Modelling Perceptually Efficient Aquatic Environments

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Humans effortlessly recognize water, but what makes recognition possible? We conducted empirical studies where target images of water are paired with similar distractors.

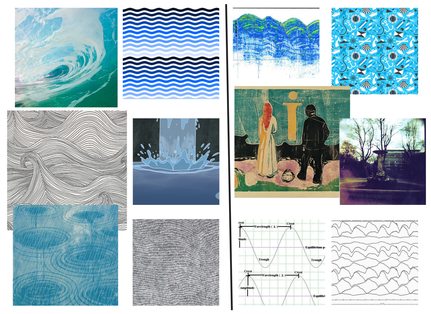
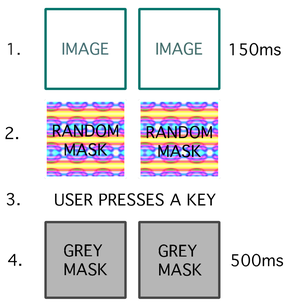


Fig. 1: Nonphotorealistic targets (left) in different styles and distractors (right) sharing context and visual features common to water.

Initial experiments produced little discernible pattern. Contextually or visually similar distractors make users slow down and make mistakes, but unrelated distractors can isolate salient aspects of the target.

Experiment Design



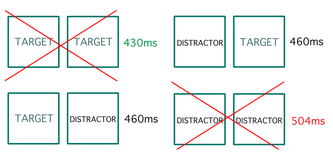


Fig. 2: An experiment trial. Trials with two targets and two distractors result in different mean reaction times consistent with the previous findings and were removed from later experiments.

Users as quickly as possible press the key corresponding to the image that represents water. We record and analyse error rates and response times using ANOVA and formulate a hypothesis of efficient water recognition.

Data Pre-processing

- Average mistake rate is 5 %
- Outliers more than 3SD from the mean are removed.
- Regression is used to remove trends because users speed up or slow down during a session.
- Responses faster than 280ms precede ERP and are ignored.
- Responses longer than 900ms are labeled as failure to respond.
- Sessions with mistake rates above 5% are discarded.

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Two Experiments

Experiments were conducted on a laptop screen with ten volunteer participants each.

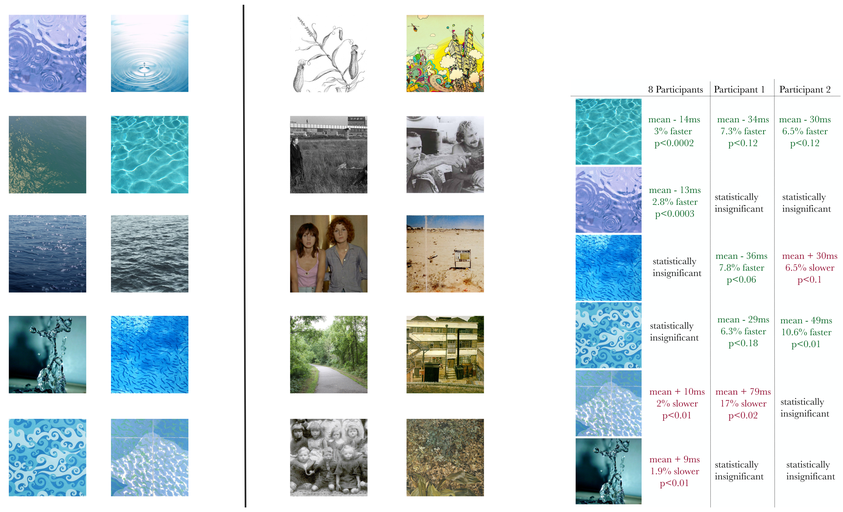

Fig. 3: Experiment 1. Targets (left) and distractors (right). Some users show statistically significant effects, which are usually stronger than the central tendency. Preferences differ for the same user from day to day.

Second experiment is a refinement based on observations made above.

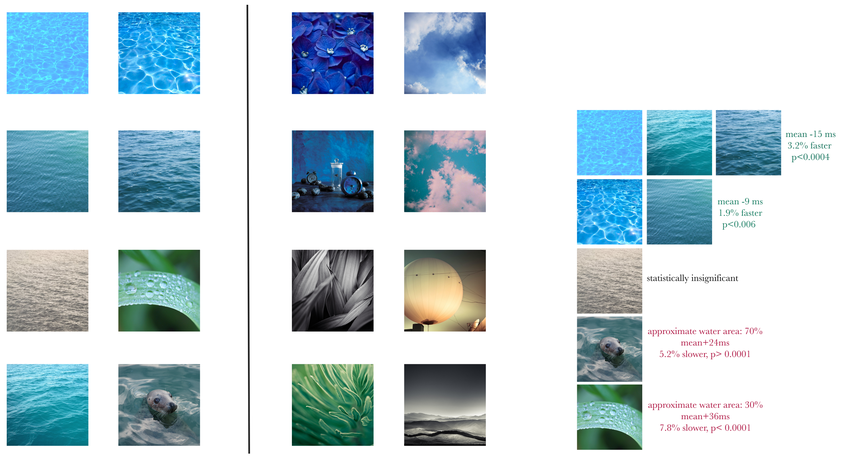

Fig. 4: Experiment 2. Targets (left) and distractors (right). Images with elements other than water take longer to recognize.

Fig. 5: Distractor effects, Experiment 1

Fig. 6: Distractor effects, Experiment 2

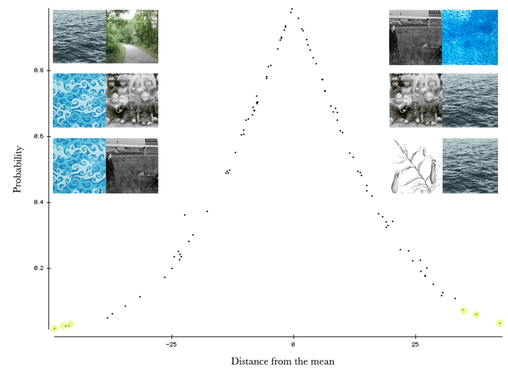

Fig. 7: Recognition of individual image pairs, each shown for 18 trials on average, including both trials with targets on the left side and targets on the right side.

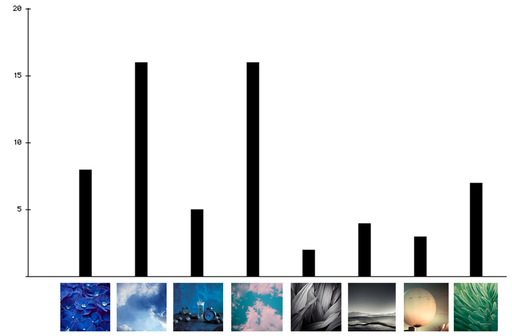

Fig. 8: Mistake rates by distractor. Blue sky distractors resemble a reflection and cause mistakes. Unrelated blue distractors have no significant effect.

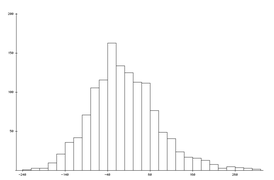

Fig. 9: Experiment 1, 2700 trials

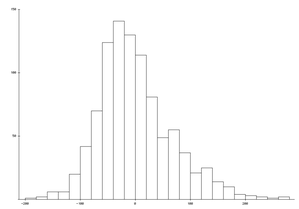

Fig. 10: Experiment 2, 1060 trials

The metodology we used produces very clean data with on average 60 trials a minute, SD=80.

Conclusion

Efficient recognition of water depends on discernible wave structure (ripples, circles or caustics), color and contrast.

Distractors containing simple visual features common to water, which are registered preattentively, affect the response.

Verifying our hypothesis with formal experiments will provide designers with a toolbox for efficiently modelling and rendering water.