

JMM 2018, San Diego, California

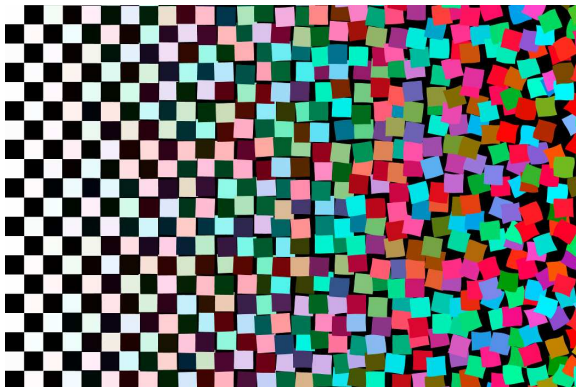
## New Metamorphosis Patterns

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# Outline

- ▶ Background and inspiration
- ▶ M.C. Escher's Metamorphosis prints
- ▶ Our metamorphosis images
- ▶ Conclusions and future work
- ▶ Contact information

## Background and Inspiration

Our goal is to show patterns with different kinds transitions.

Most of our images start in an ordered way but end up in a less ordered, more chaotic state.

In contrast, M.C. Escher's prints usually show transitions from one kind of order to another — a pattern based on squares deforming into a pattern based on hexagons, for example.

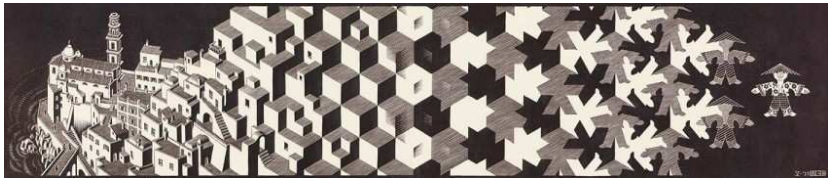
In fact, Escher's three "Metamorphosis" woodcuts were part of the inspiration for our work. We show them below.

Craig Kaplan discussed Escher transformations in his 2008 Bridges paper *Metamorphosis in Escher's Art*.

## Escher's Metamorphosis Woodcuts Work

- ▶ *Metamorphosis I*: 1937, about 36 by 7.7 inches.
- ▶ *Metamorphosis II*: 1940, about 23 feet by 7.7 inches.
- ▶ *Metamorphosis III*: 1967, about 22 feet by 7.7 inches.

# Metamorphosis I



## Metamorphosis II

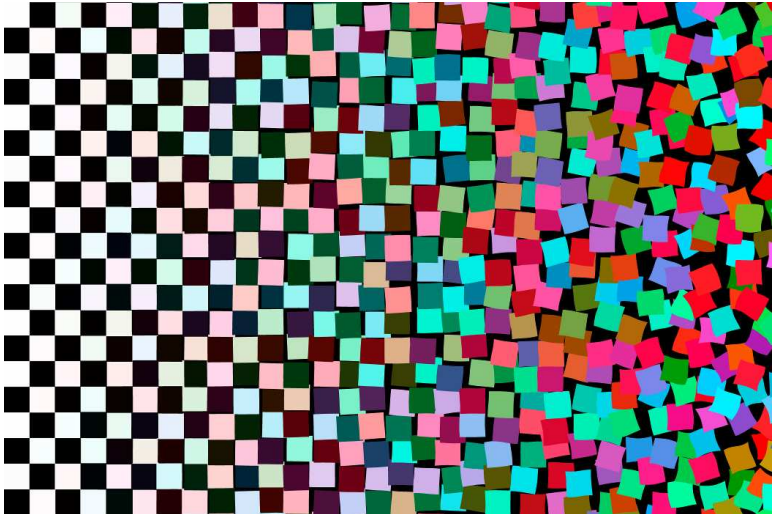


## Metamorphosis III



# Our Metamorphosis Patterns

*Order and Chaos*





## Ideas behind our patterns

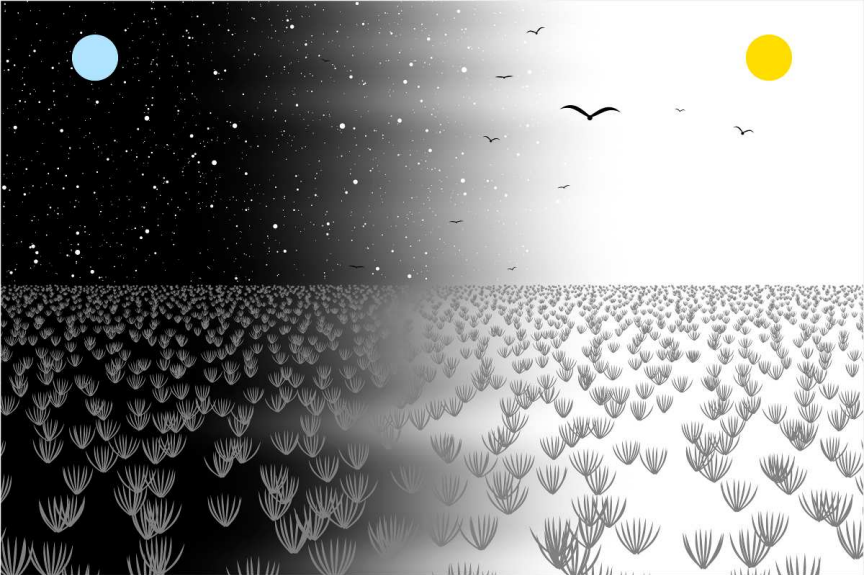
In going from order to disorder, we can vary several quantities starting with regular values and ending with random values in some range. Some of those quantities are listed below.

- ▶ The positions and orientations of elements of the image.
- ▶ The boundaries of the elements — going from flat to wavy.
- ▶ The curvature of path, starting out straight.
- ▶ The colors — often starting from black and white, then tracing a path through RGB space.
- ▶ Adding interior details to elements, starting with no such details.

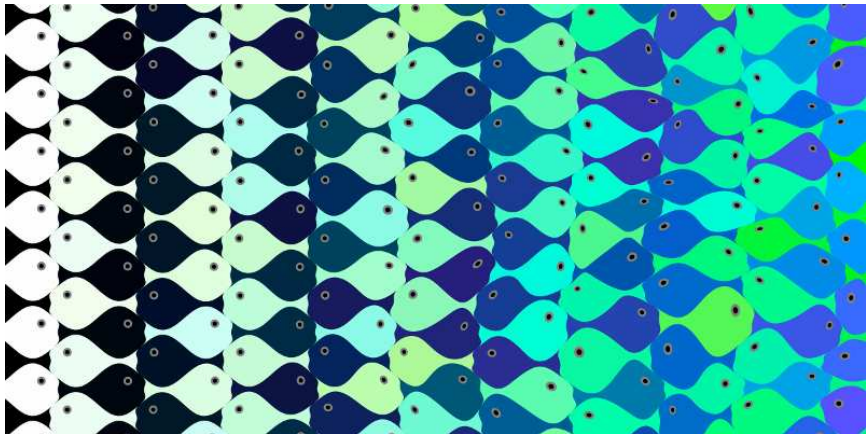
## Entropy

ENTROPY

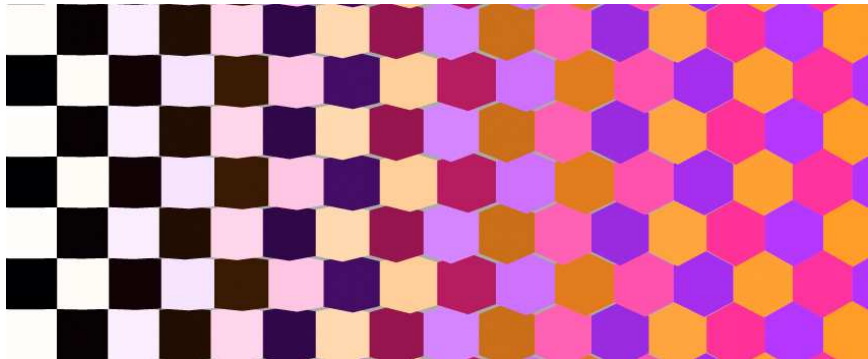
# Day into Night



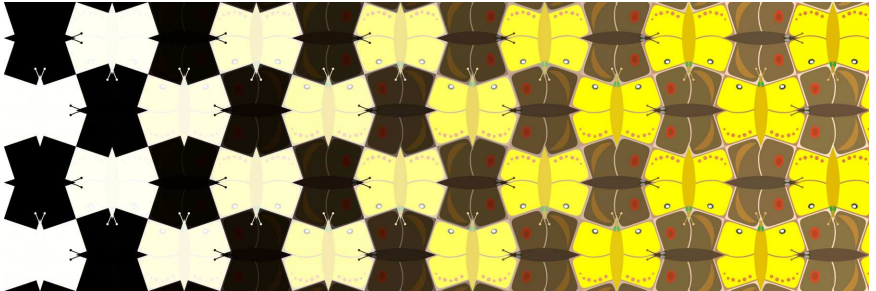
## Teach a Fish to Swim



## Squares to Hexagons



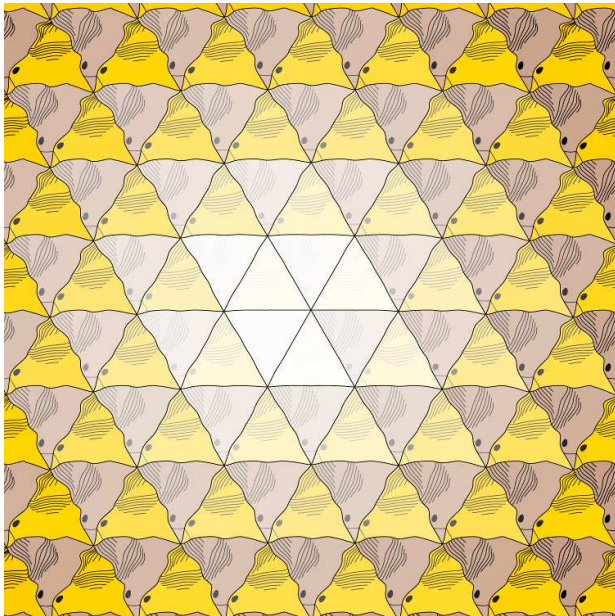
## Progressive Butterflies I



## Progressive Butterflies II

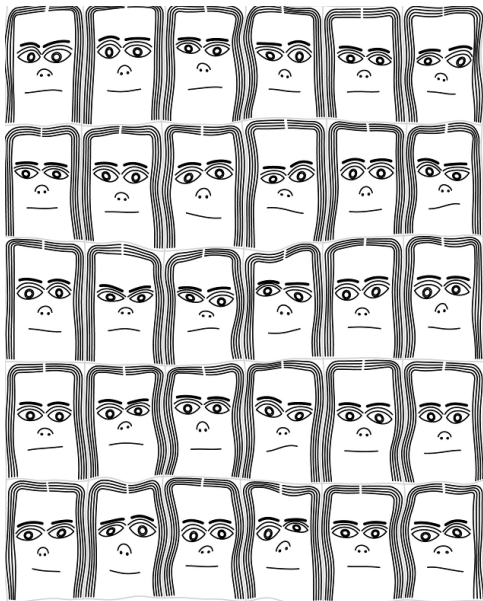


## Two Birds

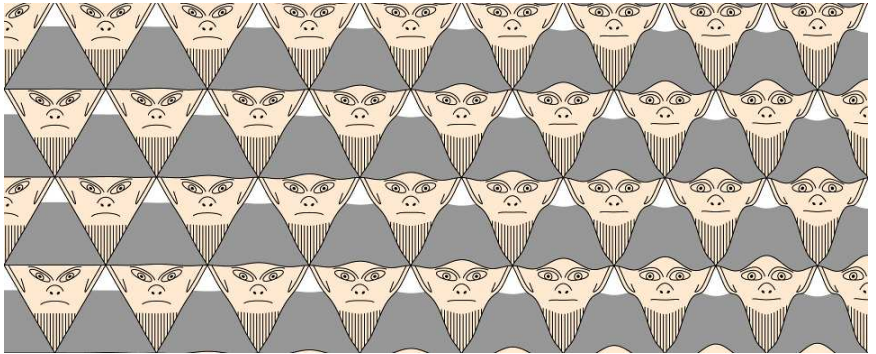




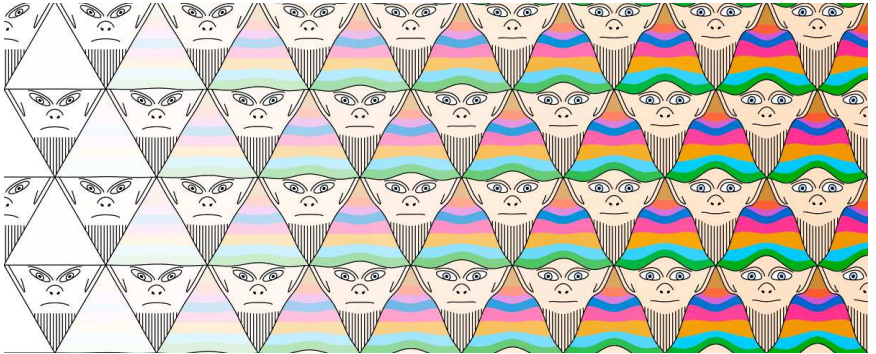
## Waves of Emotion



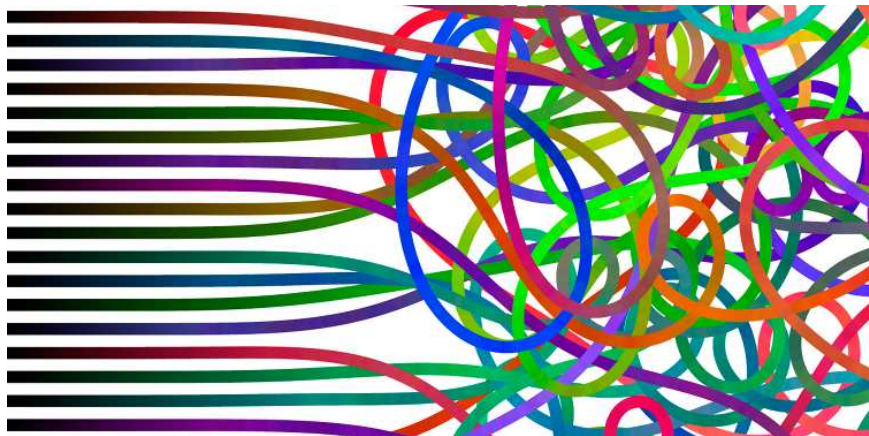
## Soldiers



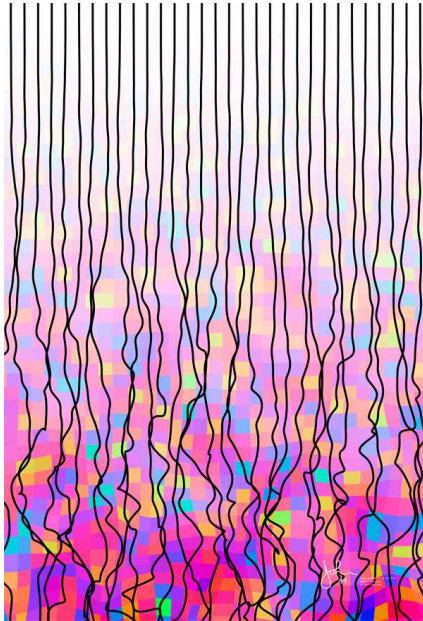
# Elves



## Quantum Entanglement Explained



## Colorful Seaweed



## Future Work

- ▶ We have shown some transitioning patterns, but certainly there are more possibilities. We have not even explored all the Escher prints for more inspirations.
- ▶ We have shown some elements that can be varied, such as position, orientation, shape of the boundary, and color. But there are an unlimited number of functions to apply to achieve such variations, and we have barely begun to explore them.

## Acknowledgements and Contact

Of course we owe Reza Sarhangi a tremendous debt for inspiring us to do mathematical art.

We would also like to thank Doug Norton for organizing the SIGMAA-ARTS sessions.

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