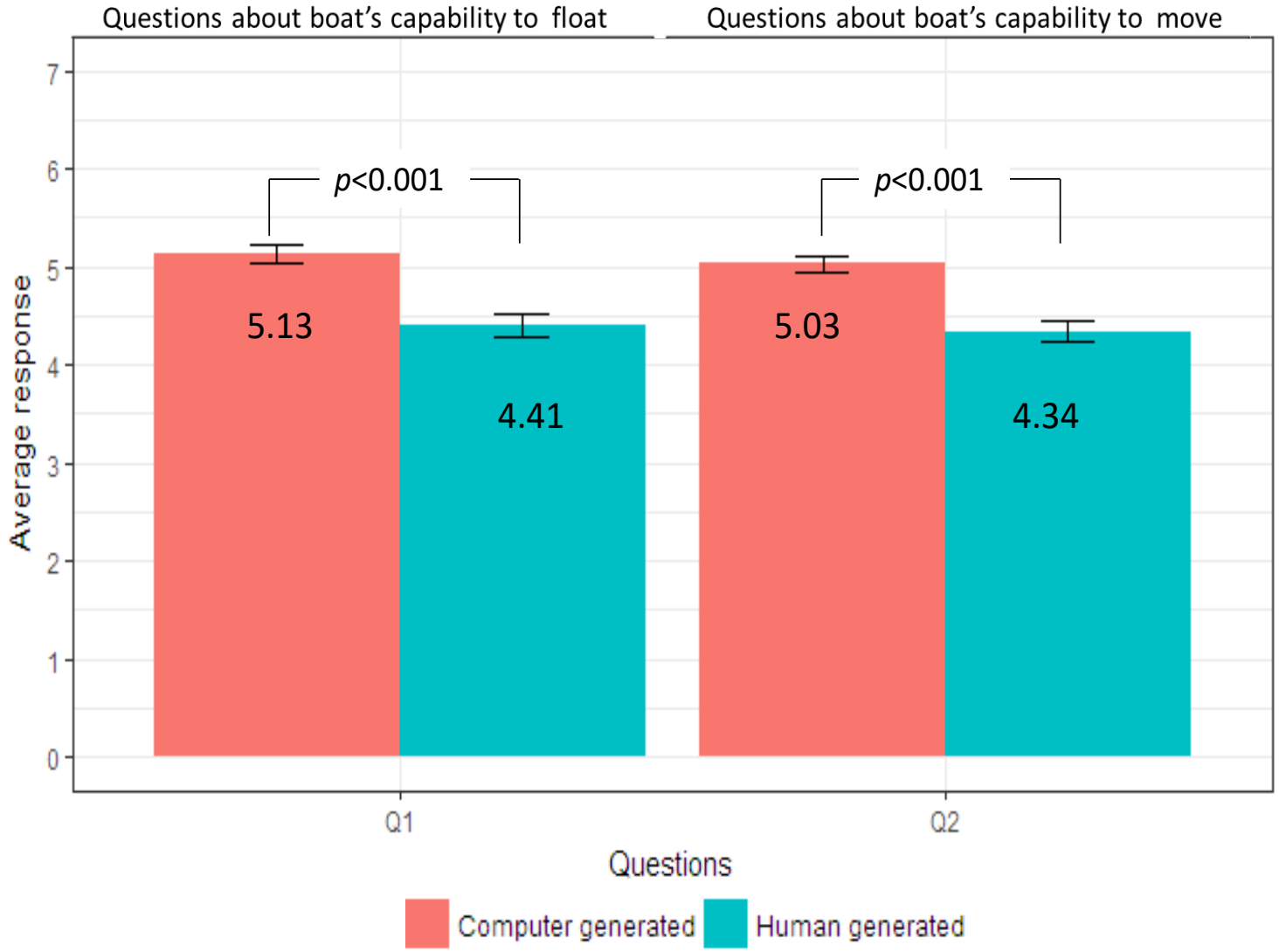


7-point Likert scale

Participants showed consensus in their responses

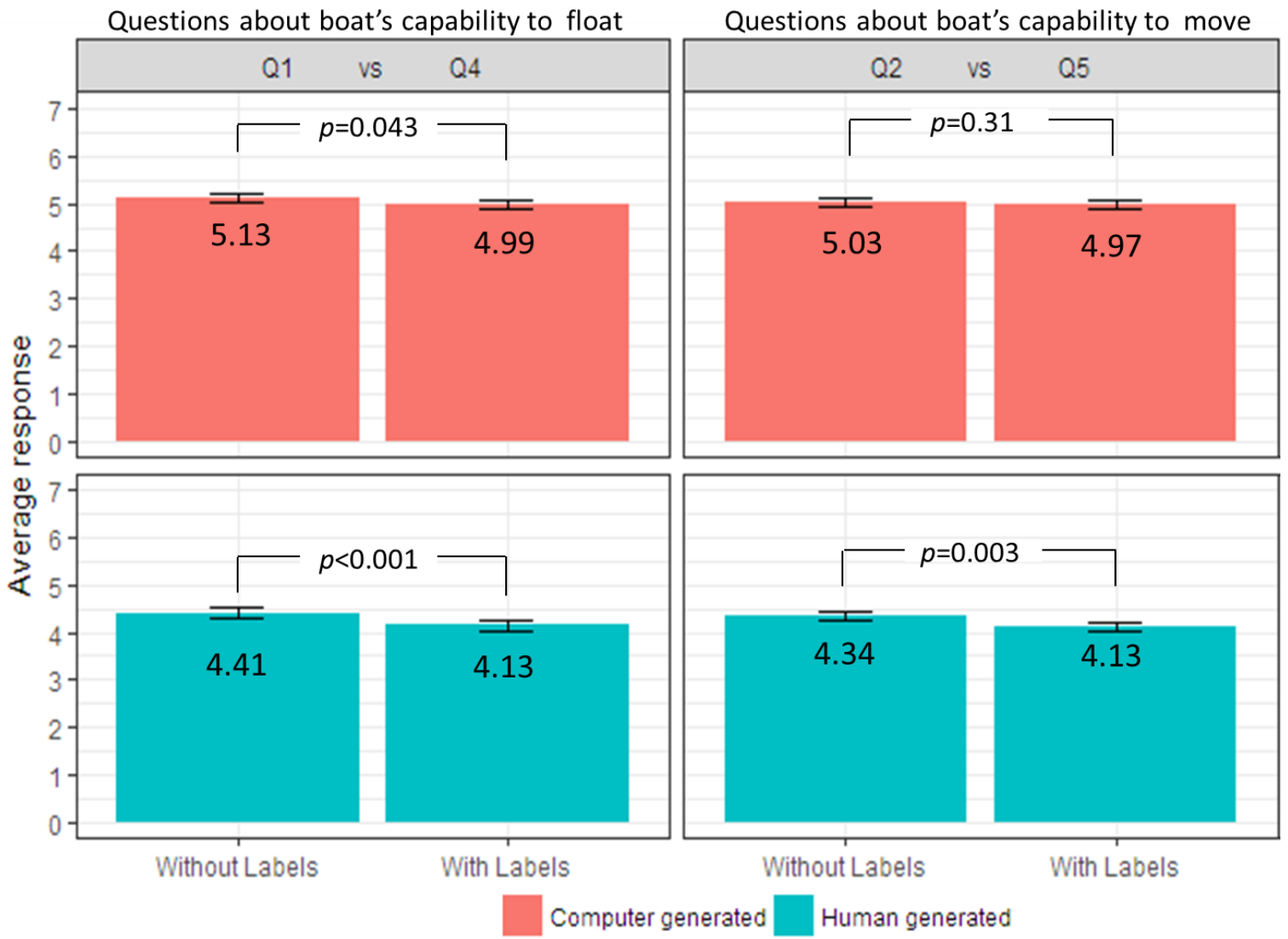


Computer generated sketches were perceived as more likely to float and move



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

- **Computer generated** sketches were perceived as **more functional** than the human generated sketches.

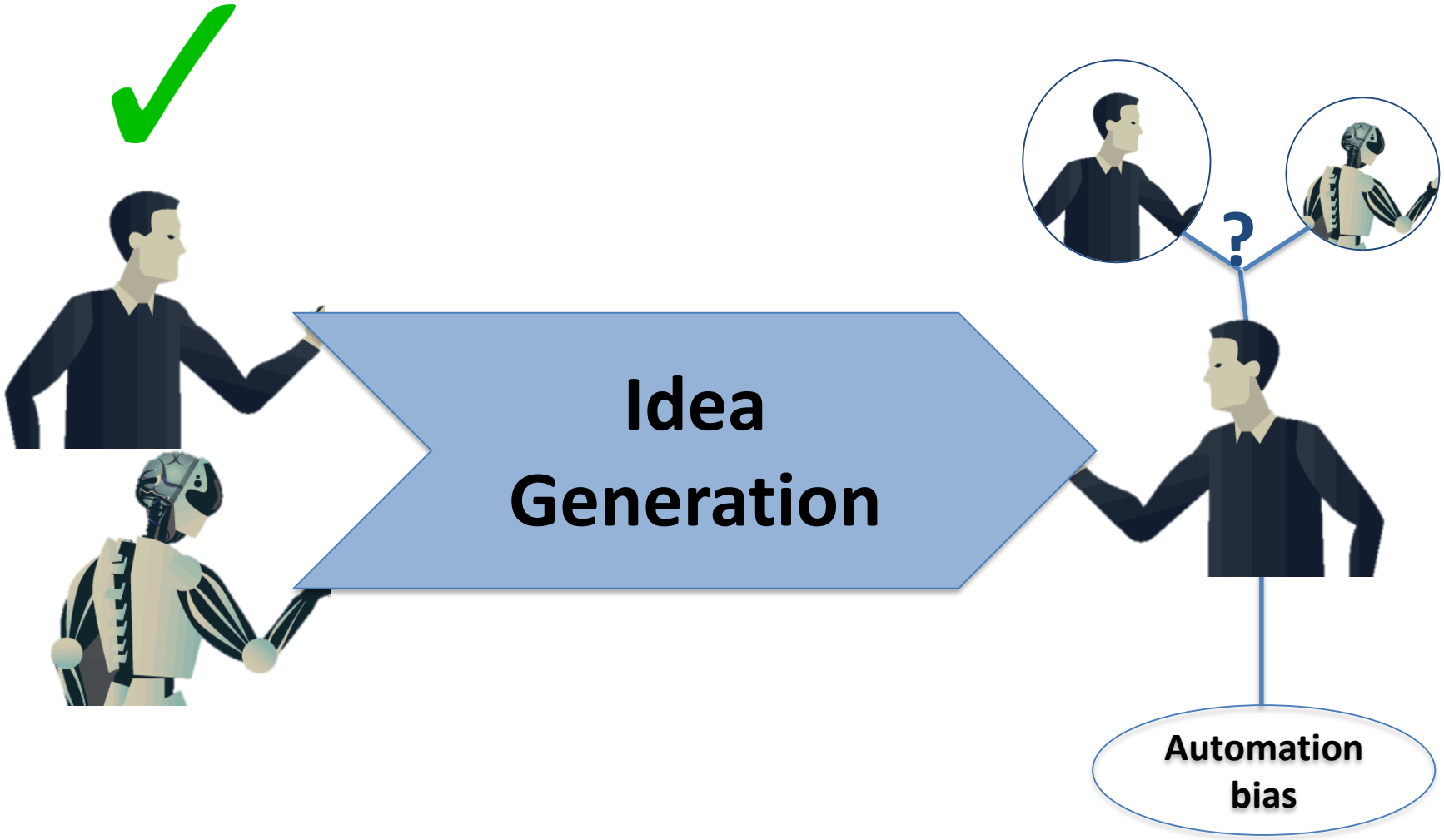
- The perceived functionality of **computer generated** sketches **was not affected** by explicitly presenting them as computer generated.

- The perceived functionality of **human generated** sketches **was affected** by explicitly presenting them as human generated.

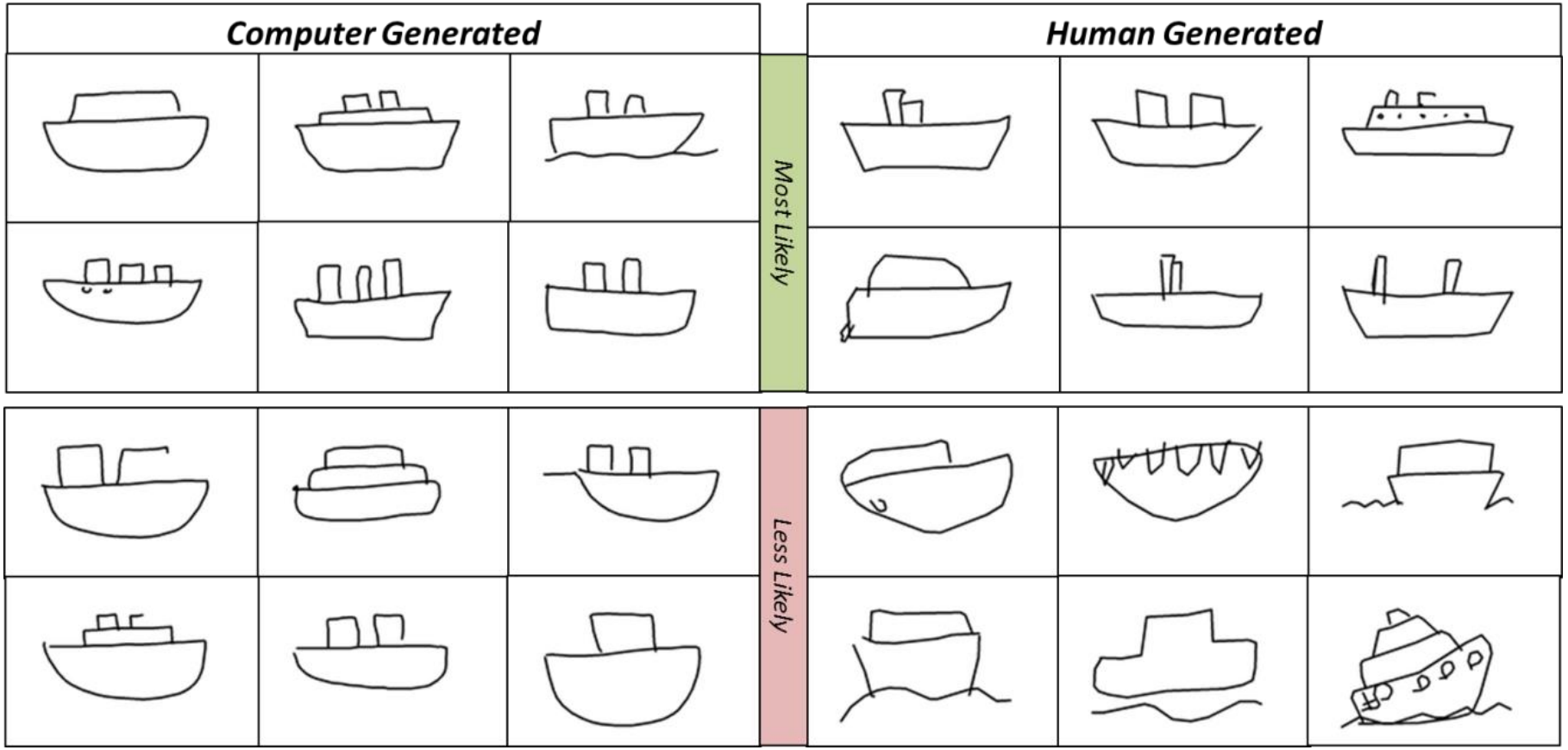
- Individuals **were not able to accurately distinguish** between the human and computer generated sketches.

As computational tools become more efficient, they will foster designers' creativity

[Liapis *et al.*, 2016]



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



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D.A.T.A. Design Analysis Technology Advancement Laboratory

www.engr.psu.edu/datalab

Thank you!

sites.psu.edu/clopez

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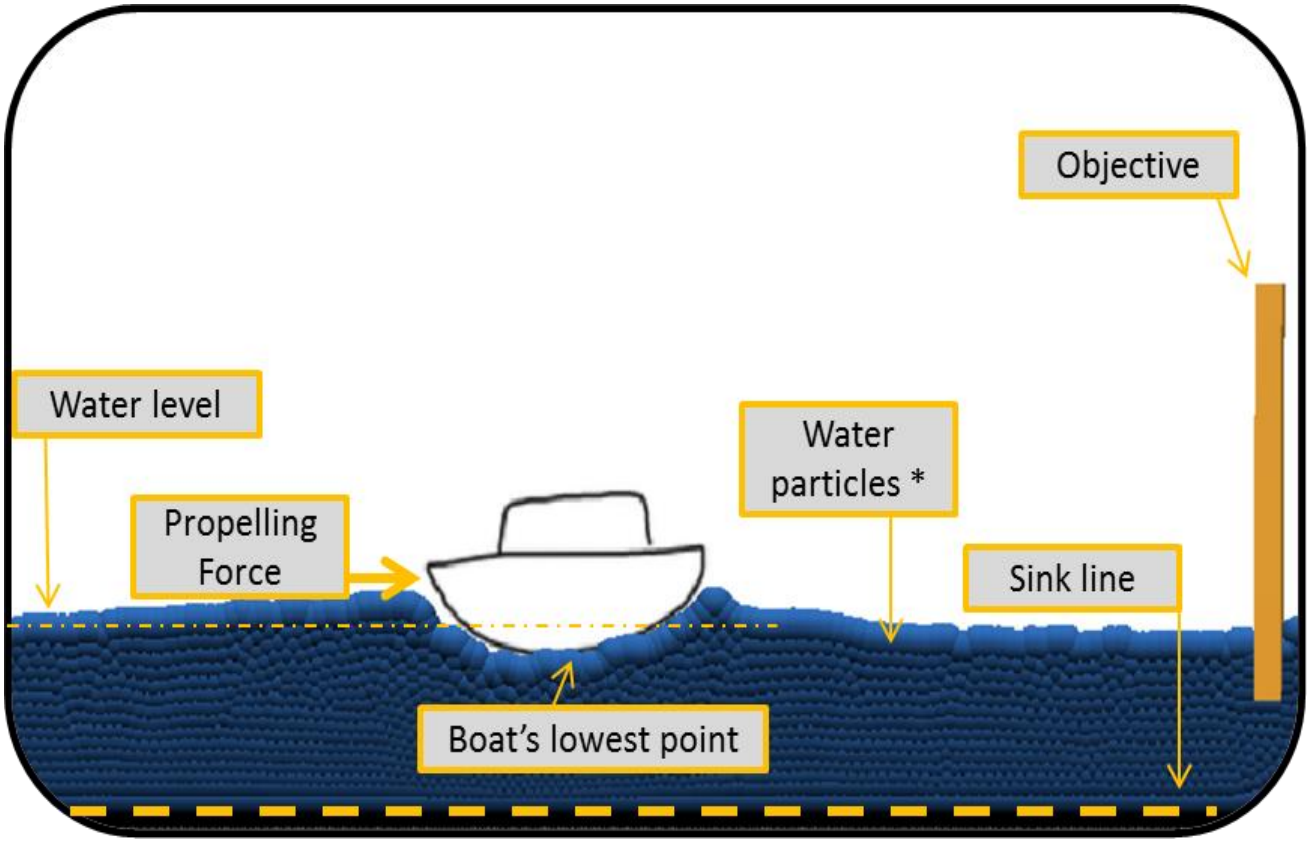
Validating raters' perceived functionality

Physics Computer Simulation



[Cunningham and Tucker (2018)]

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

Variables		Pearson correlation (ρ)	p-value
Float Score	***Speed Score***	0.83	<0.001
Float Score	***Q1***	0.3	<0.01
Speed Score	***Q2***	0.5	<0.001
Q1	***Q2***	0.82	<0.001