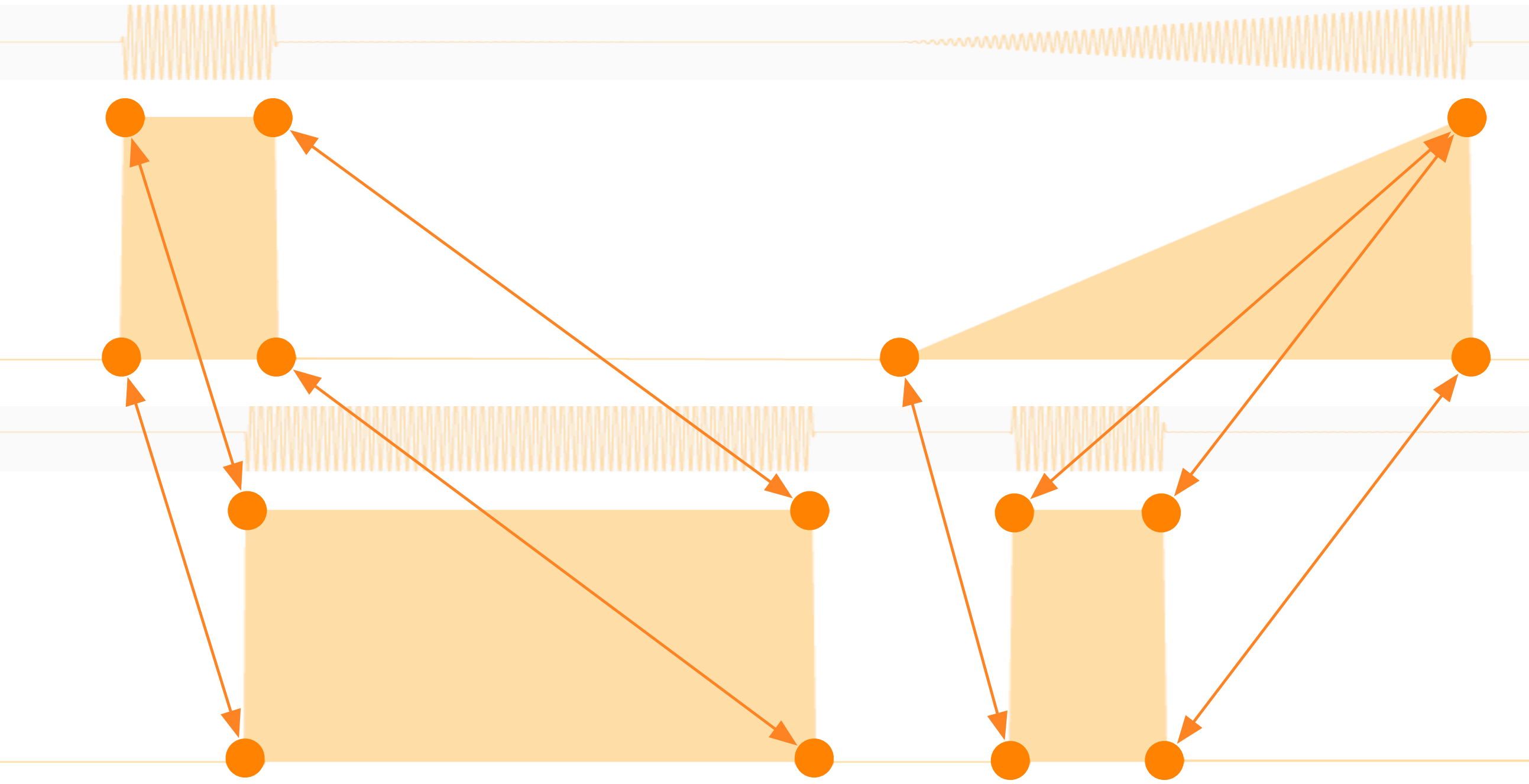


Predictable and distinguishable **morphing** of vibrotactile rhythm



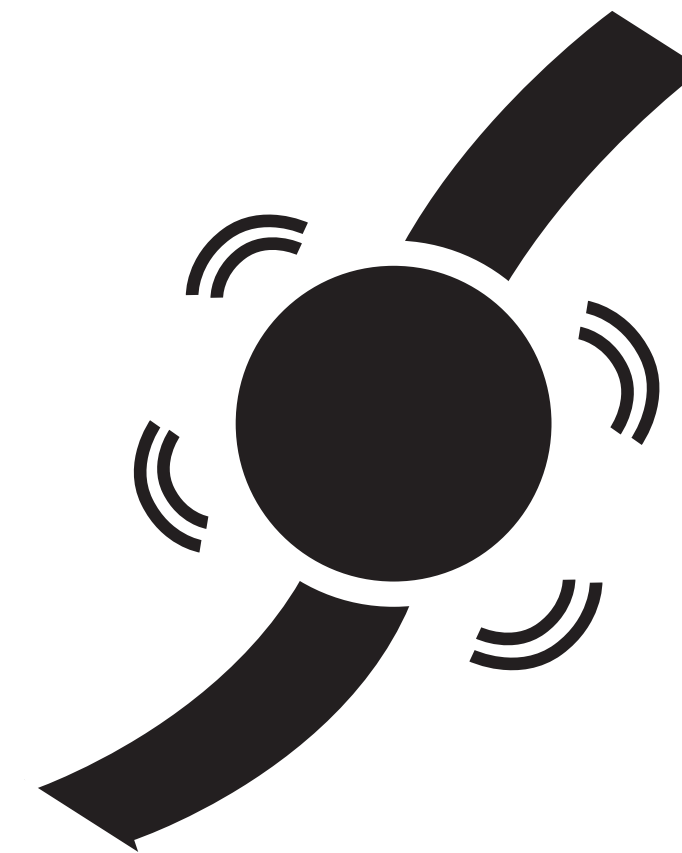
THE UNIVERSITY OF BRITISH COLUMBIA



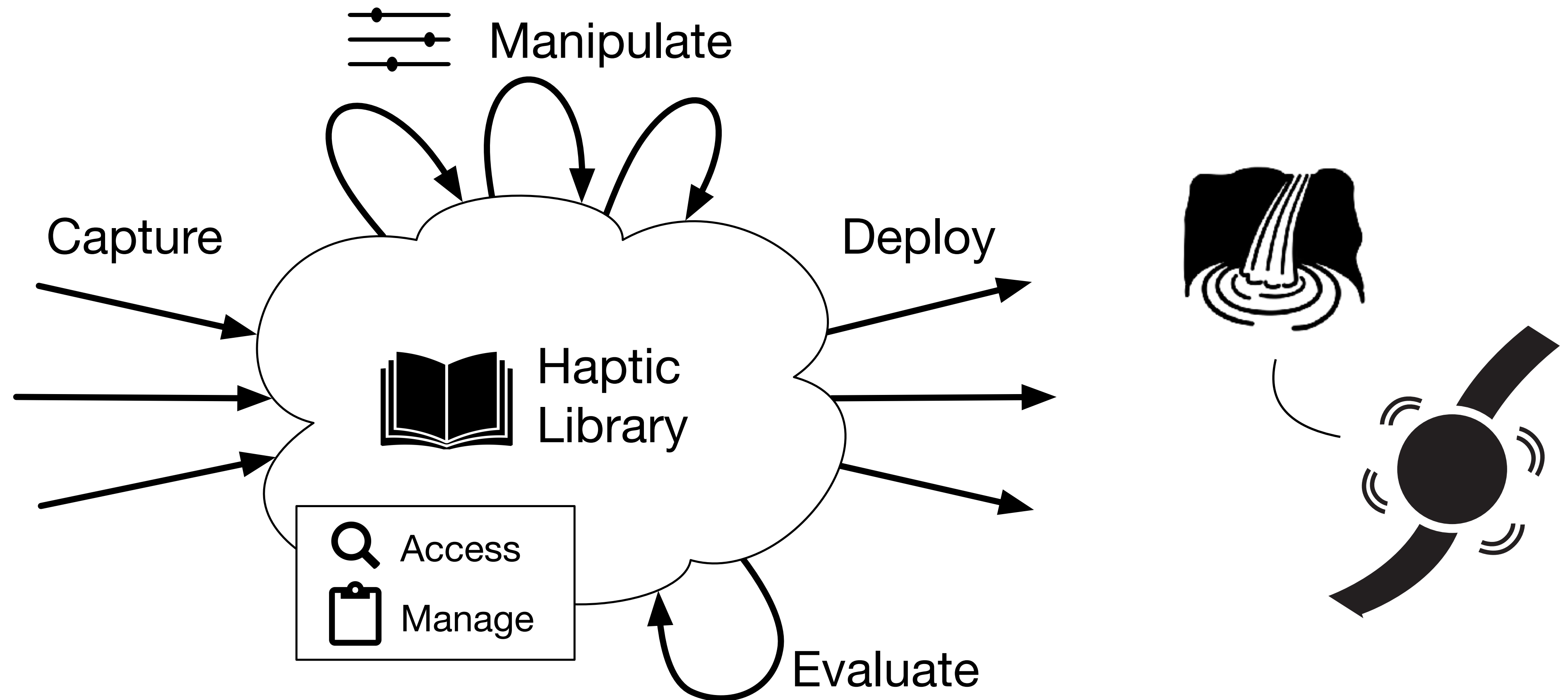
oliverschneider.ca/macaronmix

Ben Clark,
Oliver Schneider,
 Karon E. MacLean,
 Hong Z. Tan

haptic experience design



design ecosystem



design ecosystem

have

sophisticated hardware
insightful psychology

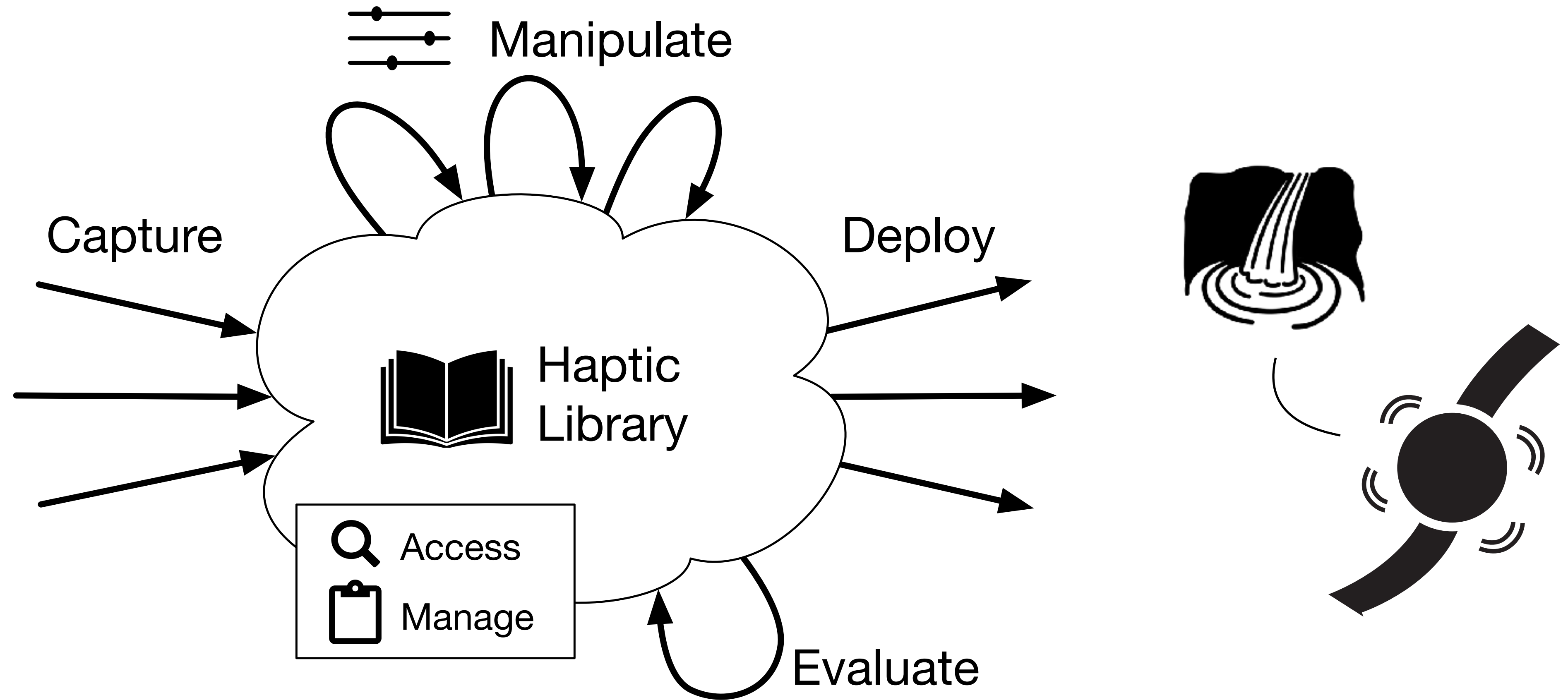
**bottleneck:
content creation**



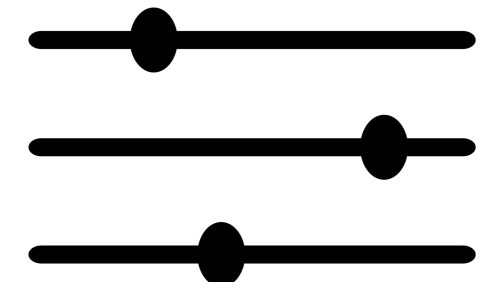
must connect to

applications:
diversity in hardware, users, needs

design ecosystem



design ecosystem

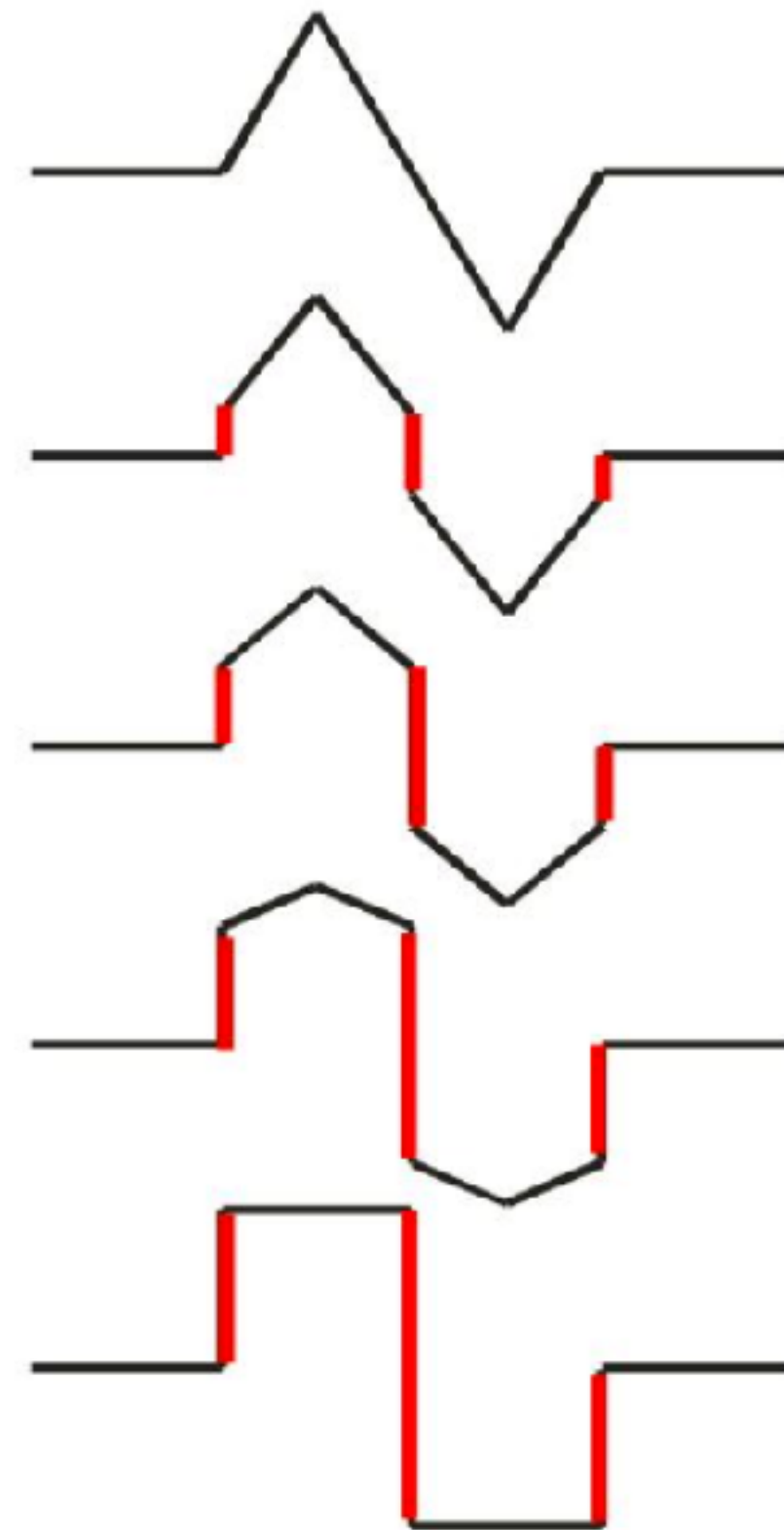


Manipulate

morphing



morphing



Triangle

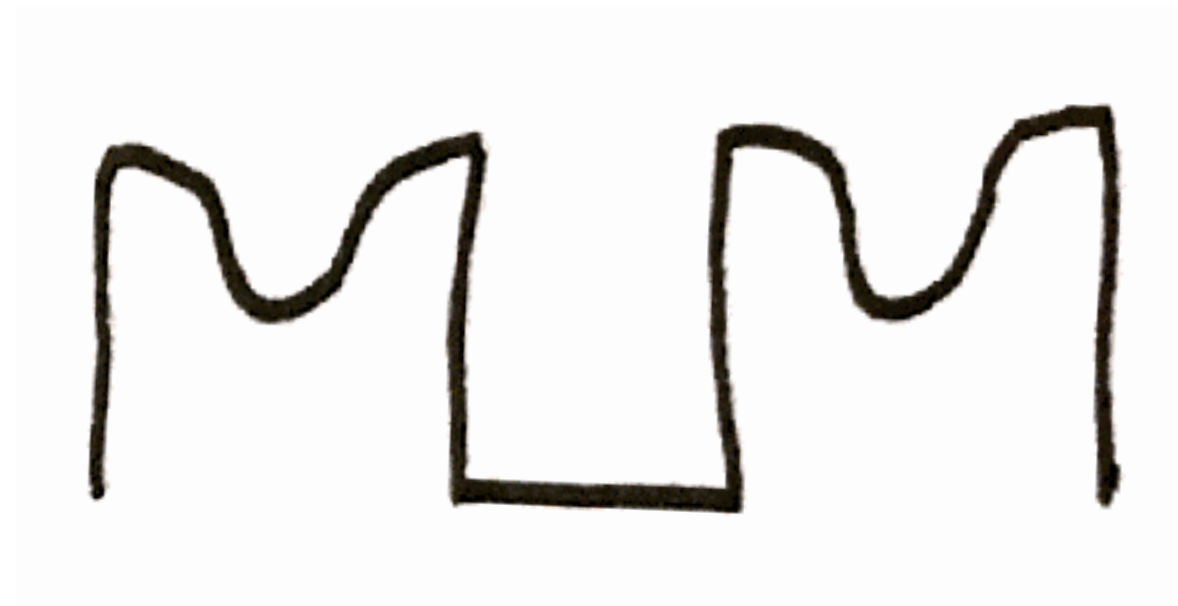
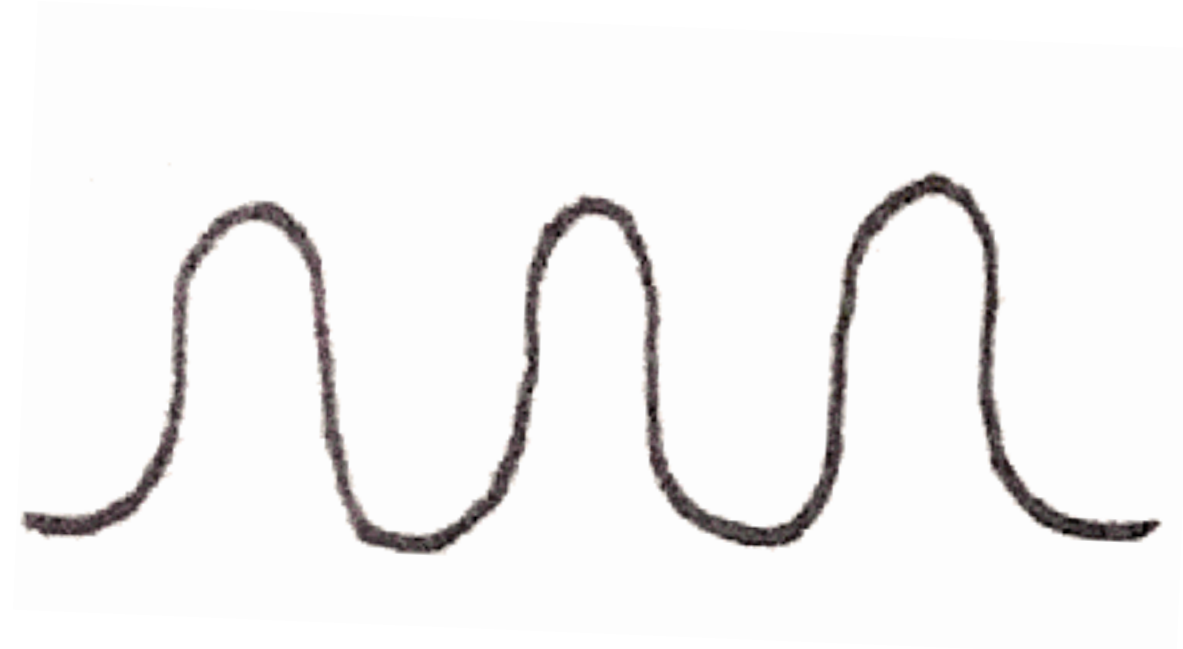
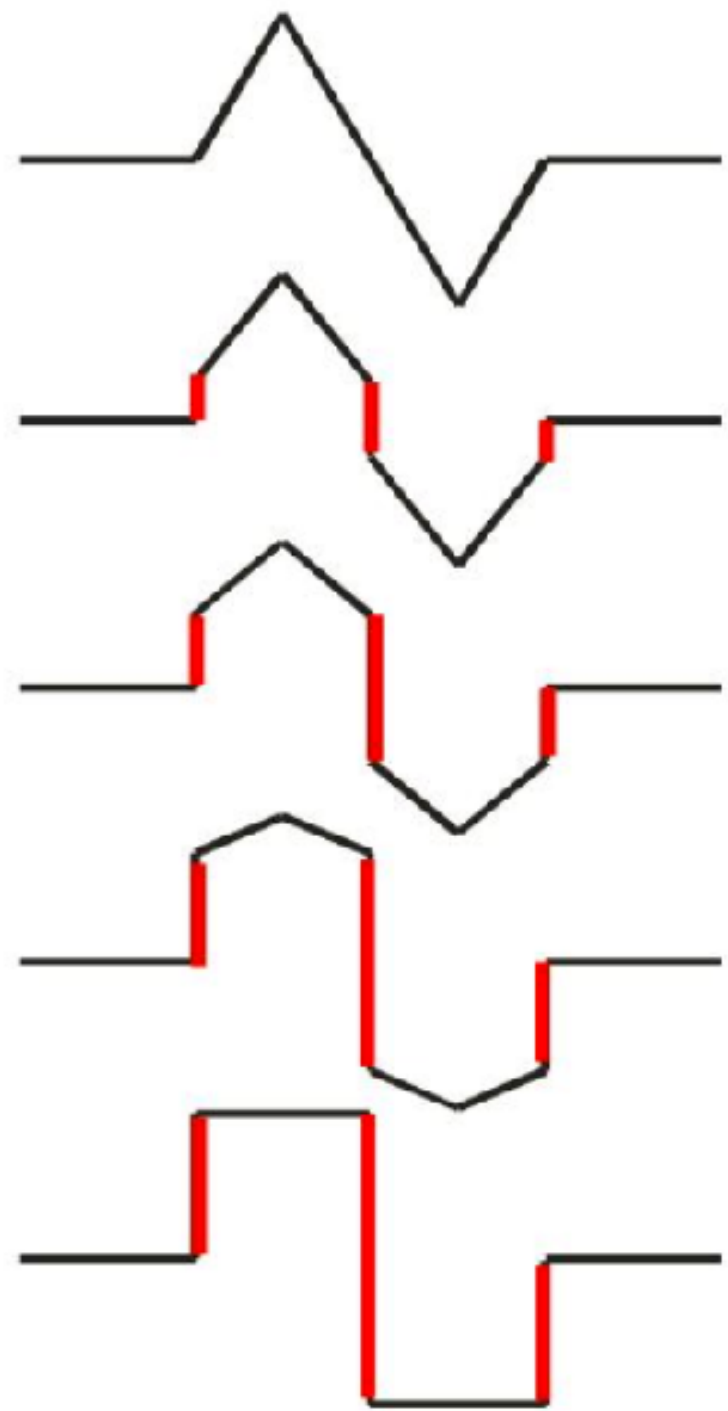
25% Morph

50% Morph

75% Morph

Square

morphing

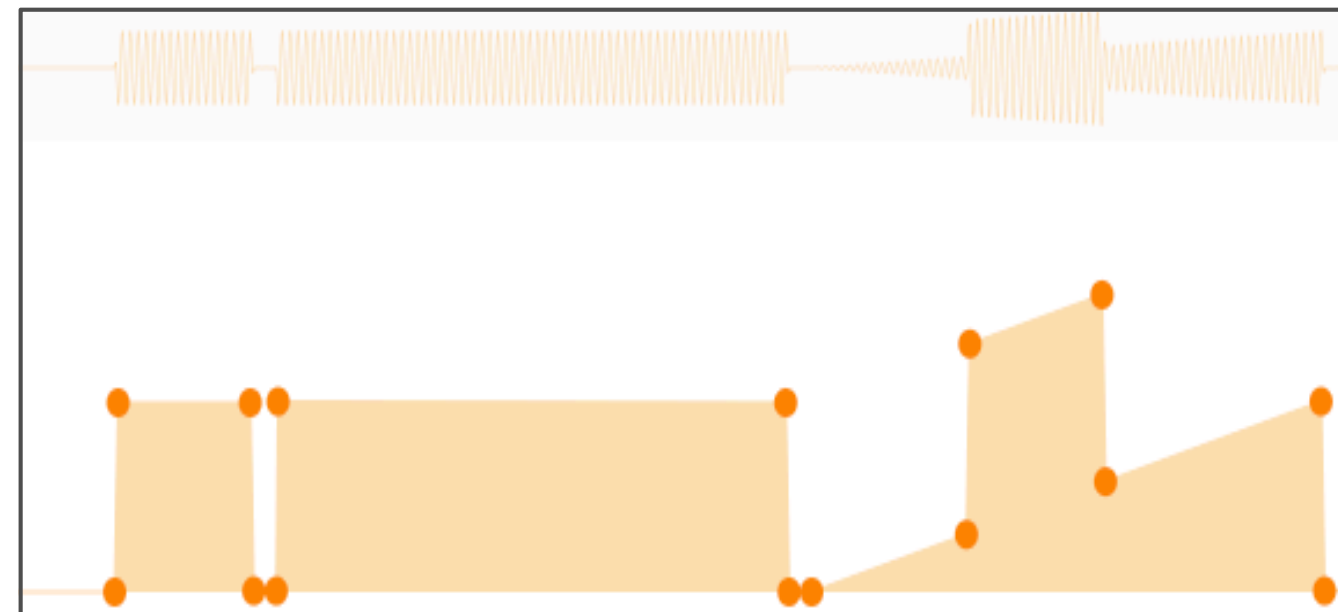
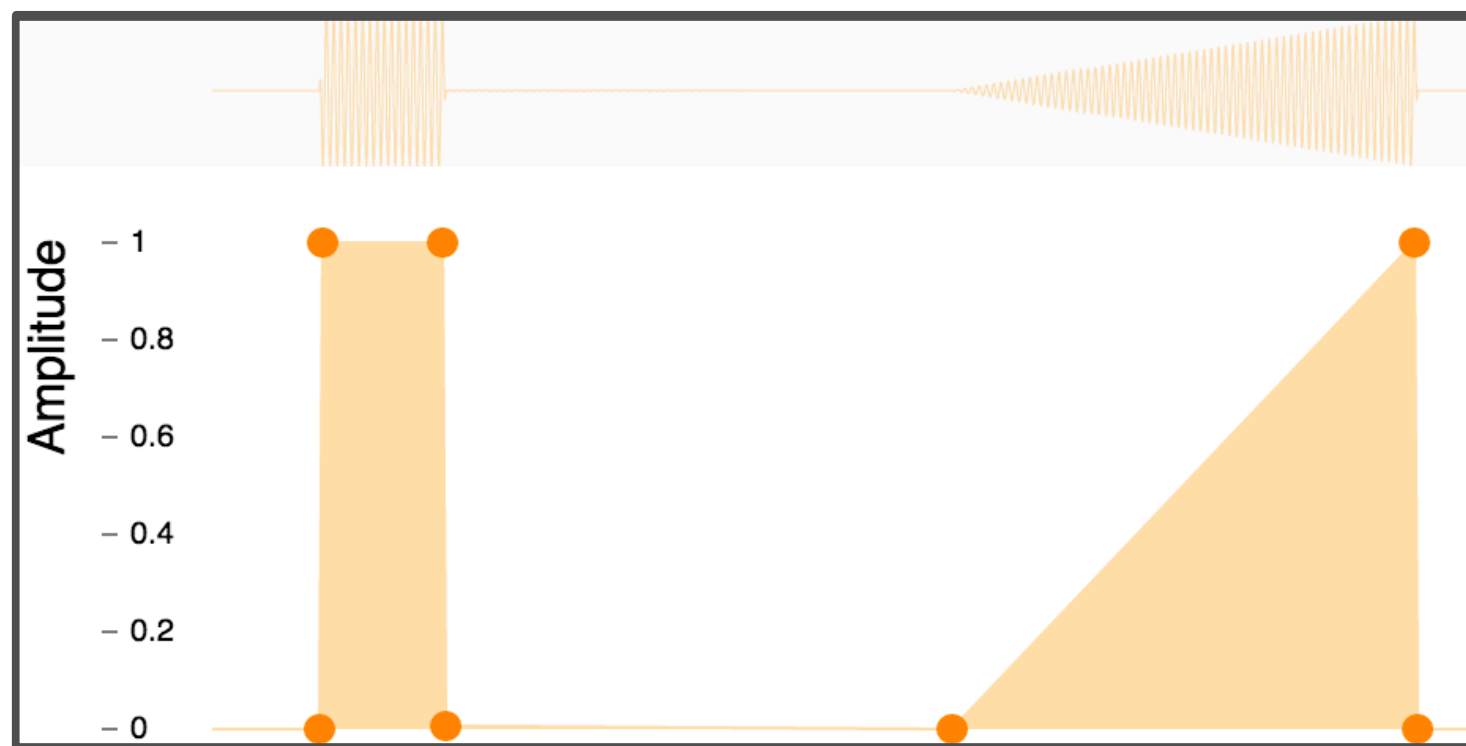




we use vibrotactile sensations as our test case

Algorithms

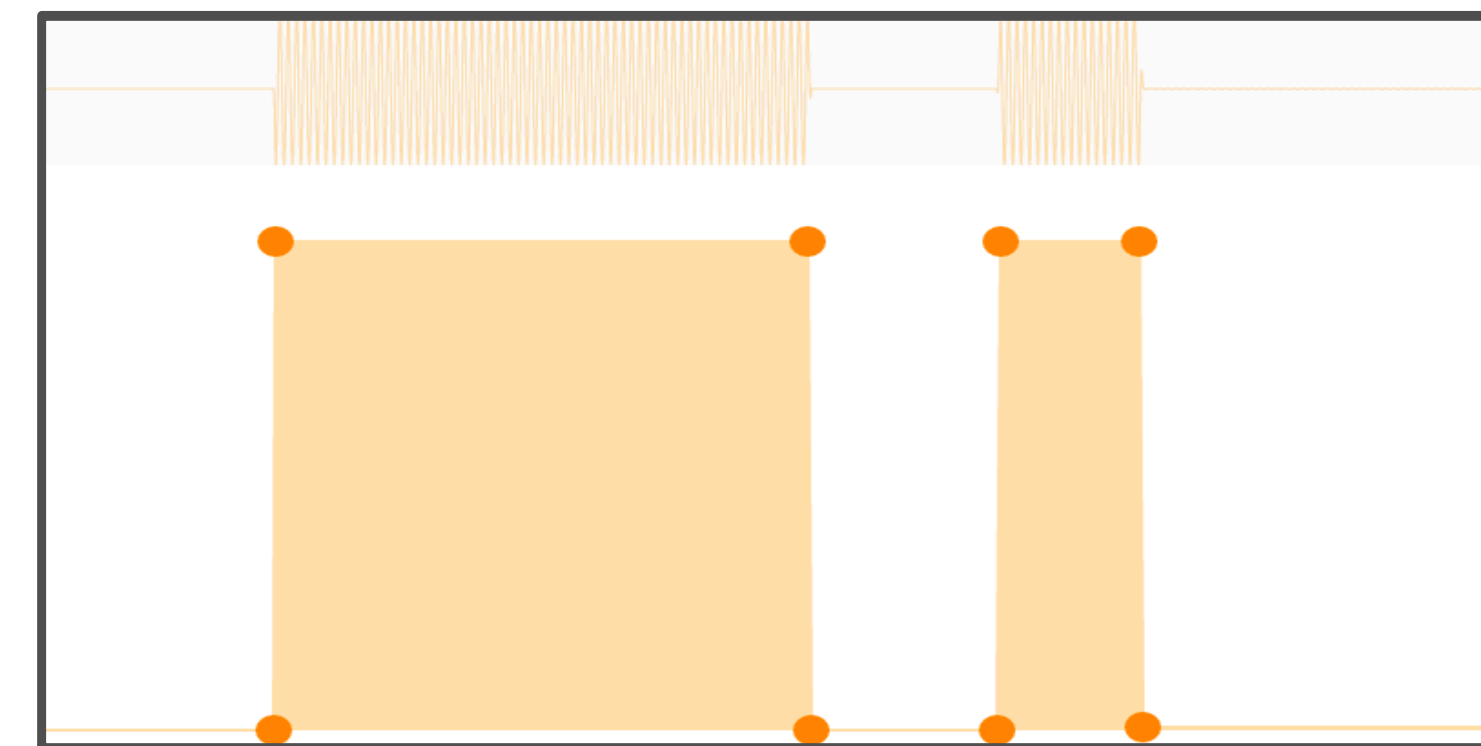
parent 1



simple crossfade

morph

parent 2



simple crossfade



simple crossfade

Select your mixing algorithm: Vector Crossfade

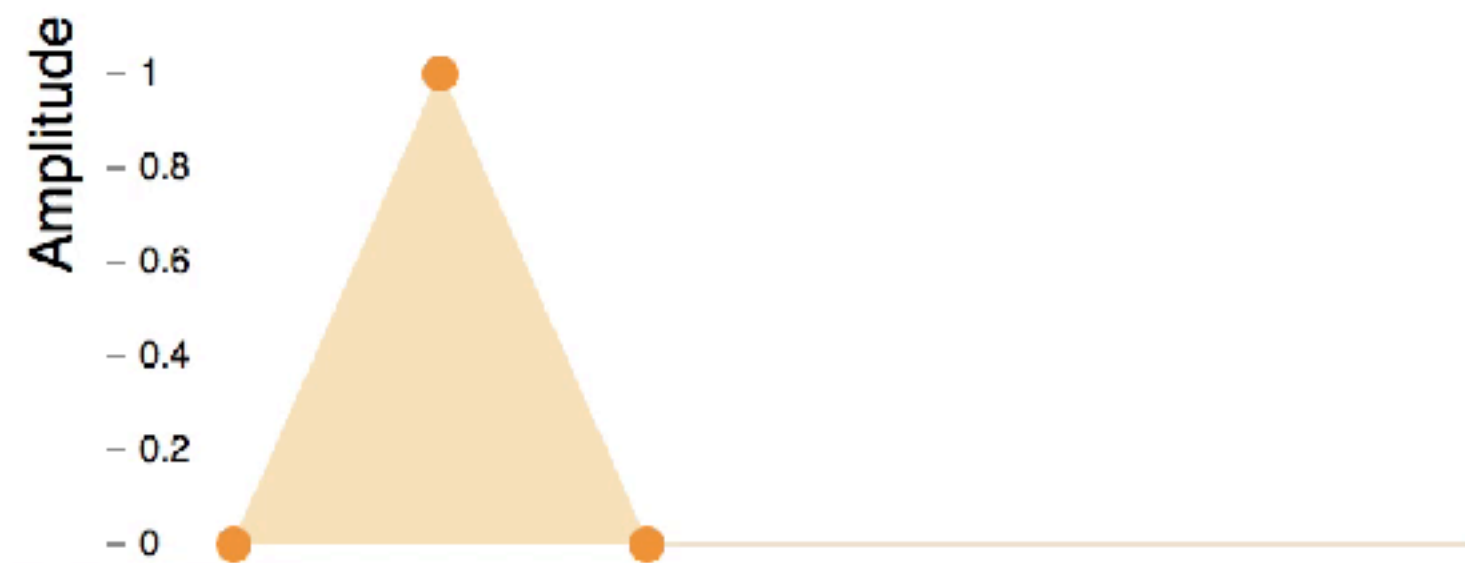
Quick Mix: 0% 25% 50% 75% 100%

load waveform 1 load waveform 2

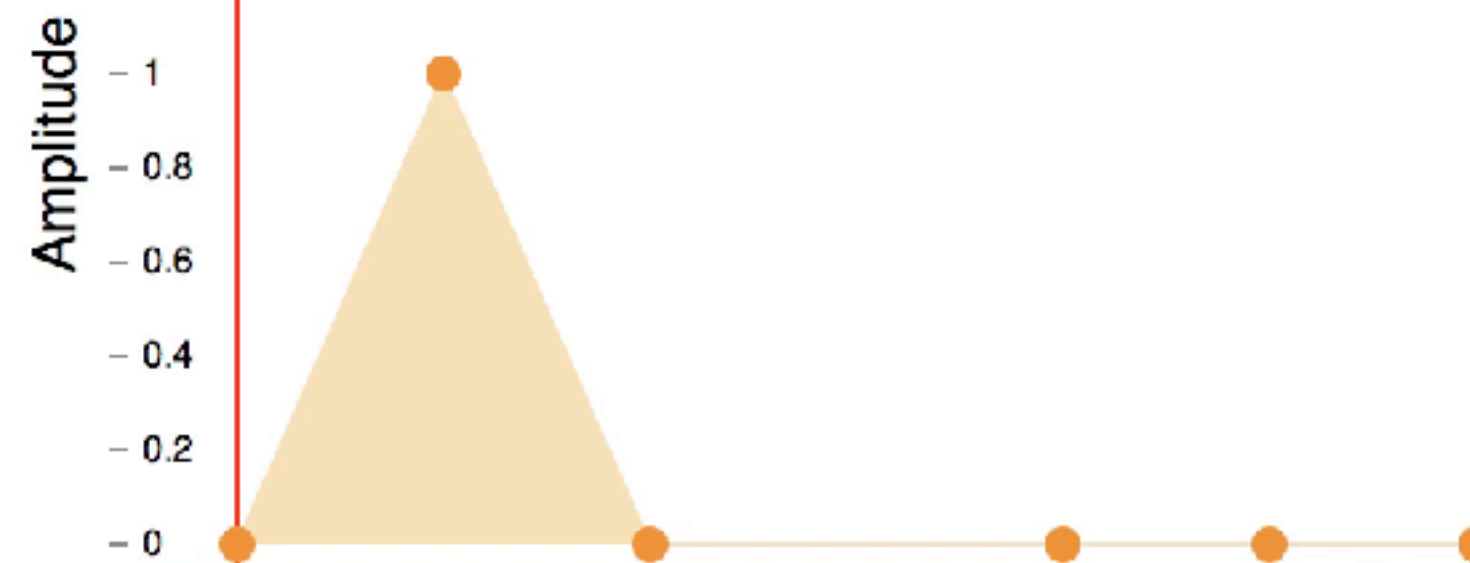
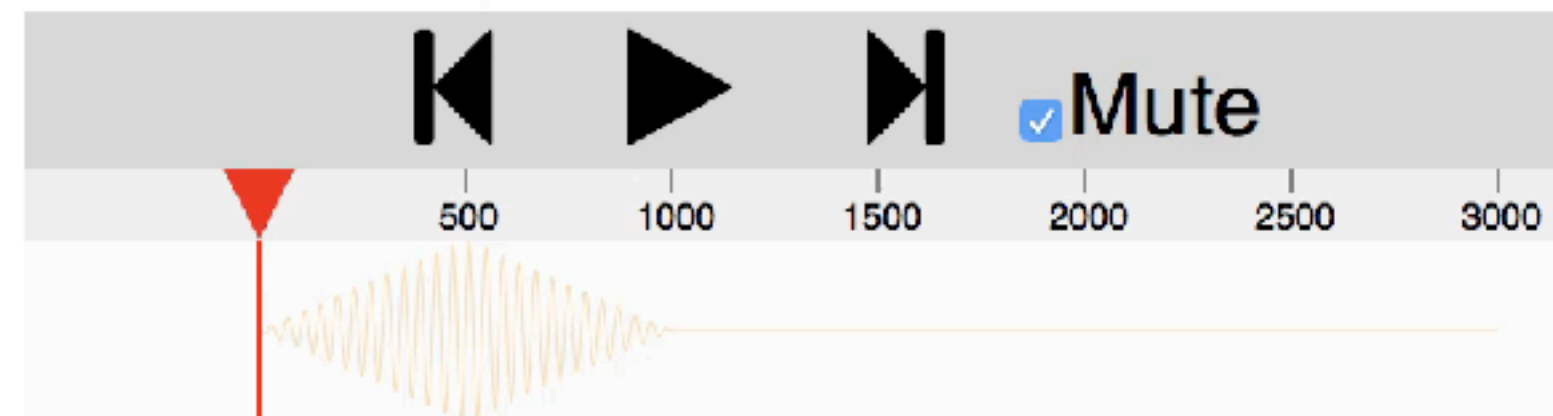
Wave 1 Wave 2

100% 0%

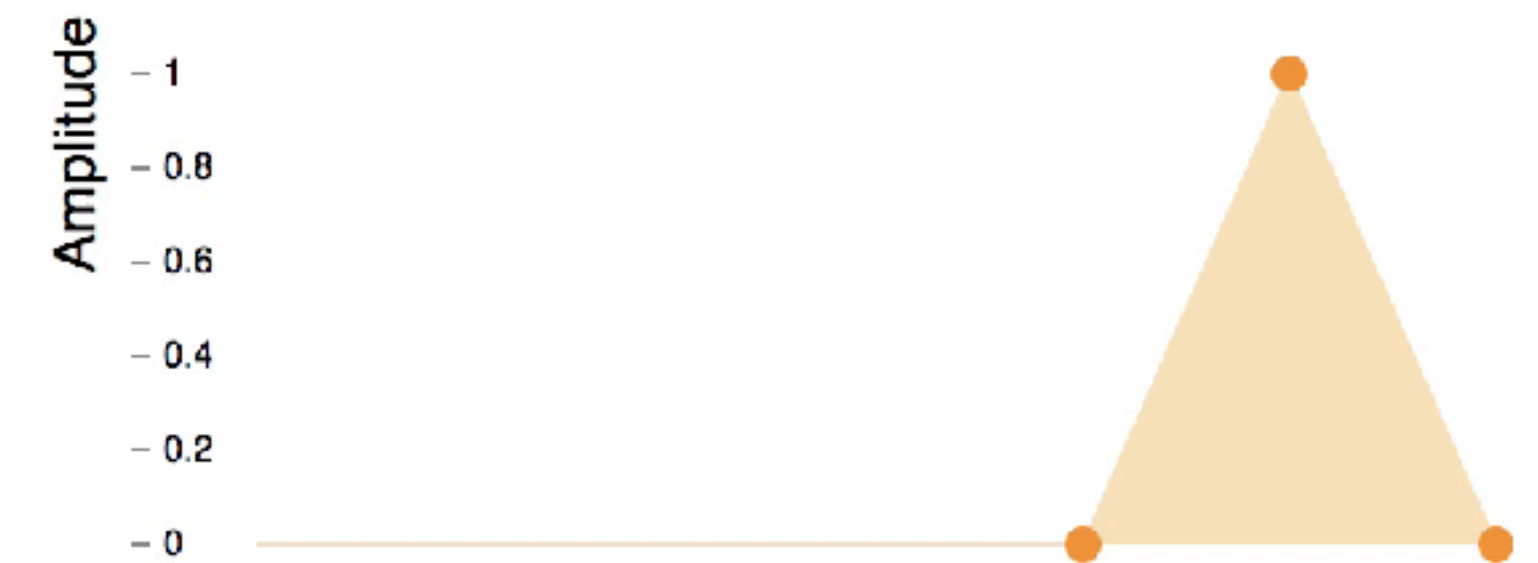
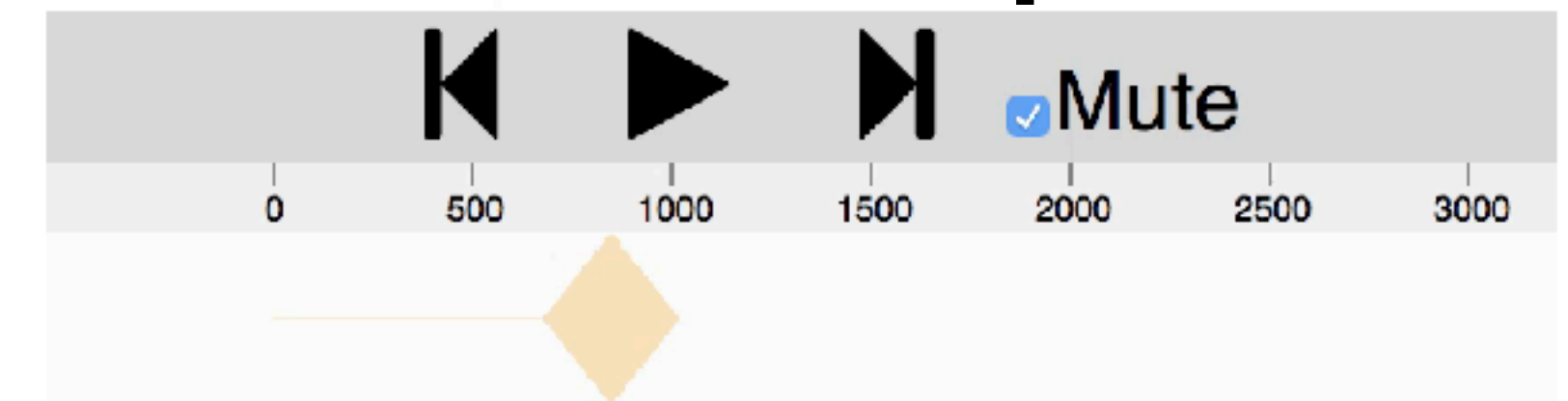
parent 1



child



parent 2



simple crossfade

Select your mixing algorithm: Vector Crossfade

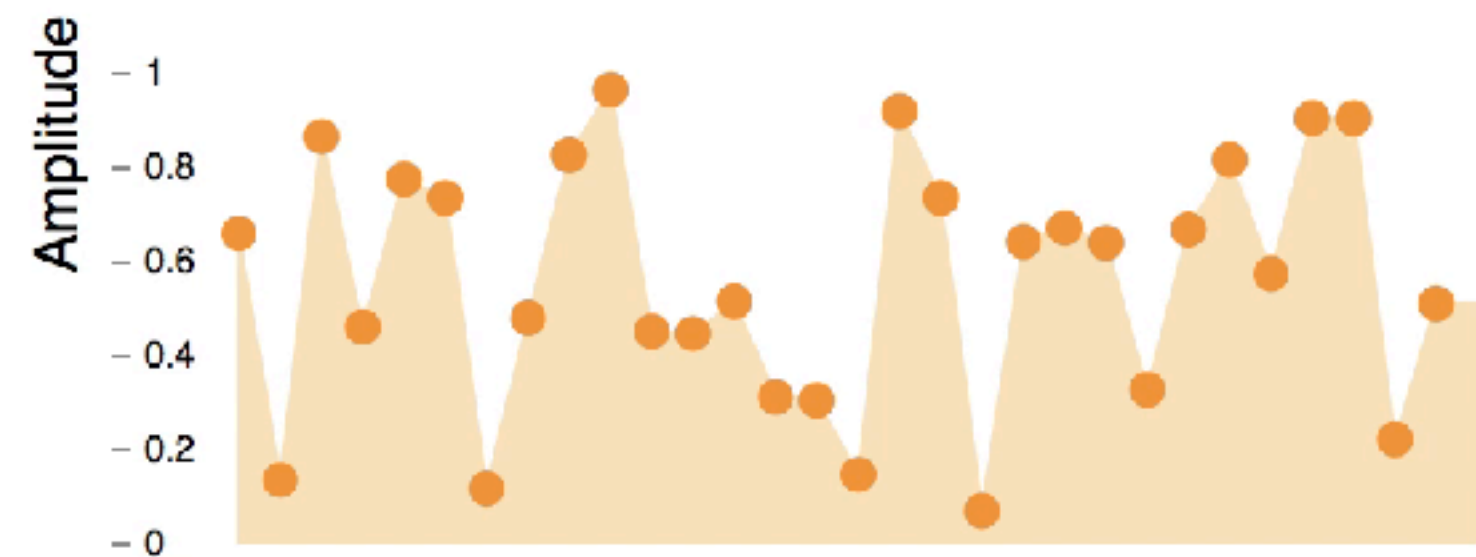
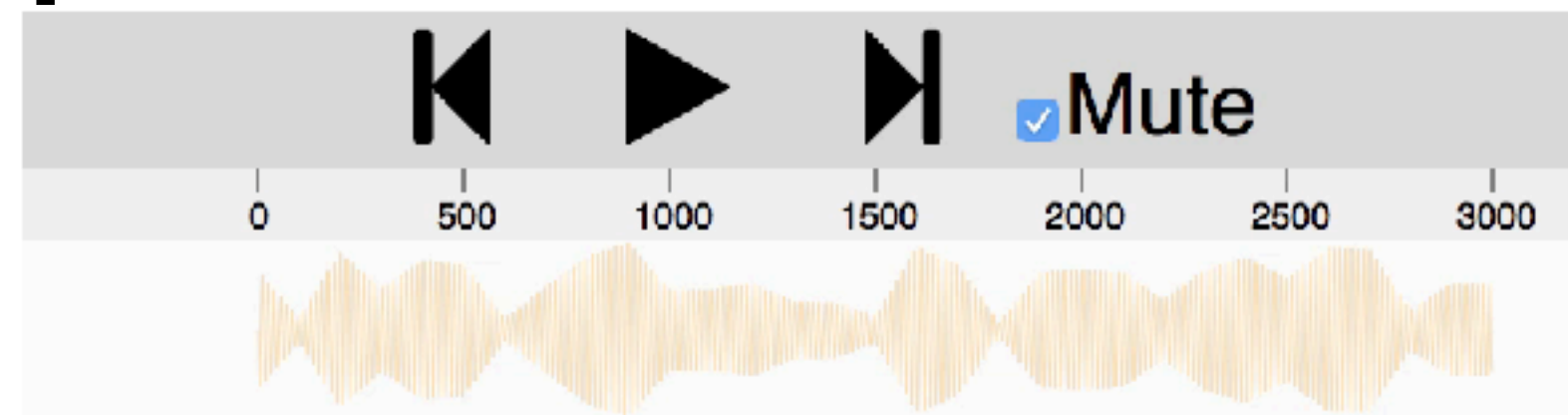
Quick Mix: 0% 25% 50% 75% 100%

load waveform 1 load waveform 2

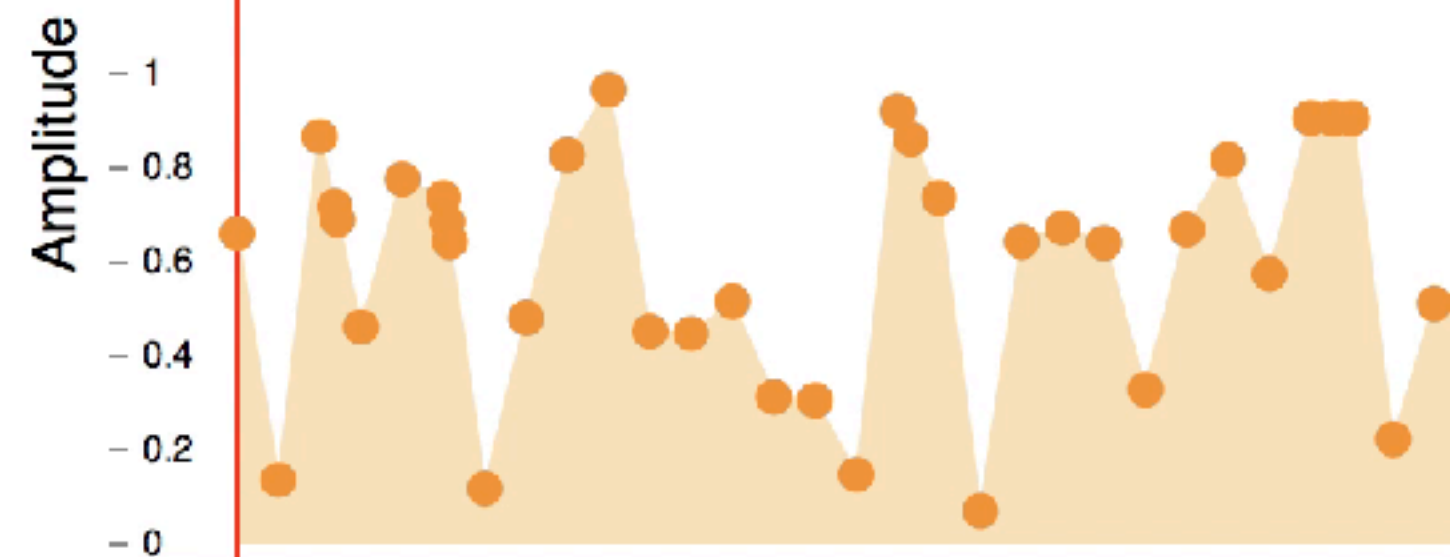
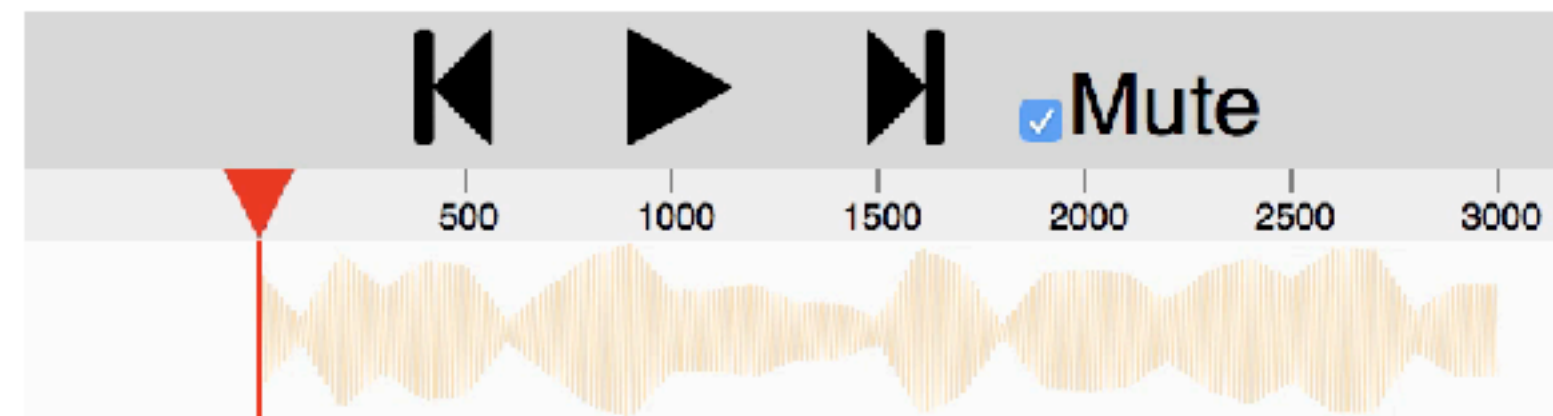
Wave 1 Wave 2

100% 0%

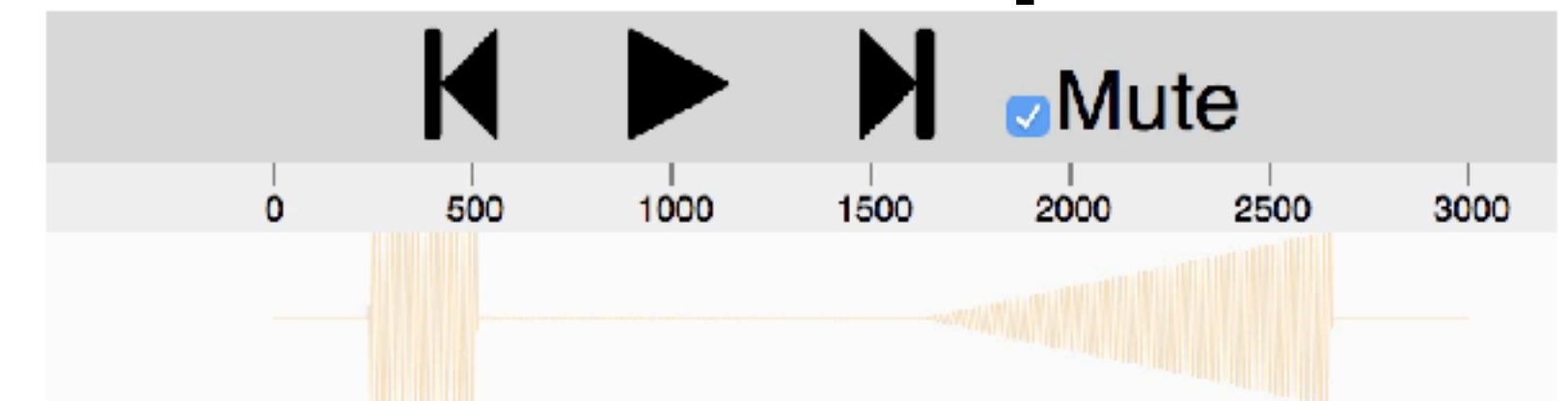
parent 1



child



parent 2



simple crossfade

Select your mixing algorithm: Vector Crossfade

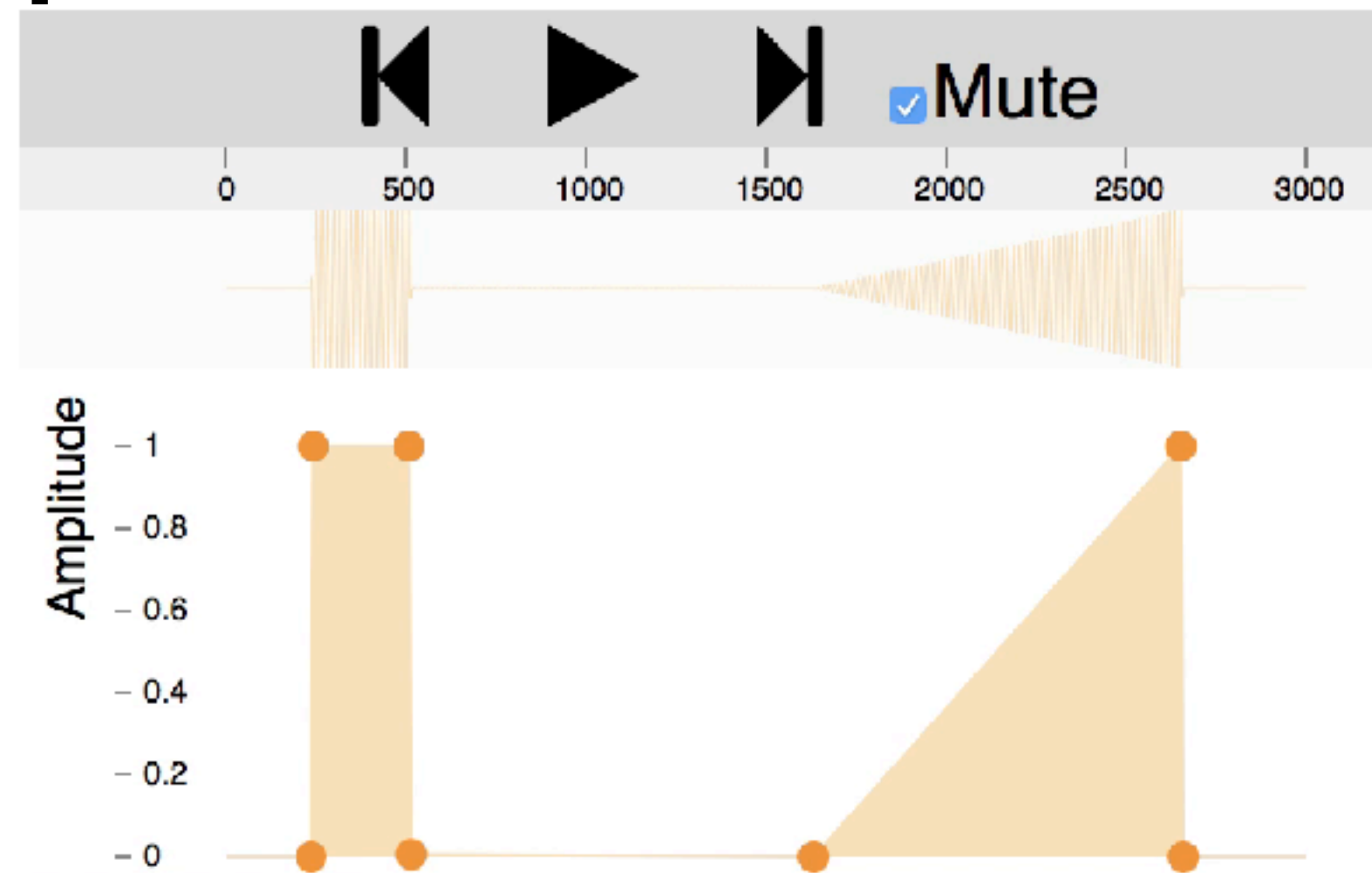
Quick Mix: 0% 25% 50% 75% 100%

load waveform 1 load waveform 2

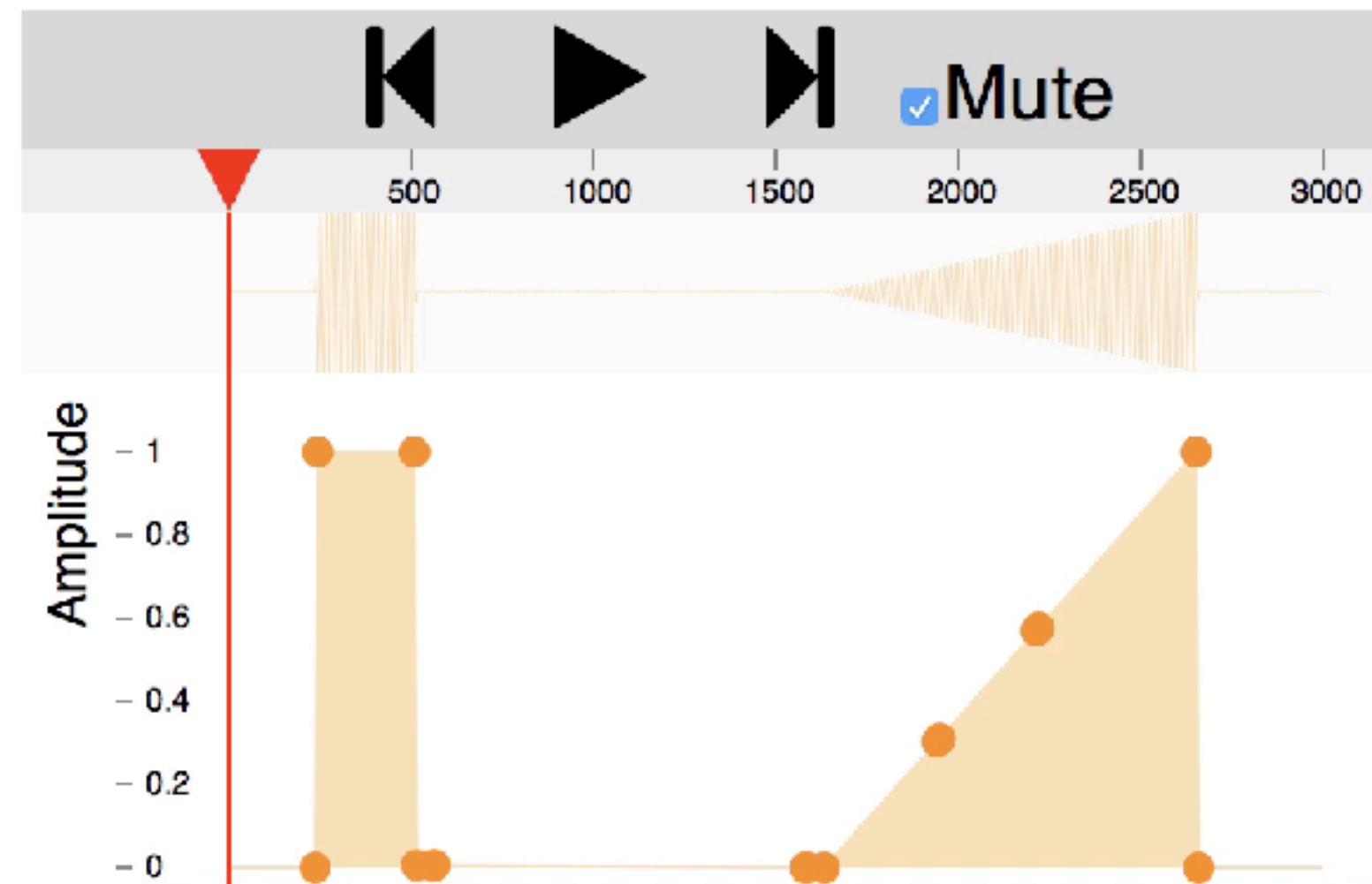
Wave 1 Wave 2

100% 0%

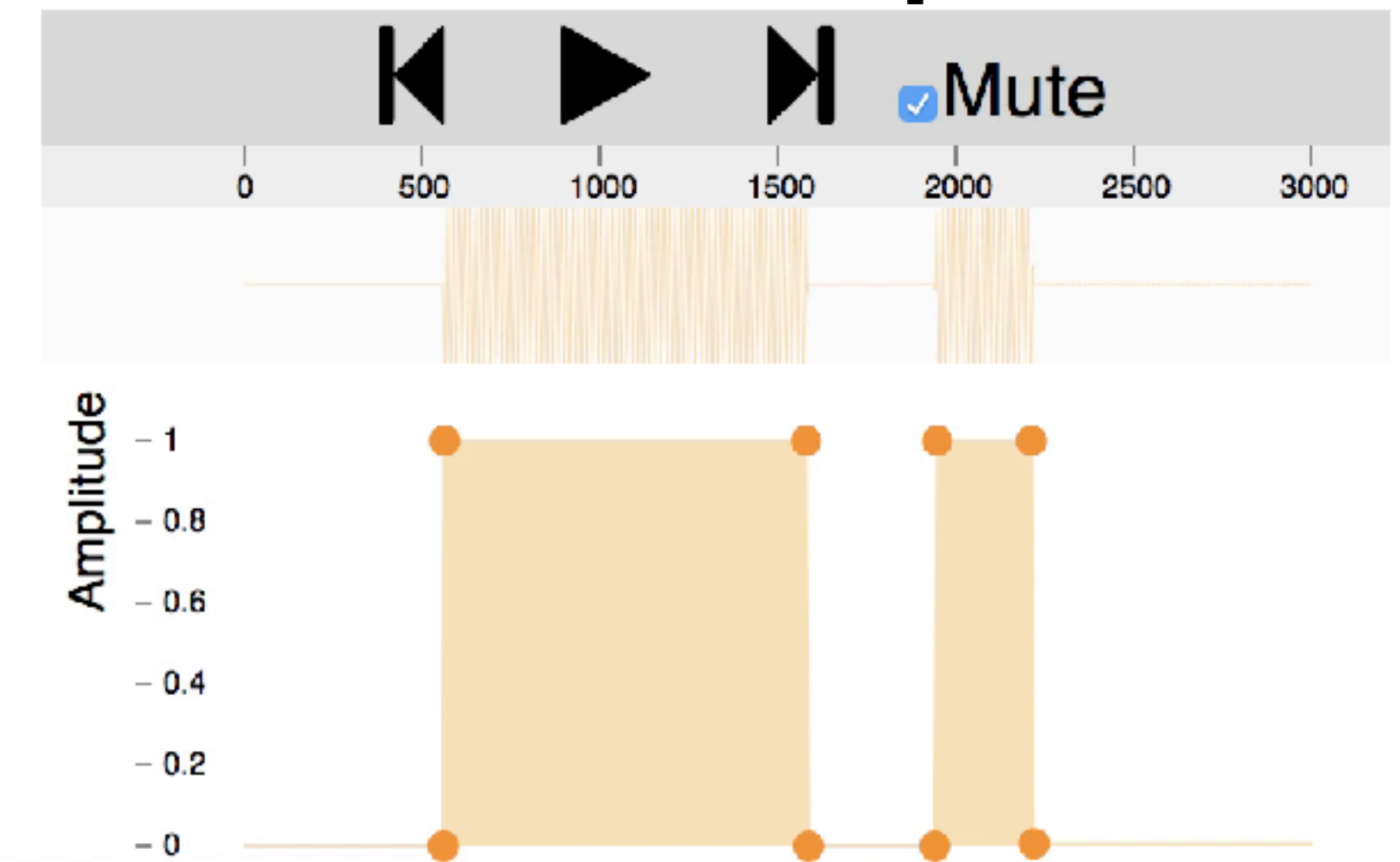
parent 1



child

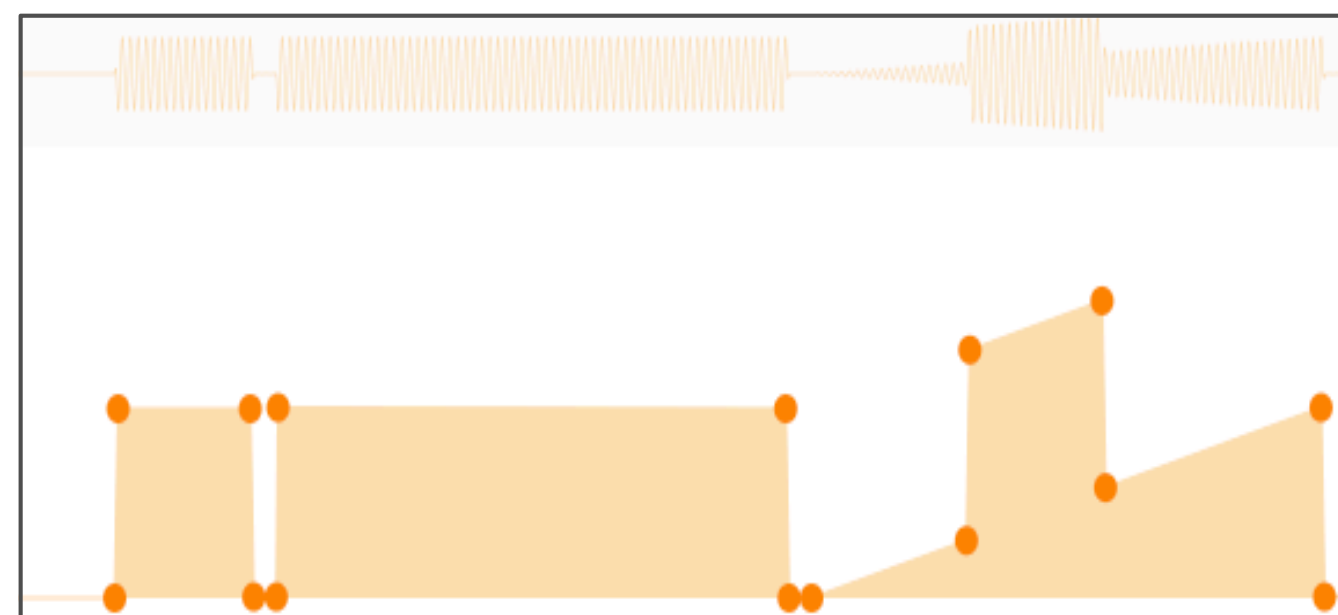
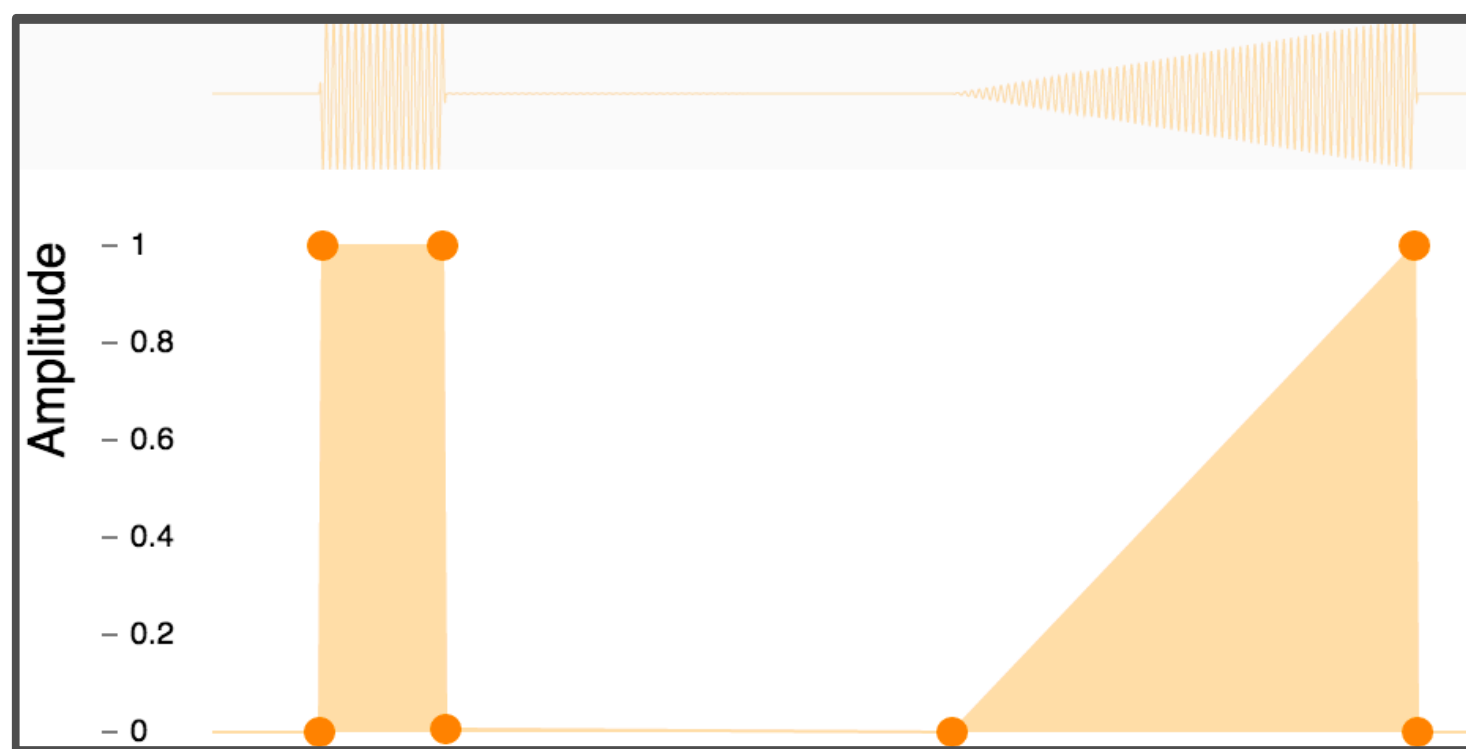


parent 2



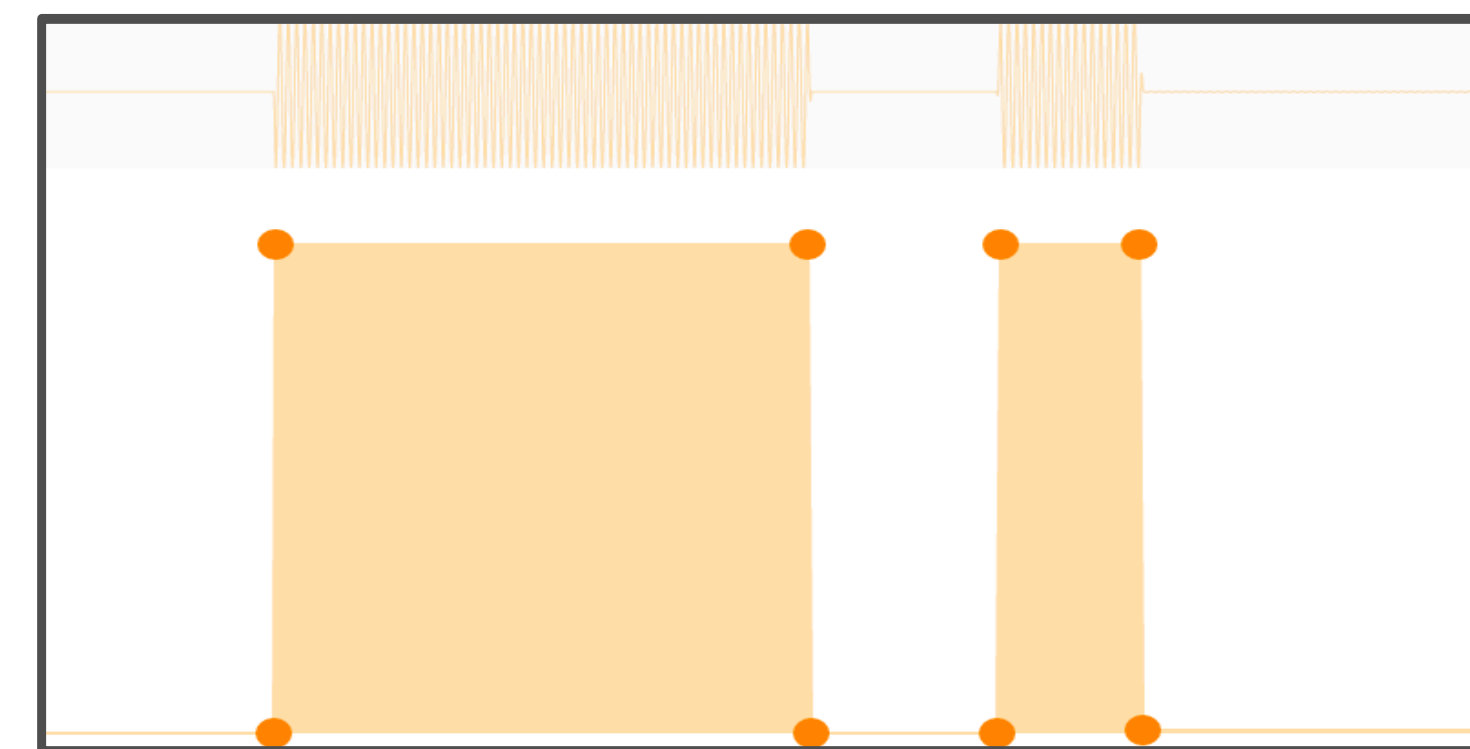
Algorithms

parent 1

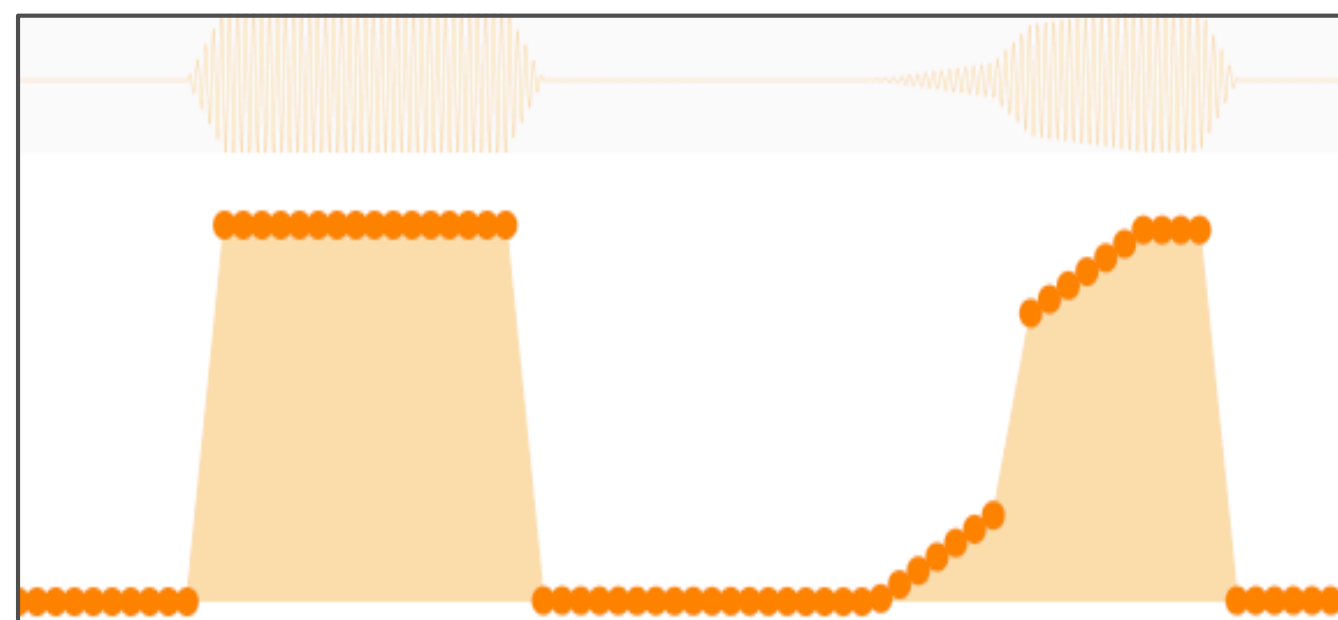


simple crossfade

parent 2

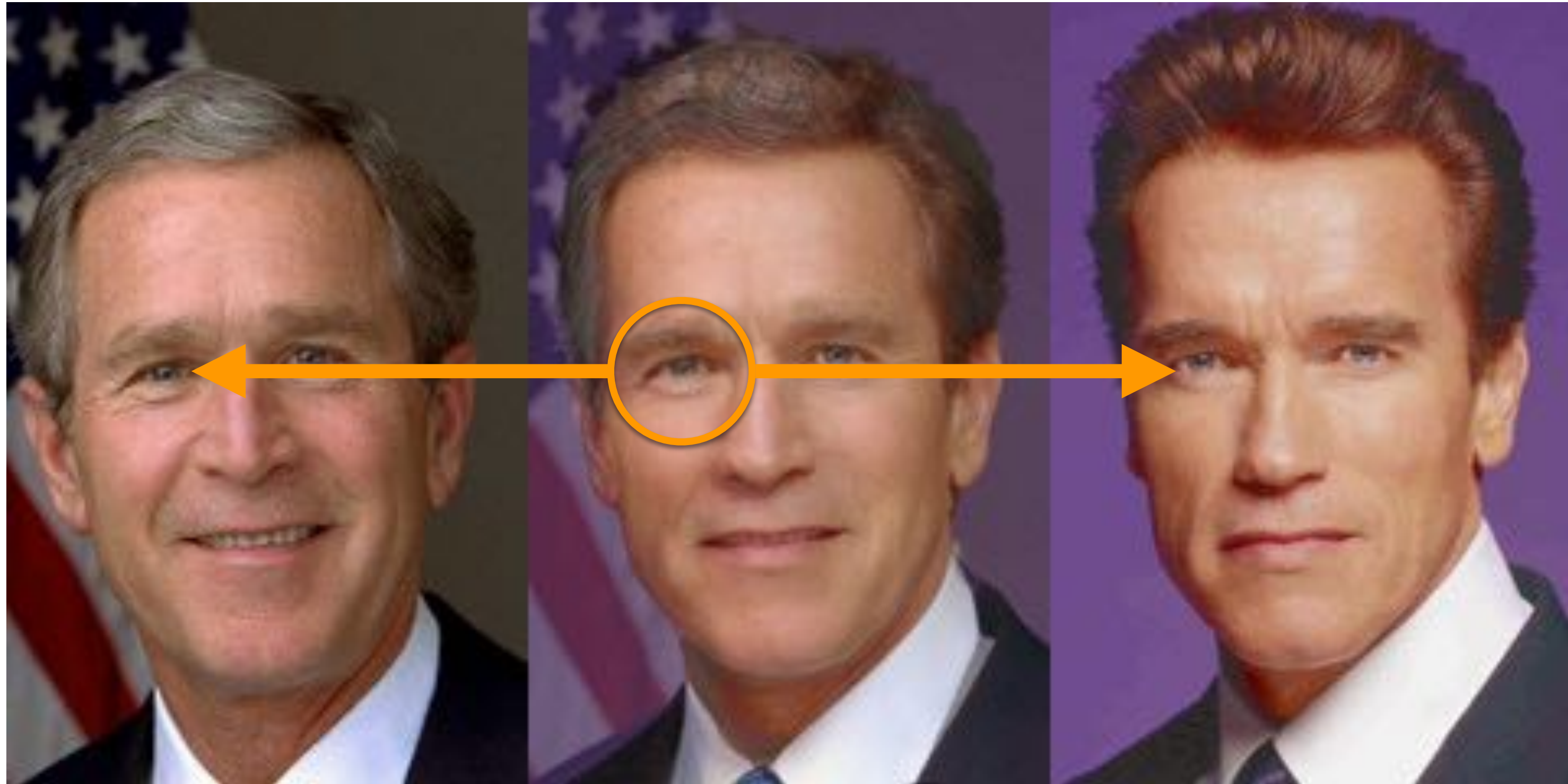


morph

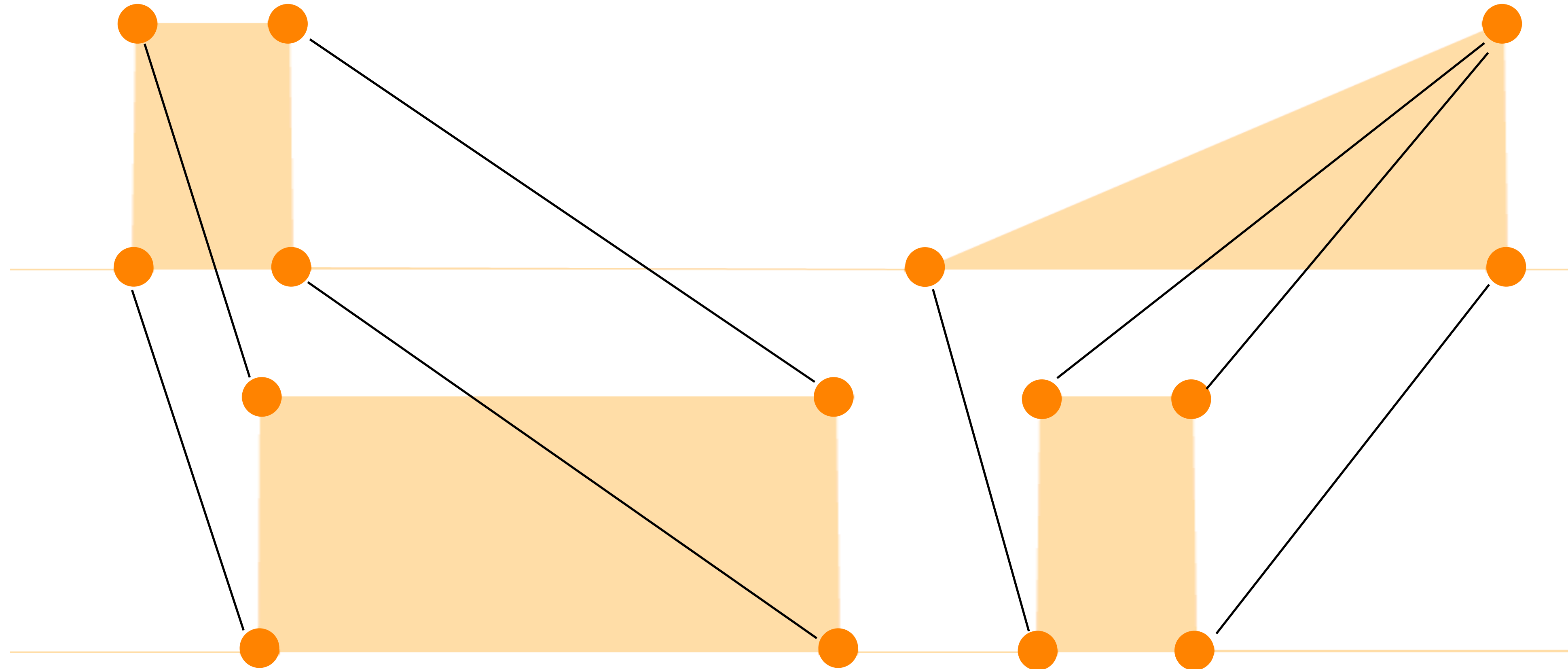


dynamic-time warping

feature-based morphing



dynamic time warping



dynamic time warping

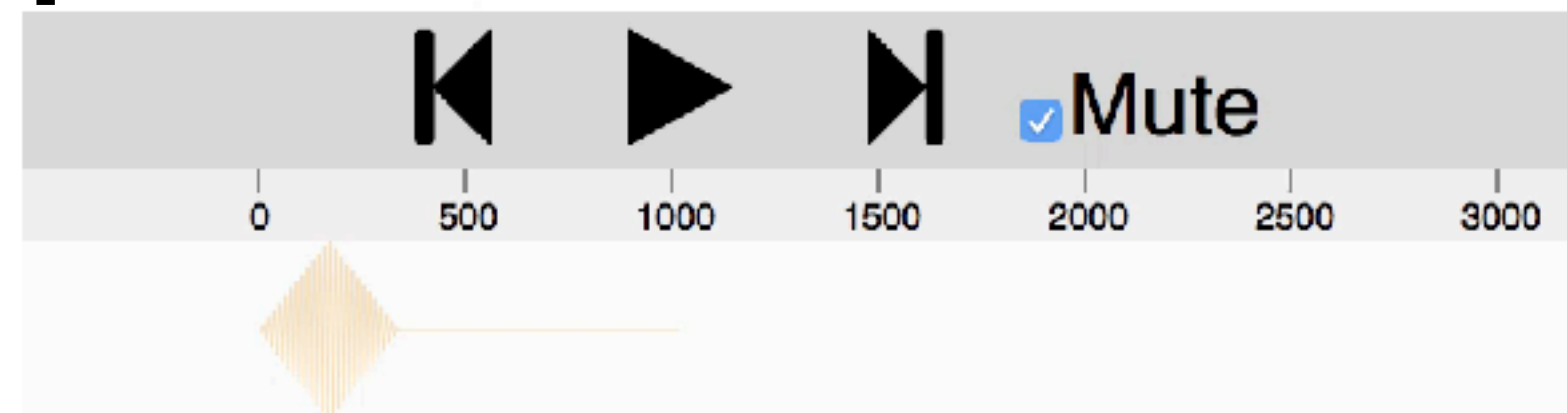
Select your mixing algorithm: Dynamic Time Warping

Quick Mix: 0% 25% 50% 75% 100%

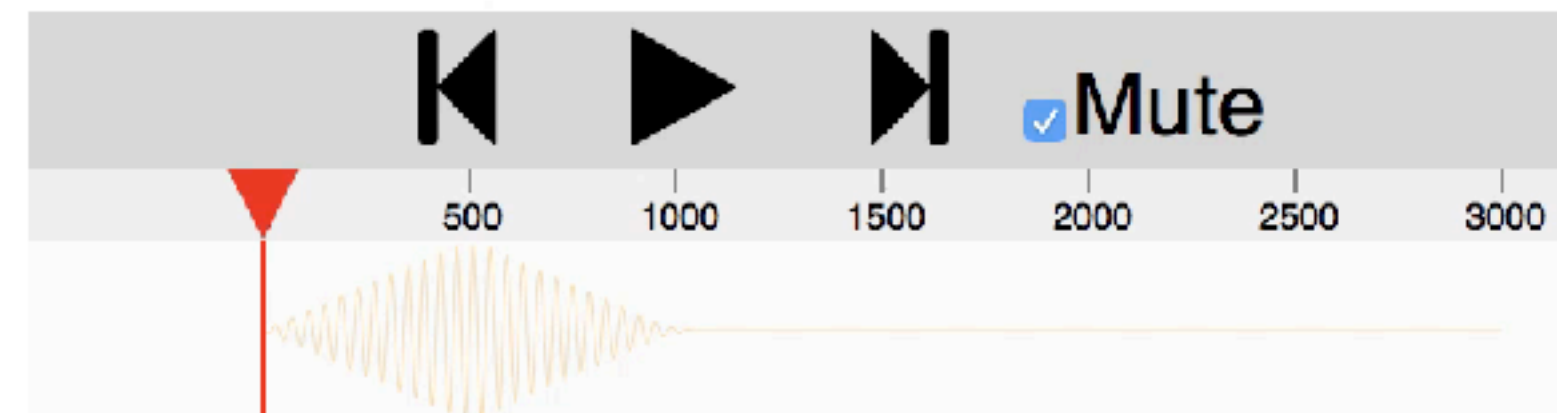
load waveform 1 load waveform 2

Wave 1 100% Wave 2 0%

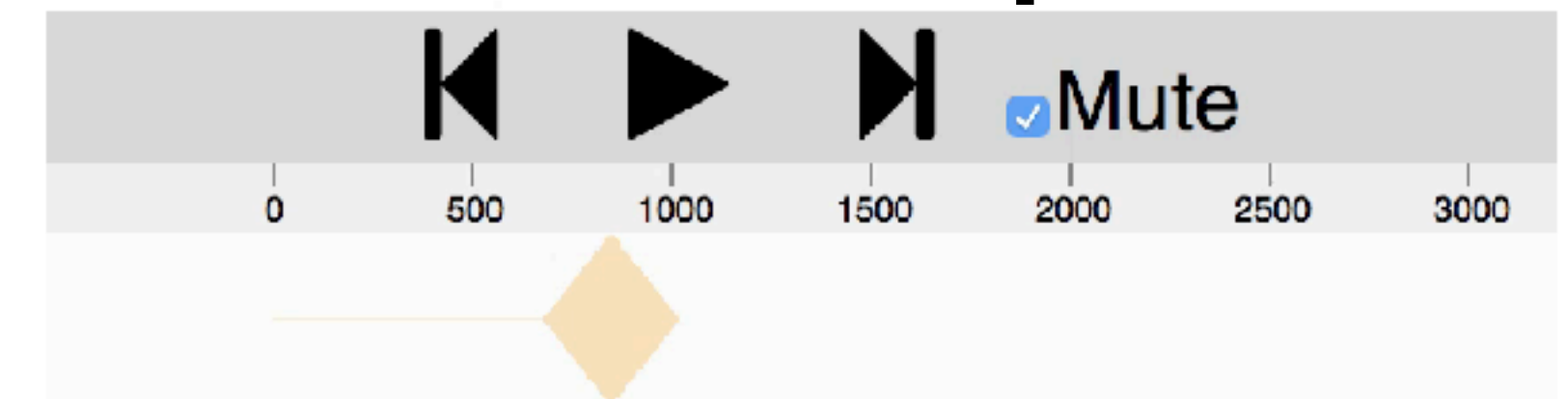
parent 1



child



parent 2



dynamic time warping

Select your mixing algorithm: Dynamic Time Warping

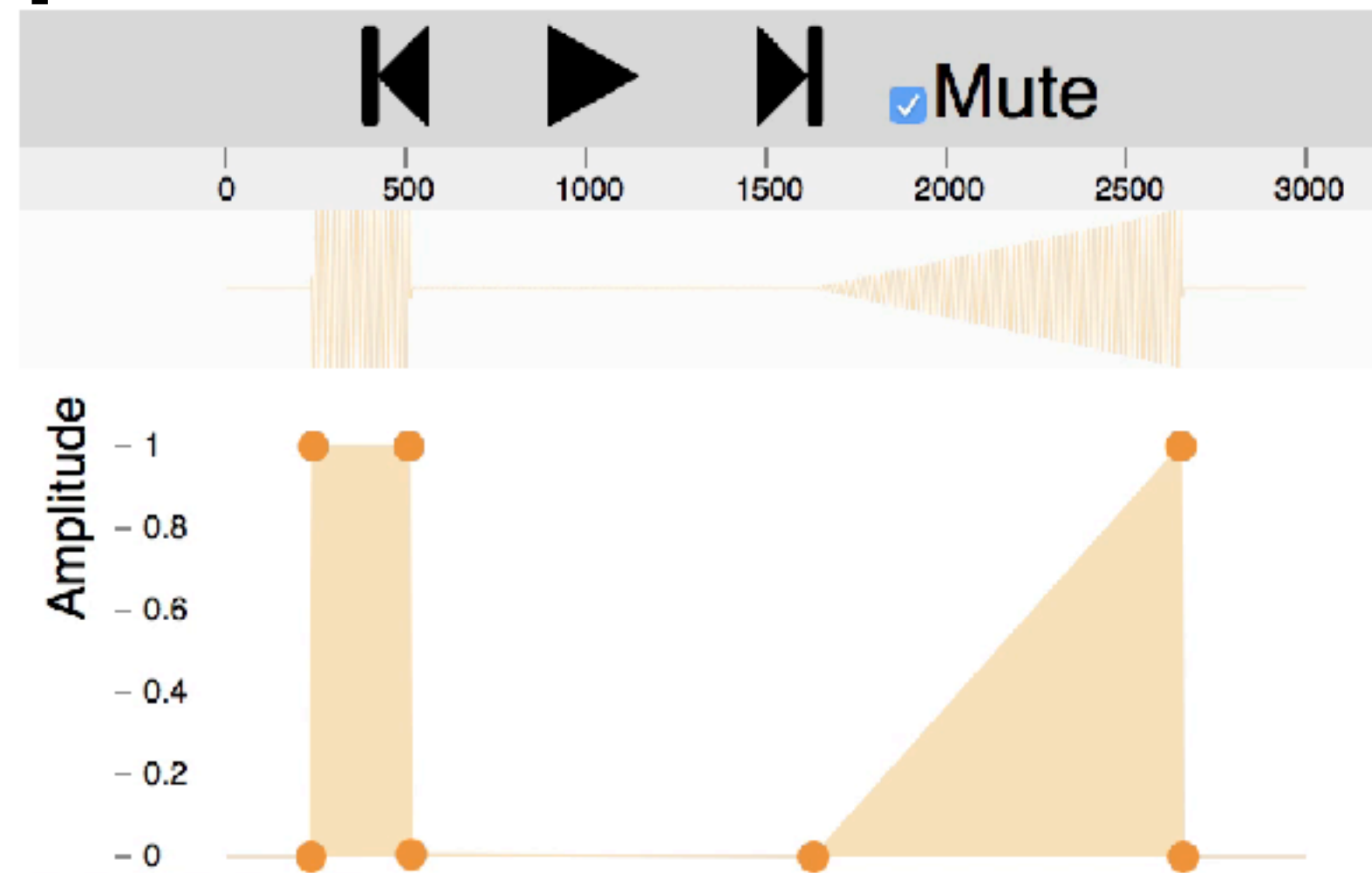
Quick Mix: 0% 25% 50% 75% 100%

load waveform 1 load waveform 2

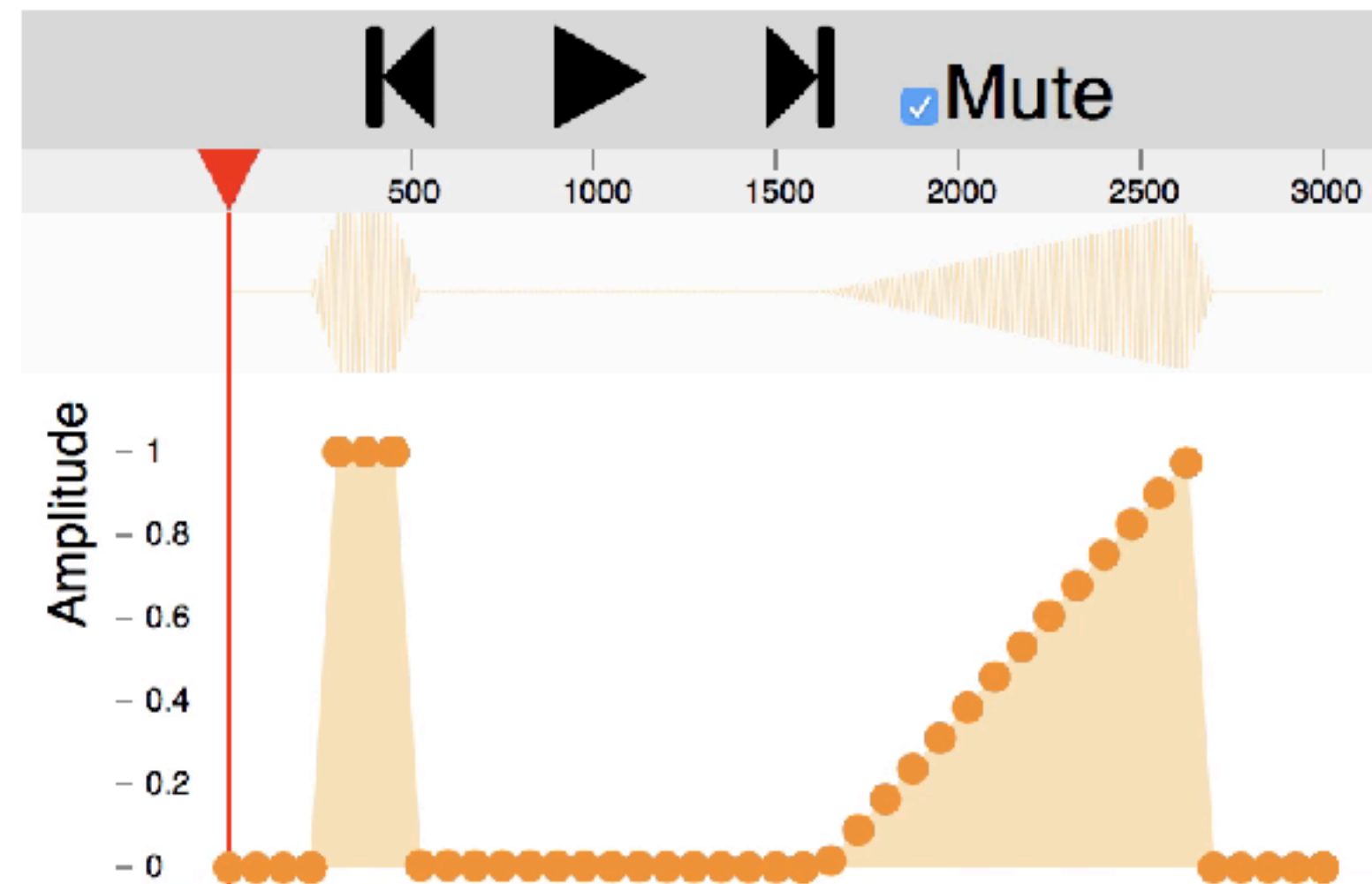
Wave 1 Wave 2

100% 0%

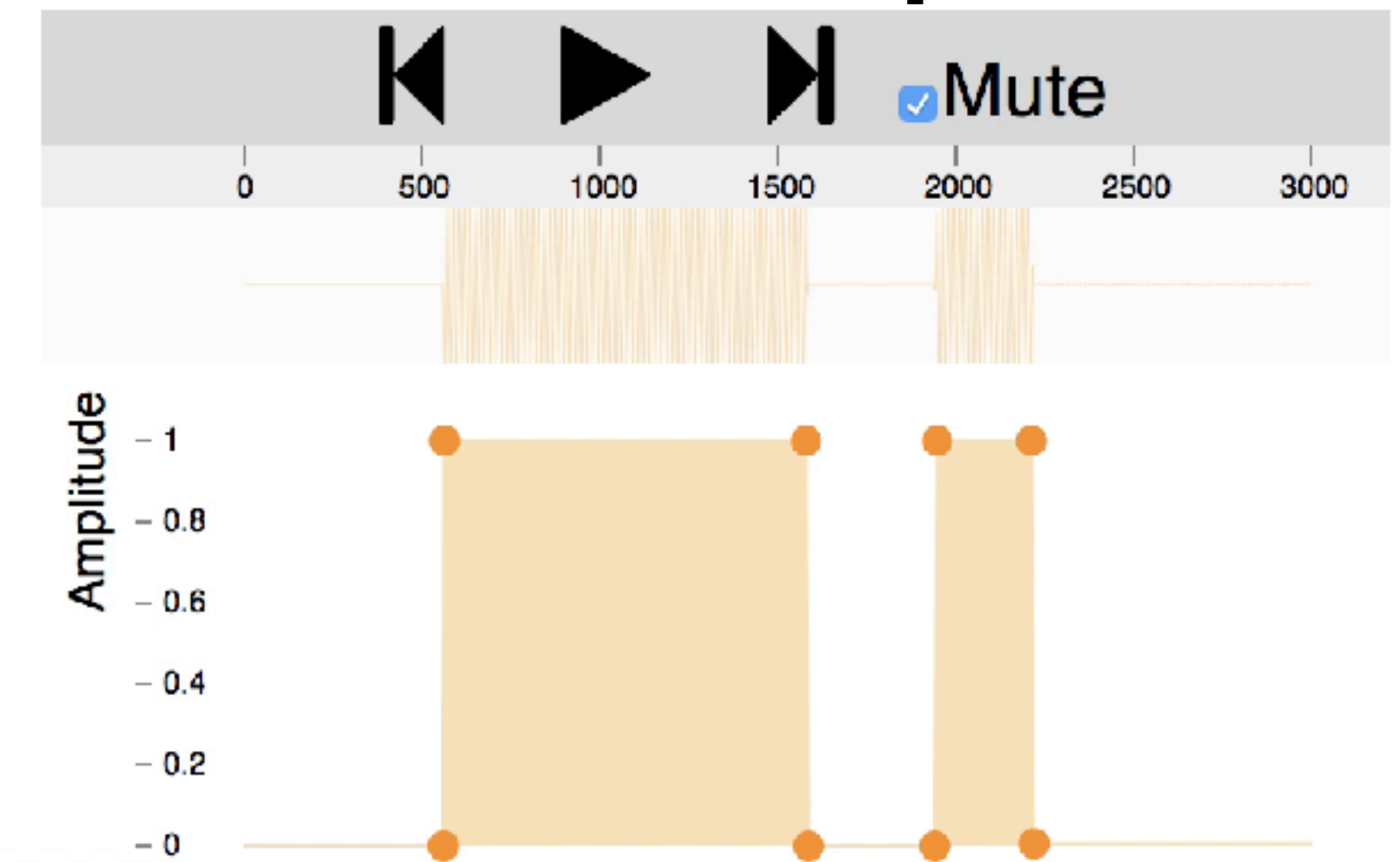
parent 1



child



parent 2



dynamic time warping

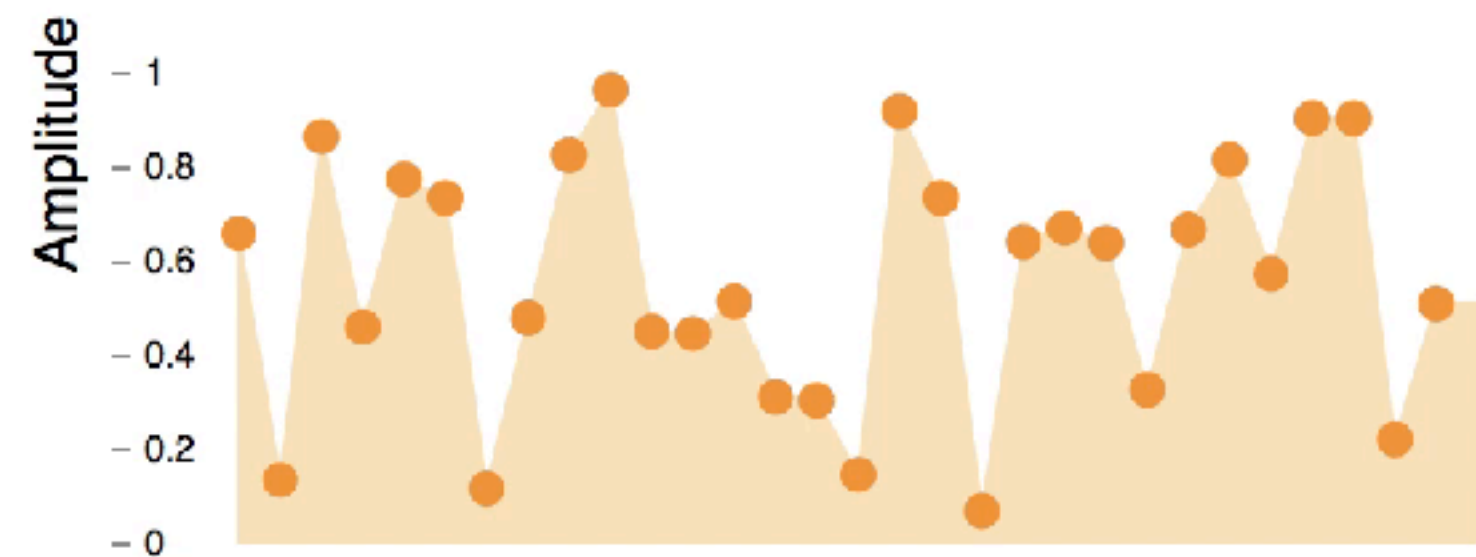
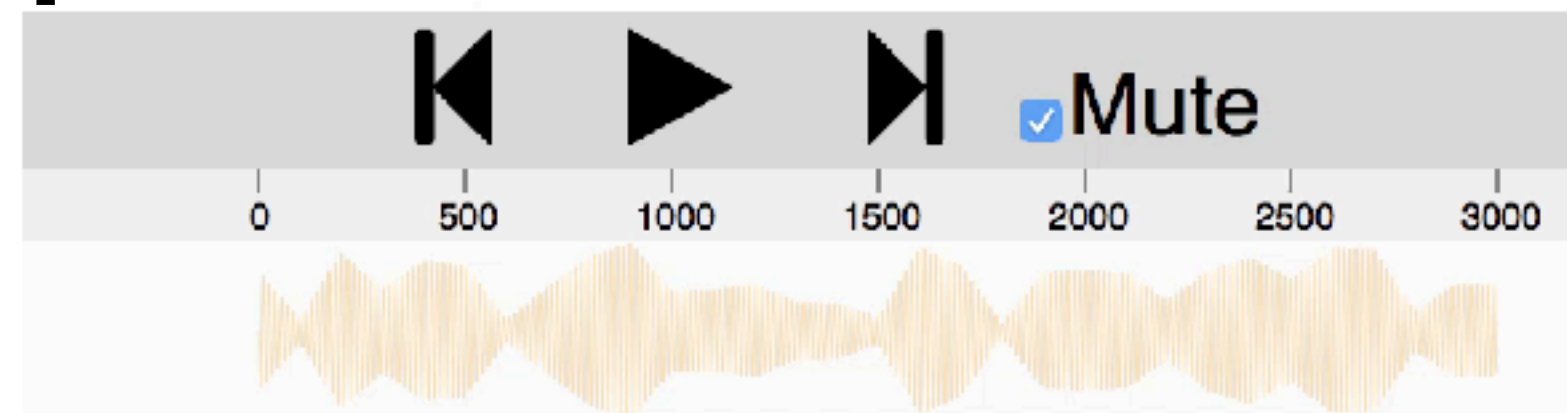
Select your mixing algorithm: Dynamic Time Warping

Quick Mix: 0% 25% 50% 75% 100%

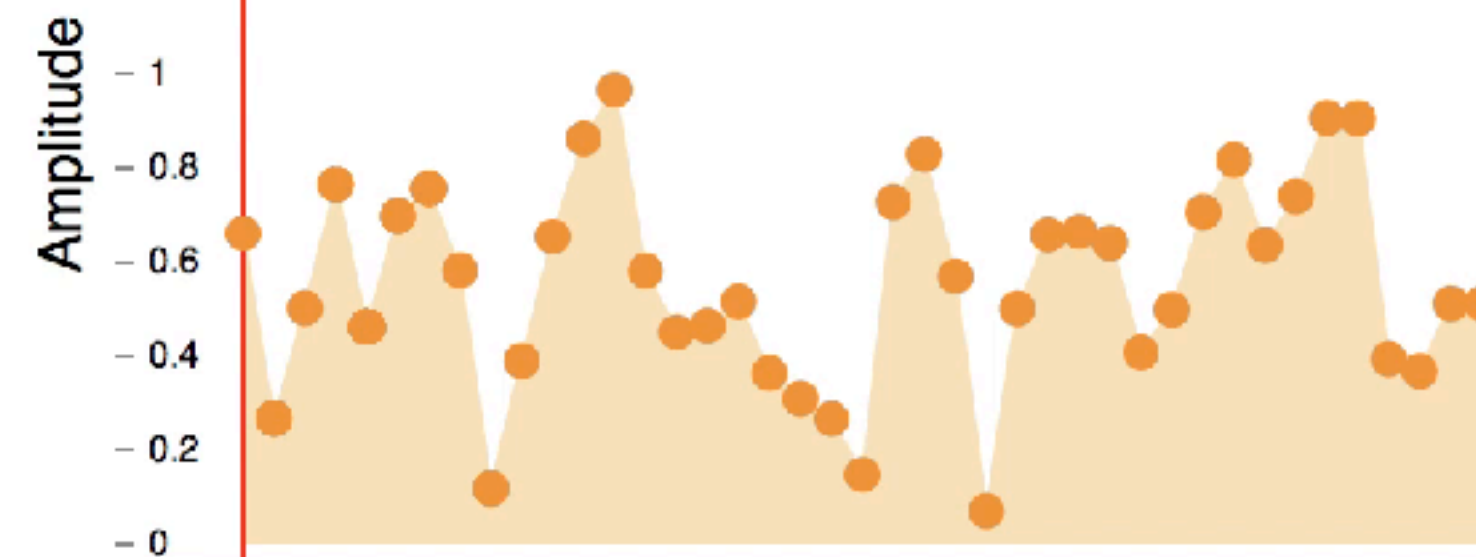
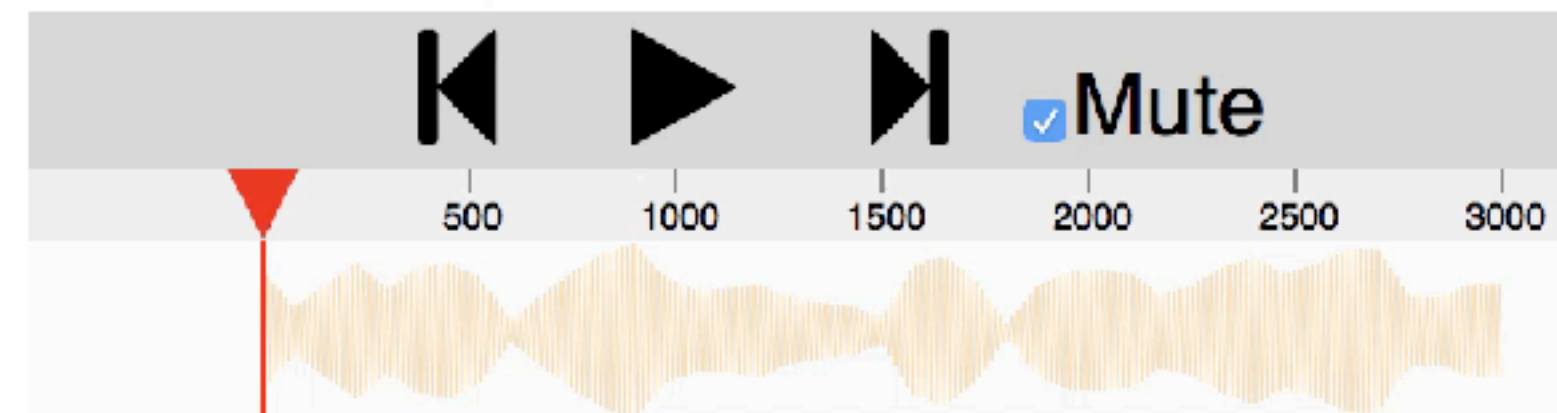
load waveform 1 load waveform 2

Wave 1 100% Wave 2 0%

parent 1



child



parent 2



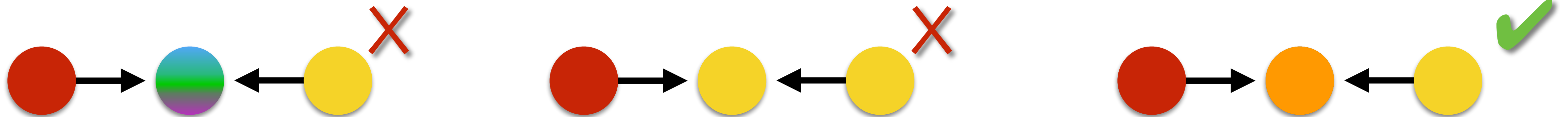
Criteria

1. Predictable

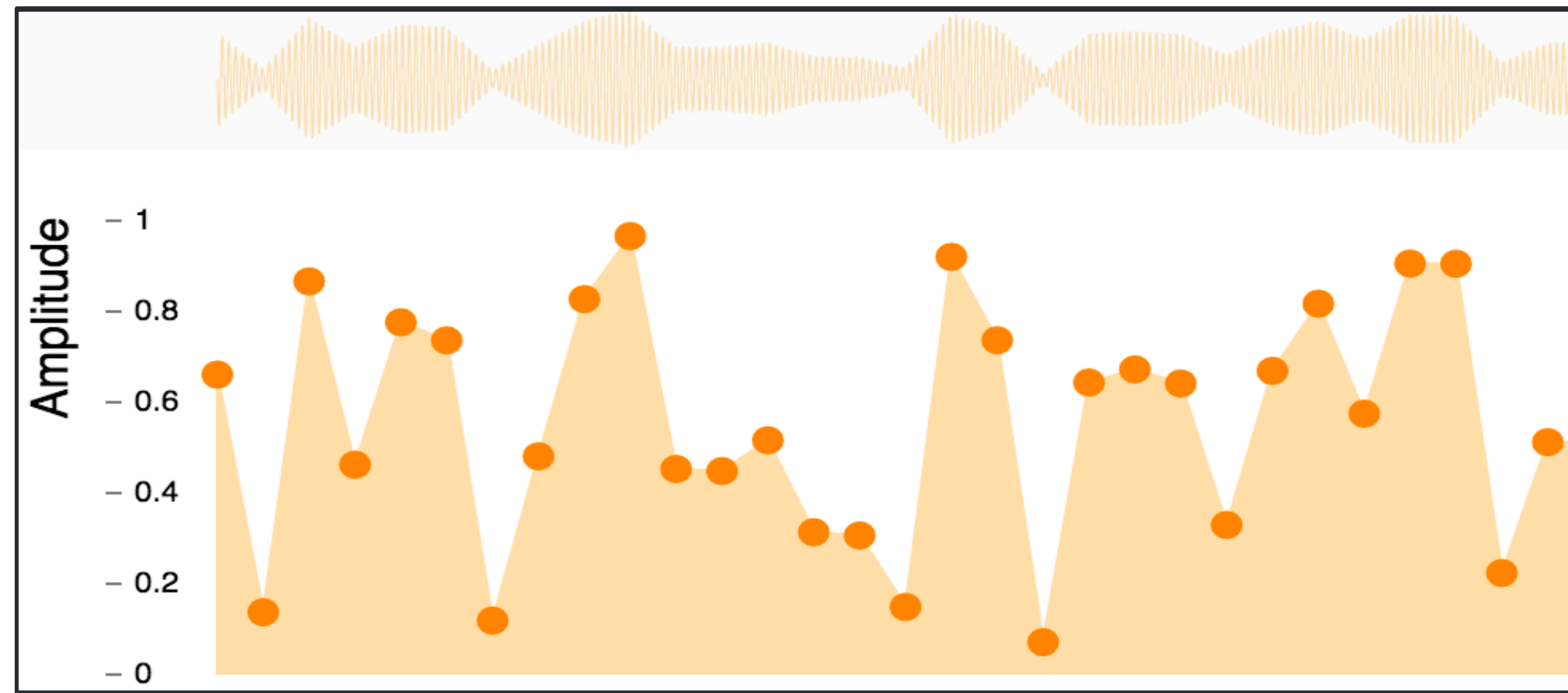
Morphs must have some perceptual resemblance to both parents.

2. Distinguishable

Morphs must be perceptually distinguishable from both parents.

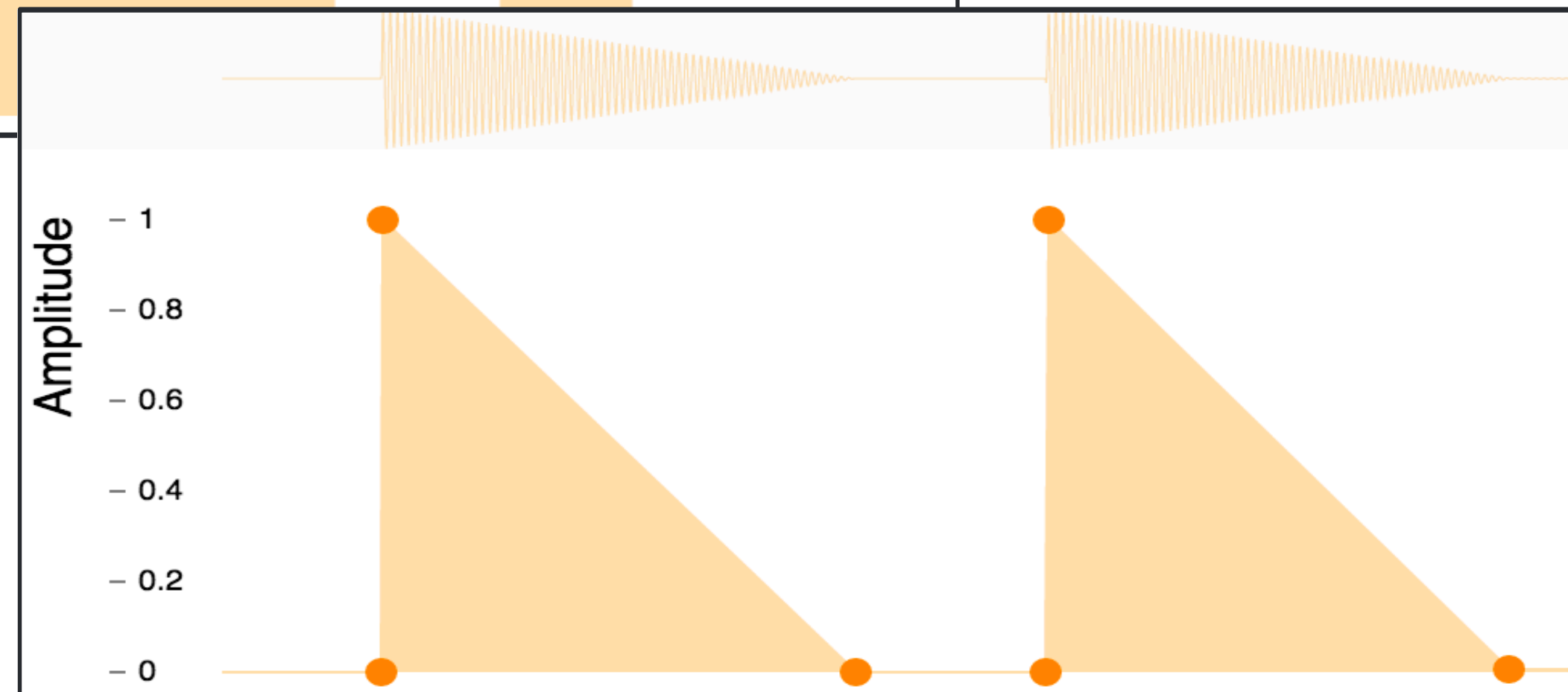
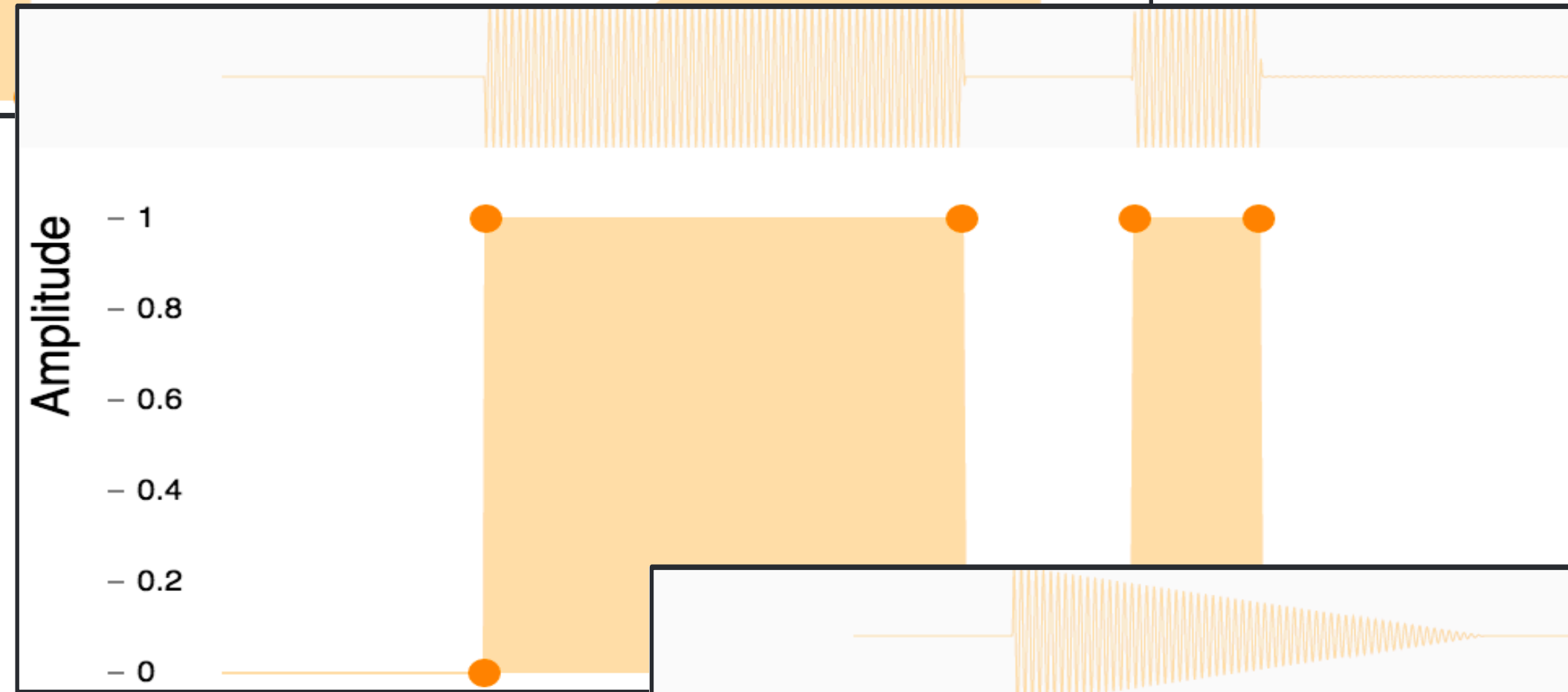
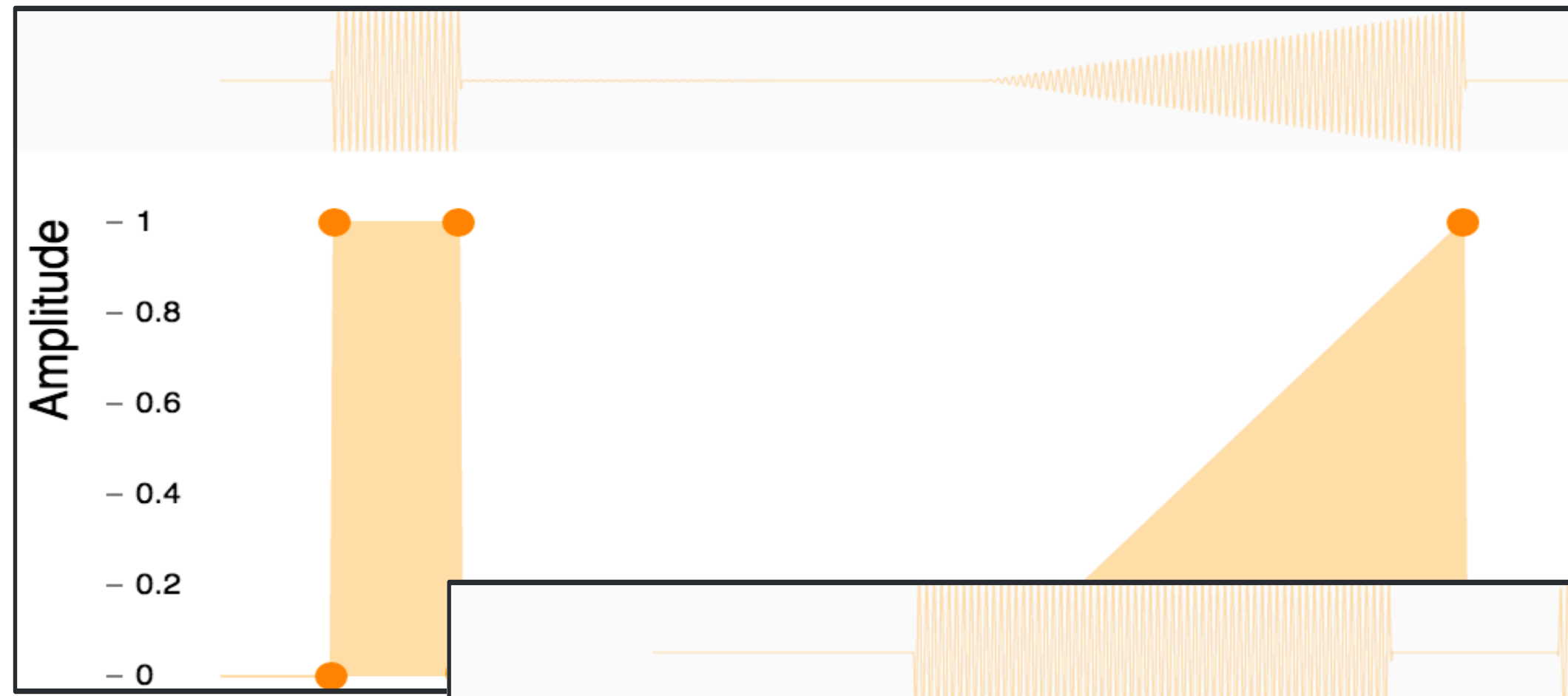


icons

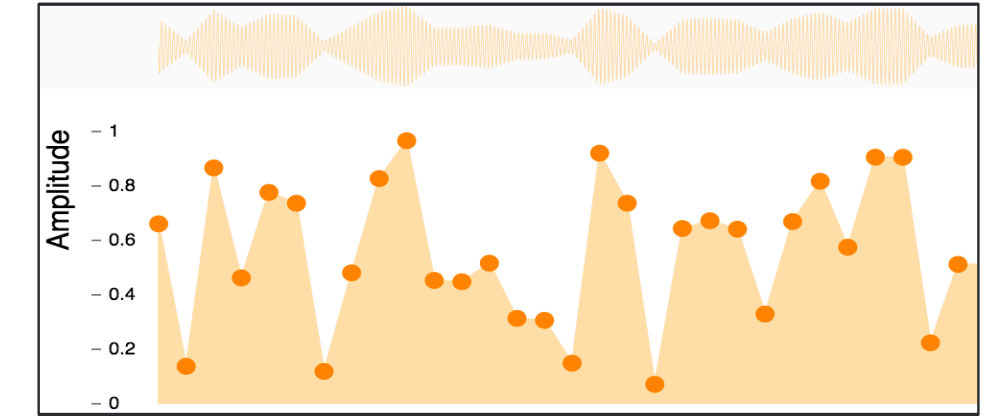


Random Noise

icons

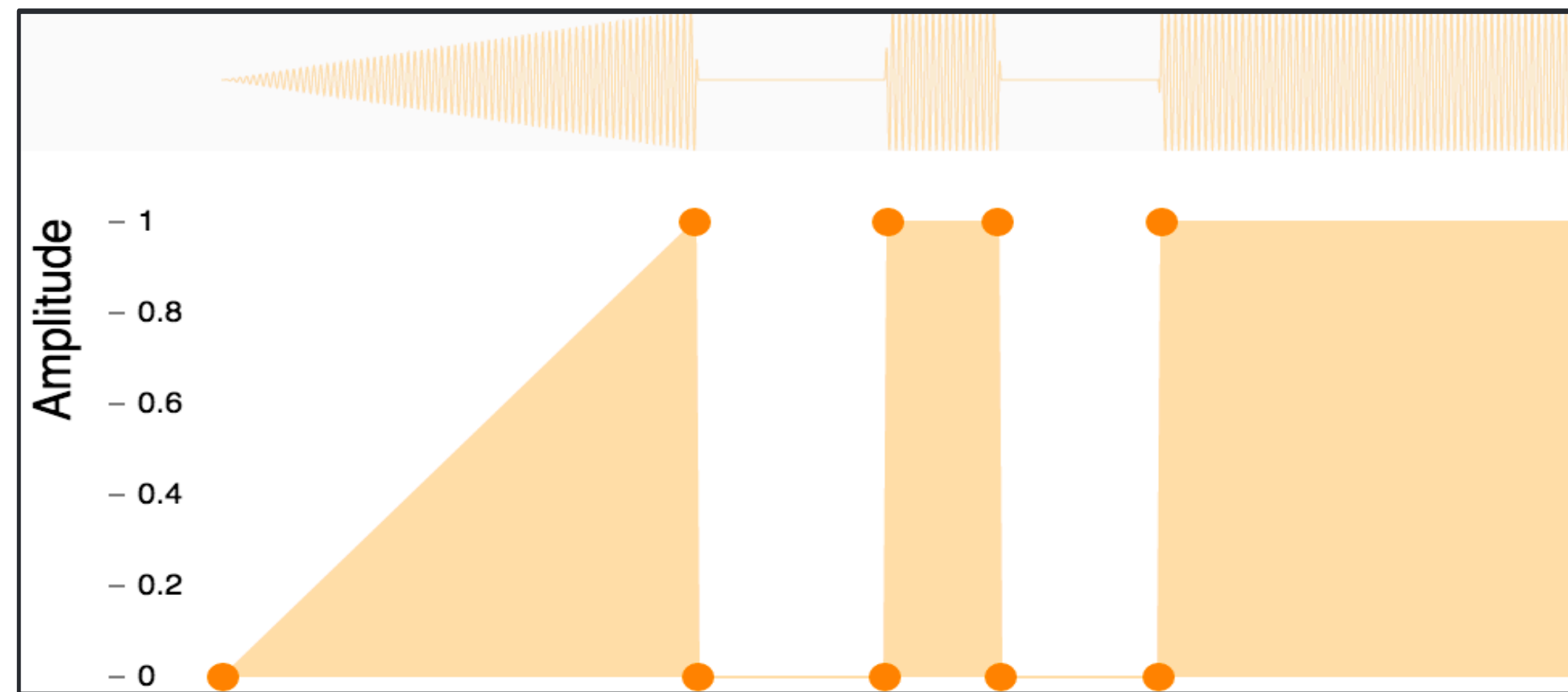
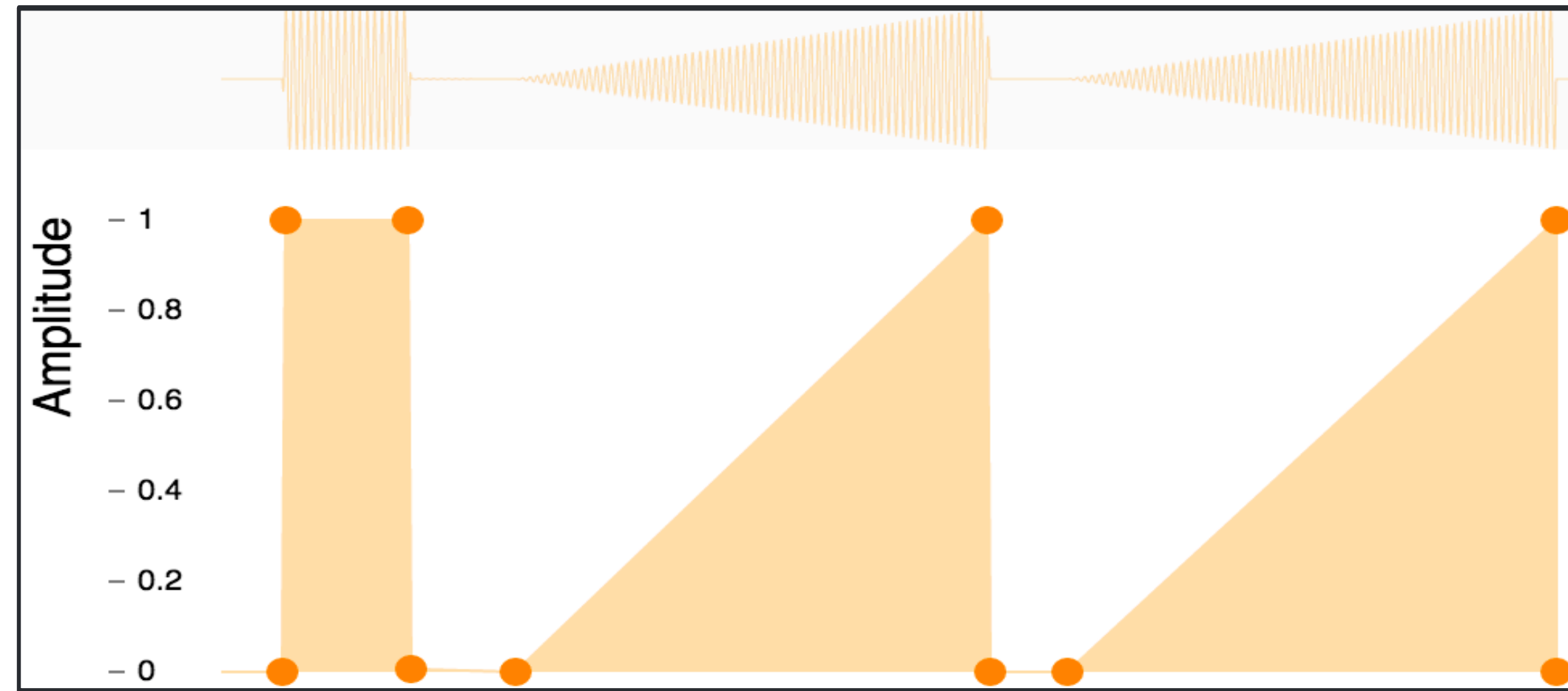


Two Pulses

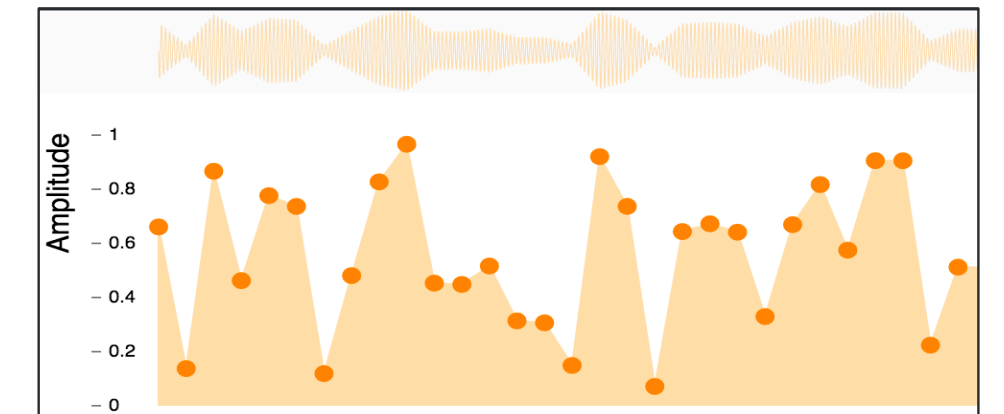


Random Noise

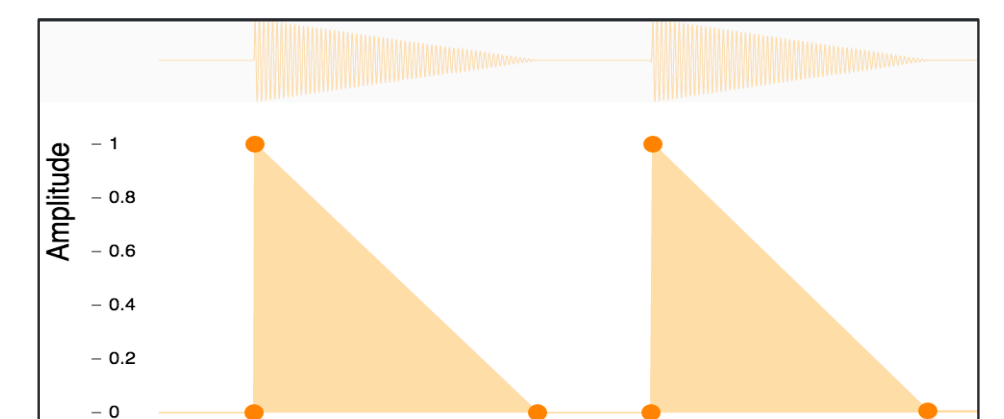
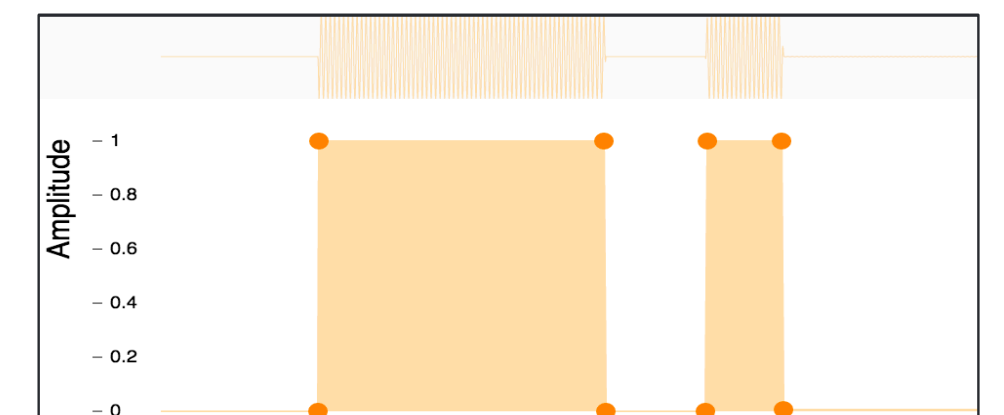
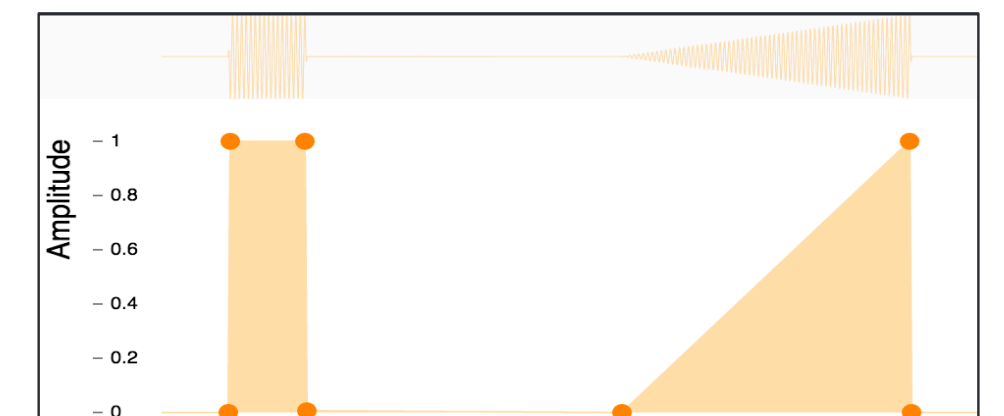
icons



Three Pulses

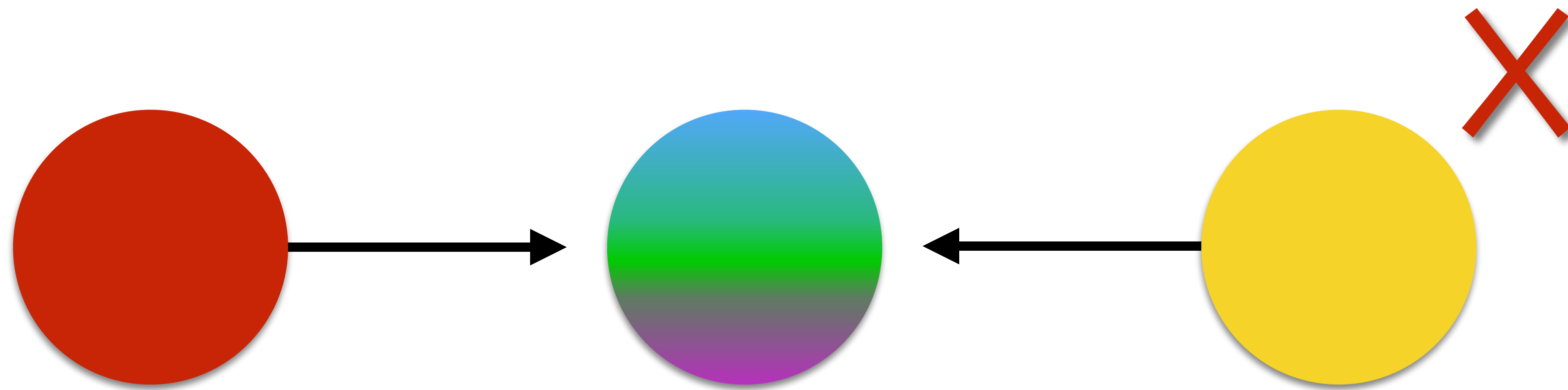


Random Noise



Two Pulses

Study 1: Predictability



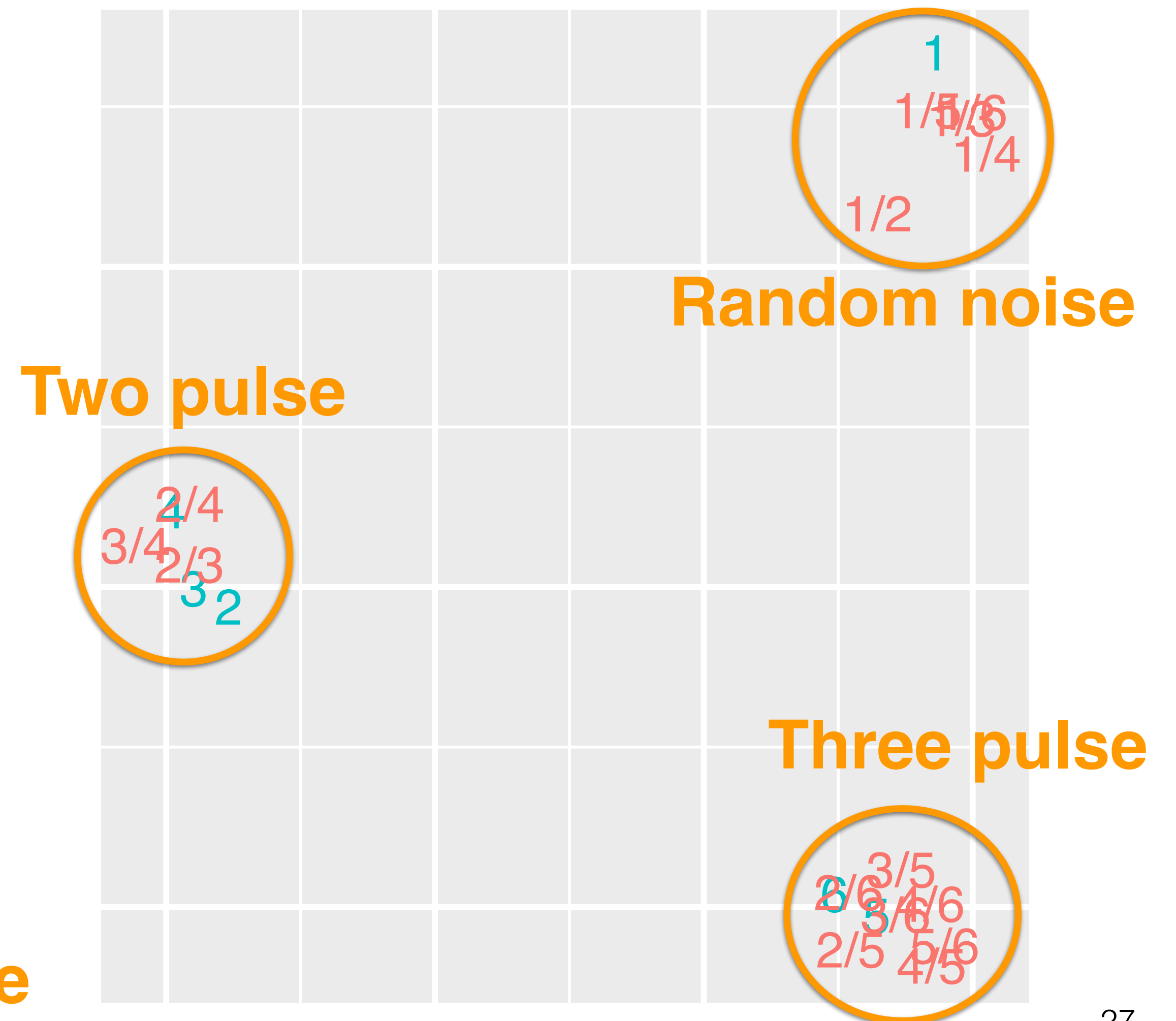
study 1 results

multidimensional scaling
N=12

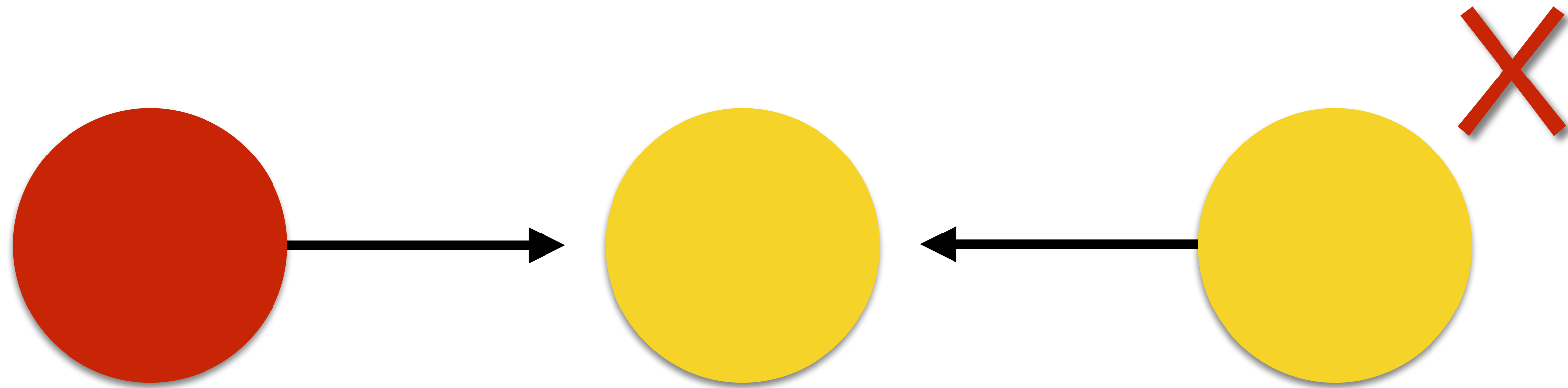
Crossfade



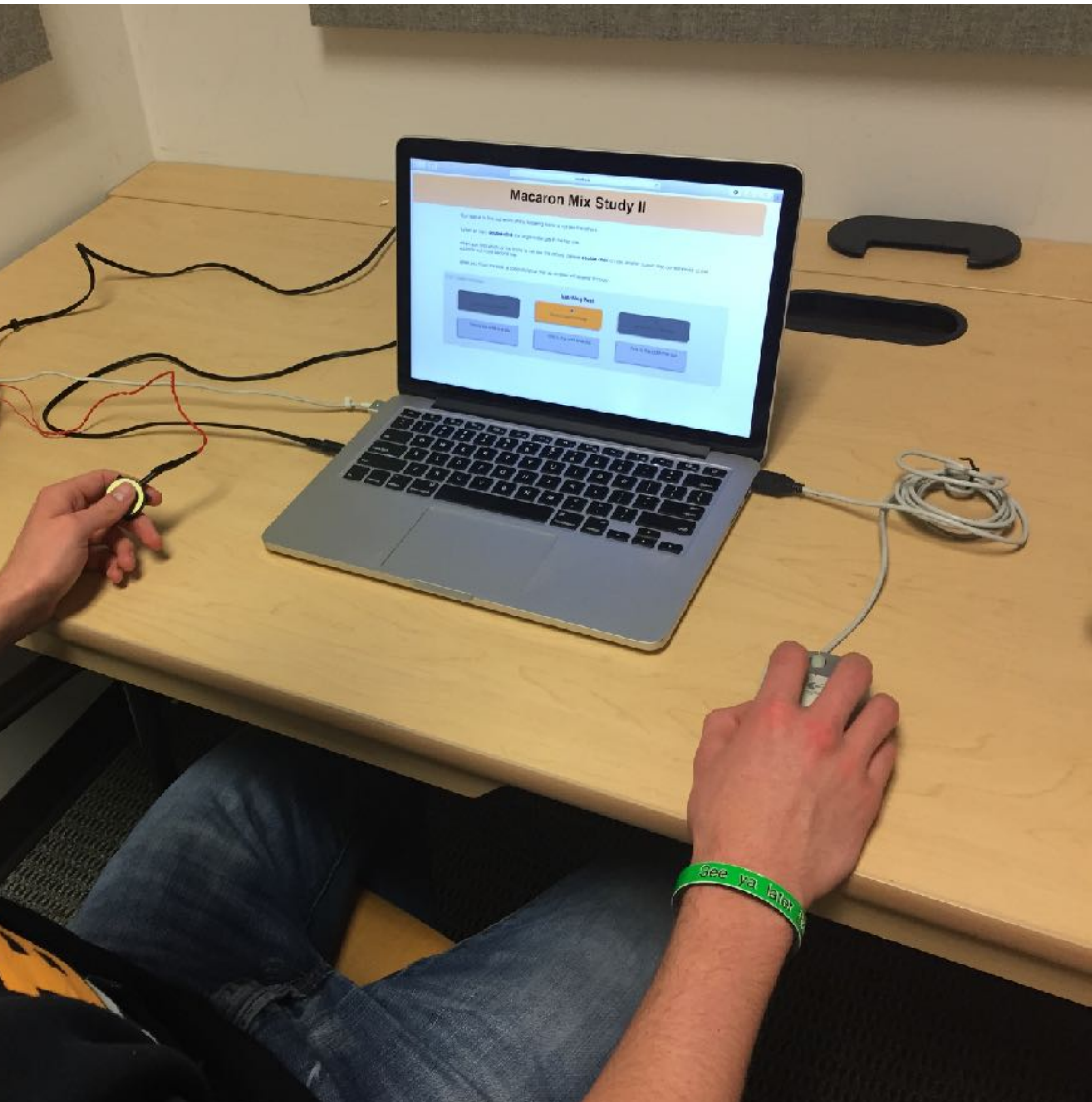
Dynamic Time Warping



Study 2: Distinguishability

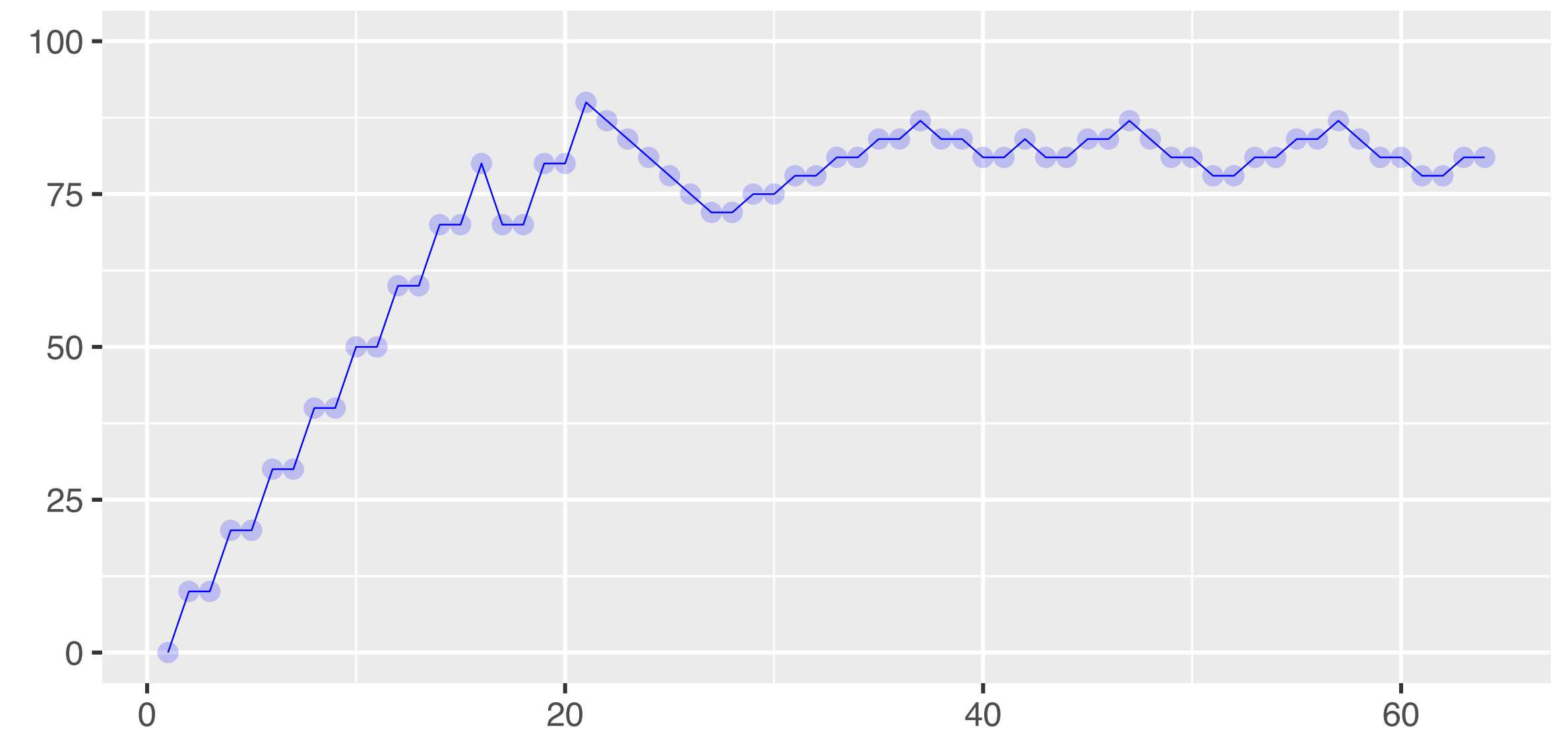


study 2 setup



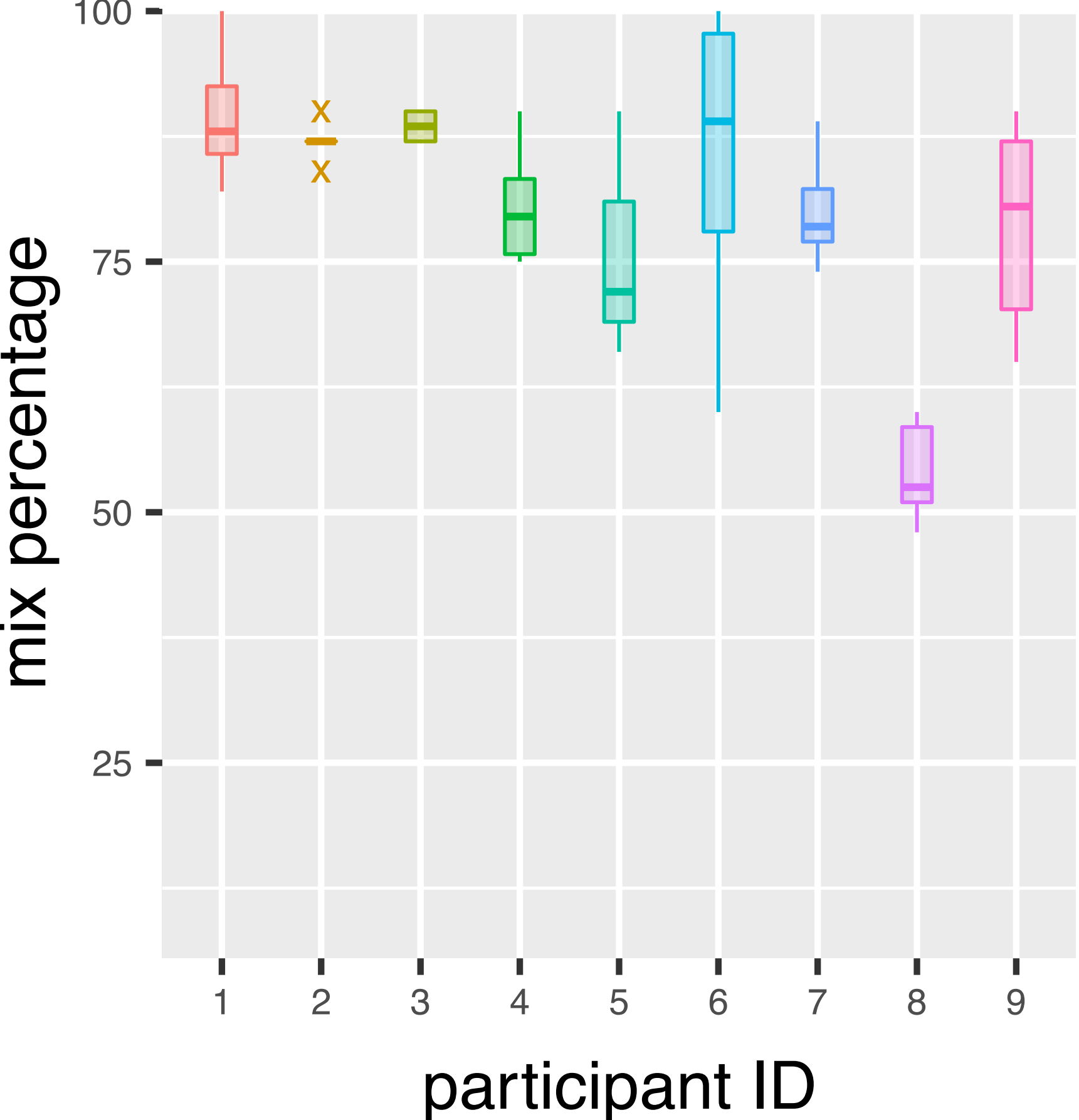
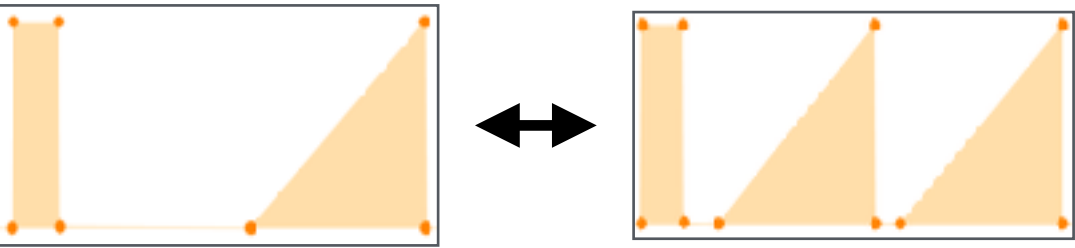
just-noticeable difference
staircase procedure:

two-up, one-down



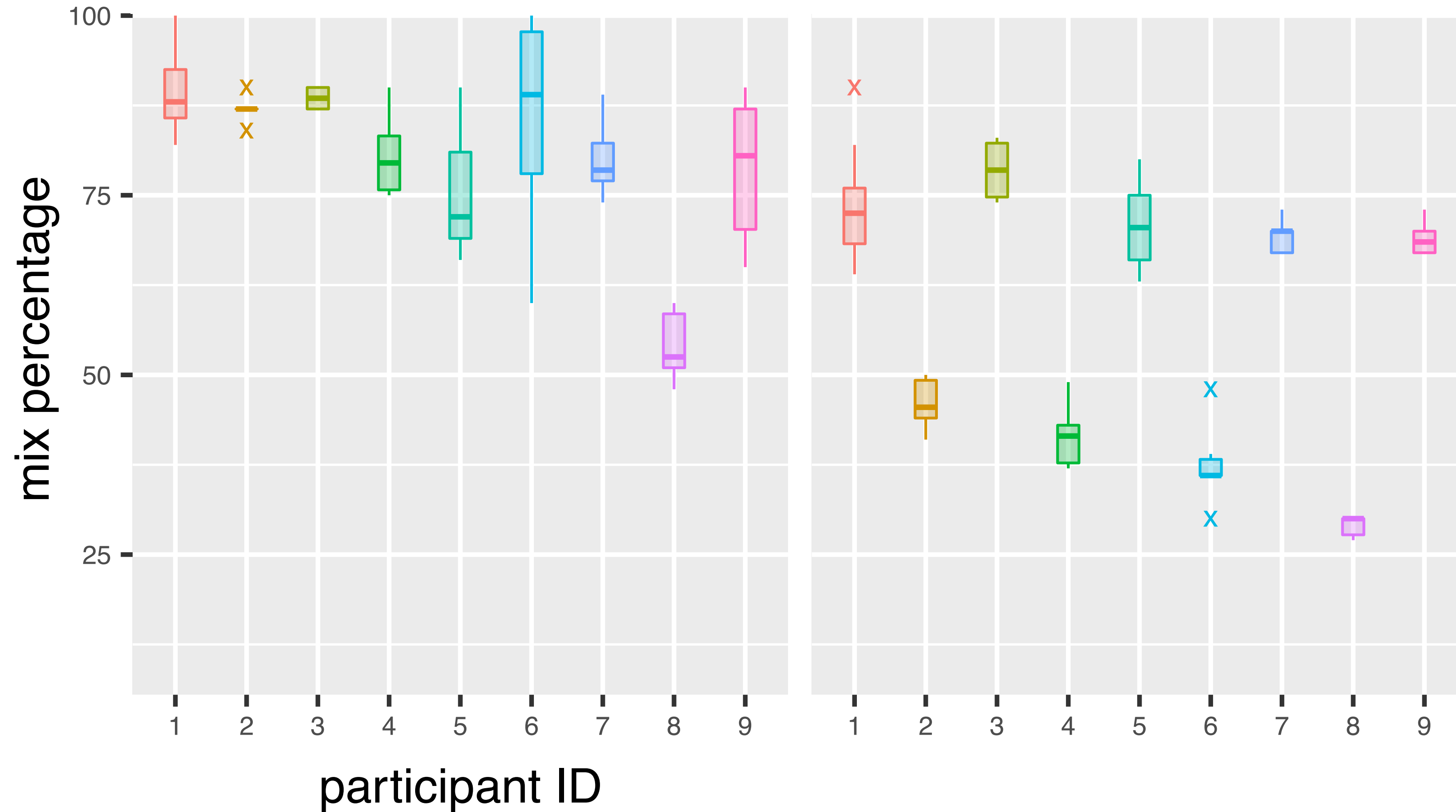
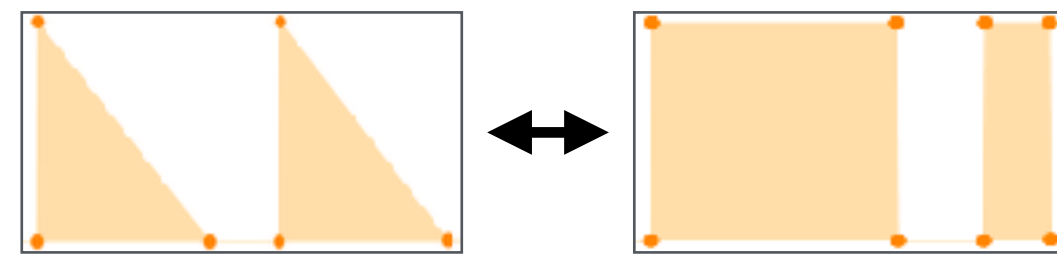
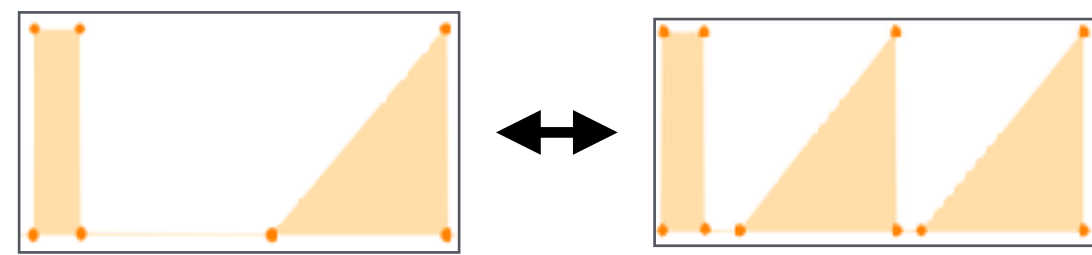
study 2 results

staircase procedure
N=9



study 2 results

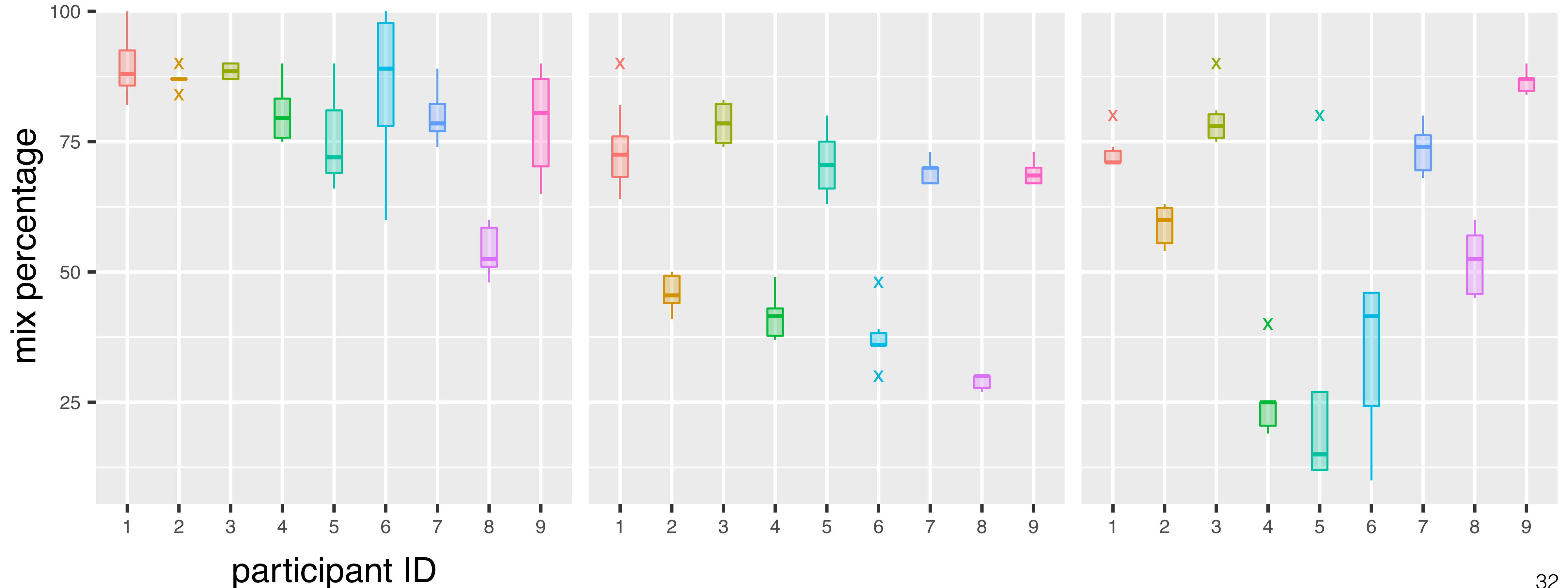
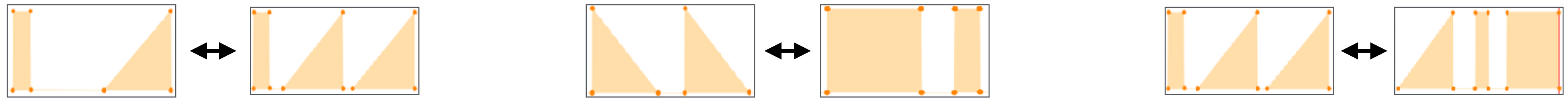
staircase procedure
N=9



study 2 results

staircase procedure
N=9

Increasing Task Difficulty



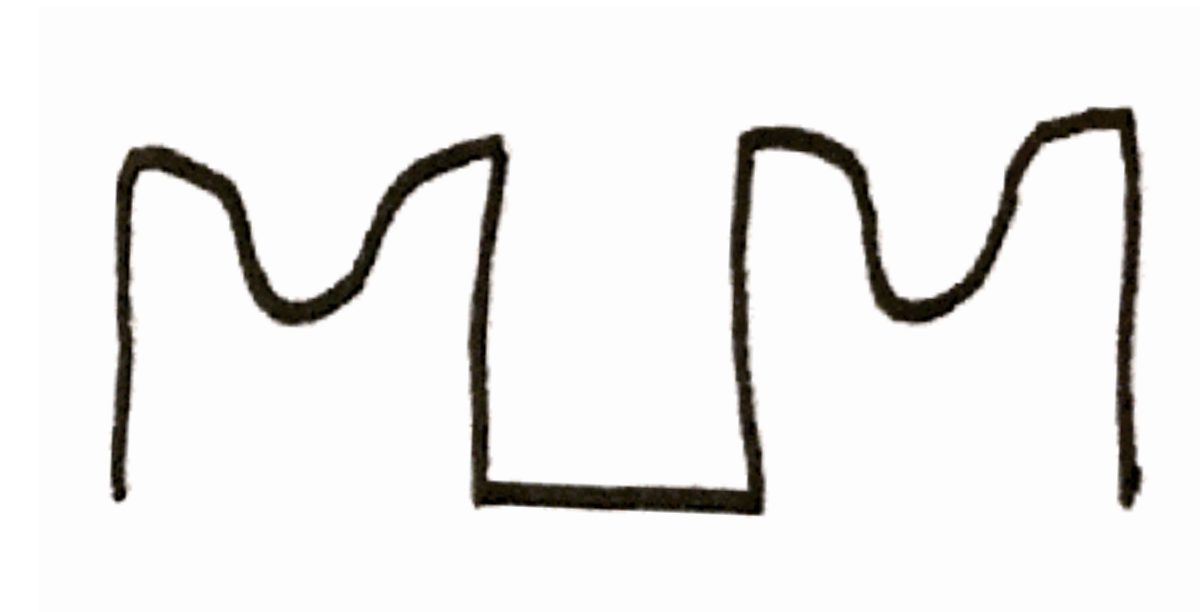
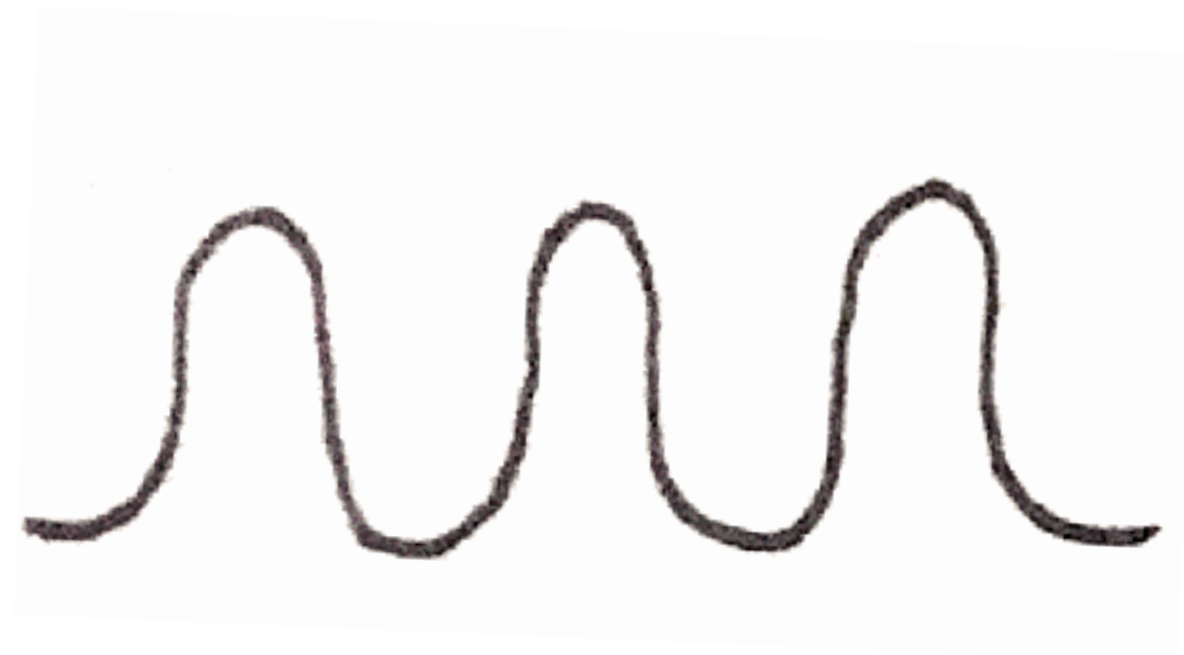
overall results

Cross-fading is not predictable → tends towards random noise.

DTW is predictable → parent properties are preserved.

DTW is distinguishable → behaves sensibly when parents are distinguishable.

**so...what about our
example?**



MacaronMix

The screenshot displays the MacaronMix web application interface. At the top, the browser address bar shows `hapticdesign.github.io/macaronmix/`. The application header includes the title "MacaronMix v1.0.0" and links for "User Agreement" and "Save".

The main control area features a "Select your mixing algorithm:" dropdown menu set to "Dynamic Time Warping". To the right, a "Quick Mix:" section includes buttons for 0%, 25%, 50%, 75%, and 100%. Below this, there are "load waveform 1" and "load waveform 2" buttons, and a central slider between "Wave 1" (set to 100%) and "Wave 2" (set to 0%).

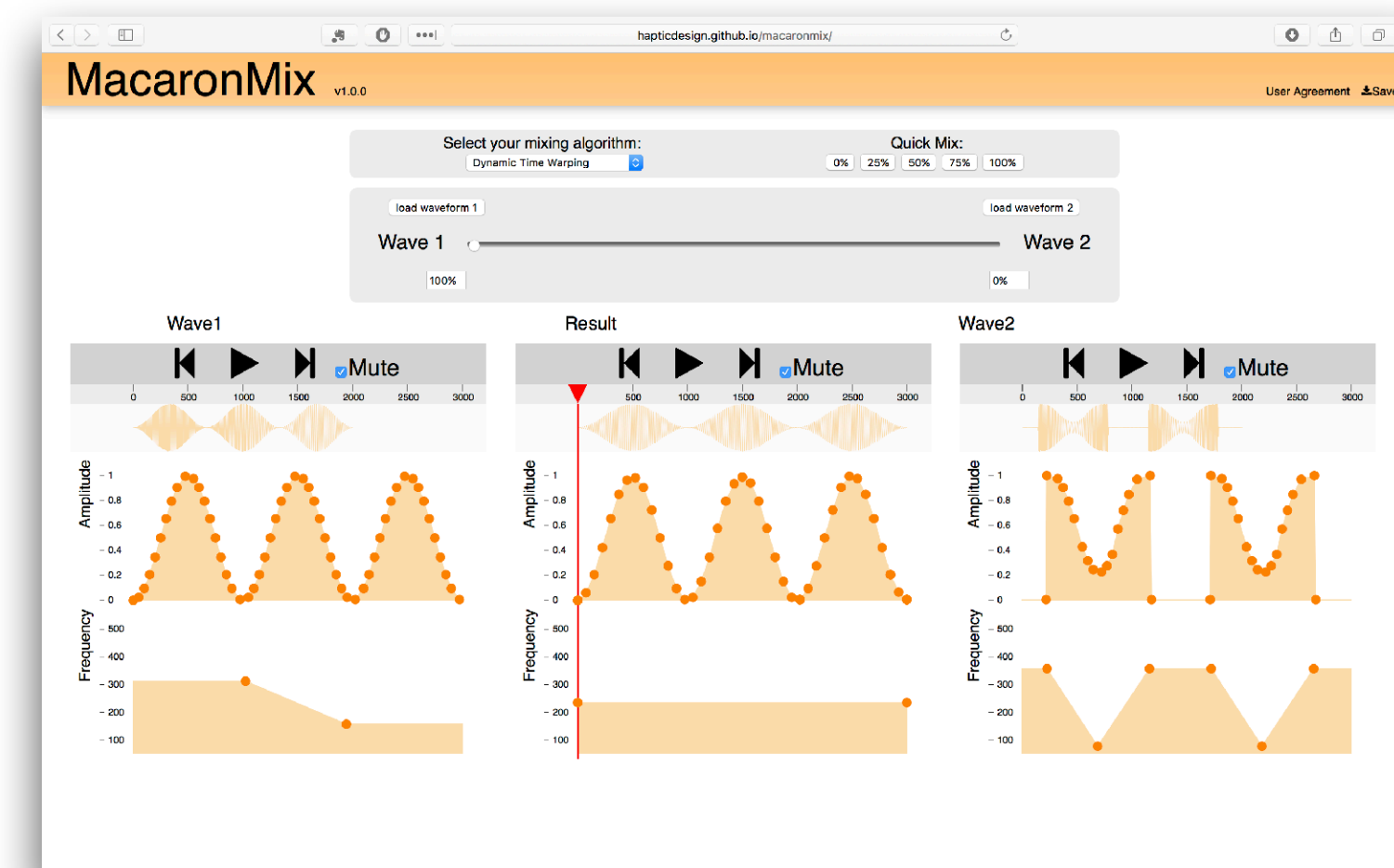
The interface is divided into three columns: "Wave1", "Result", and "Wave2". Each column contains a waveform visualization with playback controls (back, play, forward, and a checked "Mute" checkbox) and a frequency spectrum plot. The "Result" column shows a red vertical line at the beginning of the waveform, indicating the start of the mixed audio.

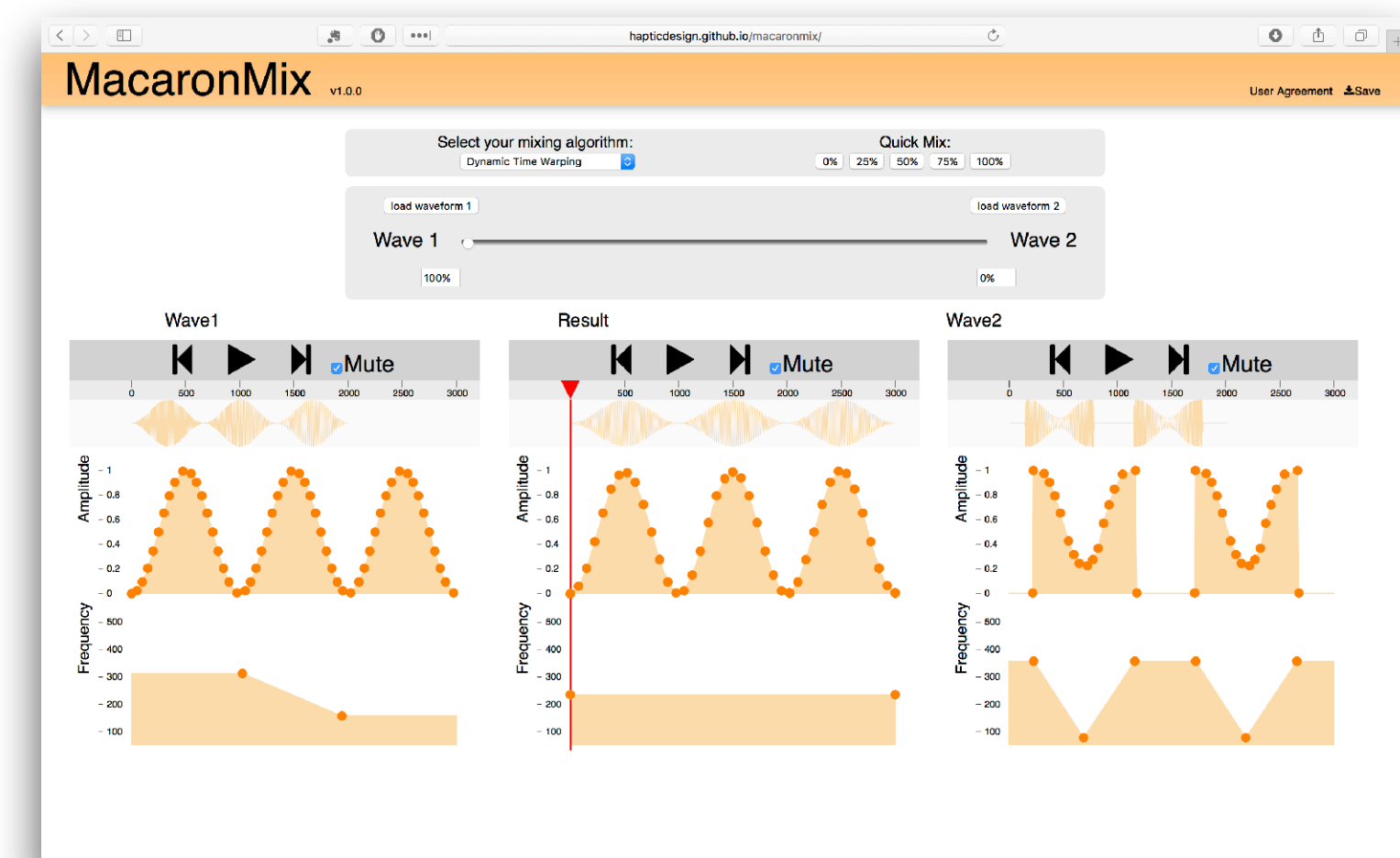
A large watermark `hapticdesign.github.io/macaronmix/` is overlaid across the bottom of the interface.

Summary

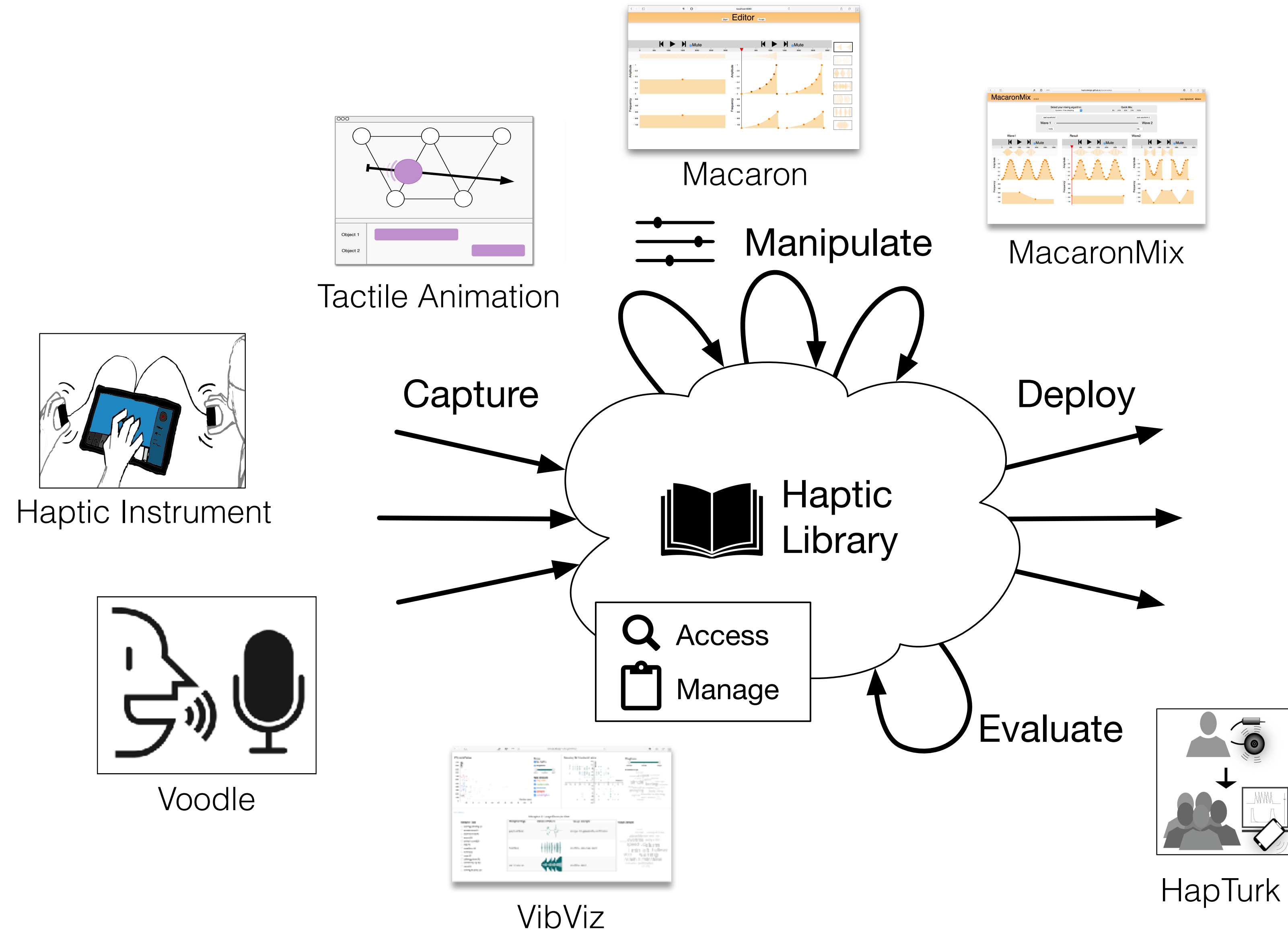
We present a **platform** for haptic morphing:

- a **new algorithm** for vibrotactile morphing based on dynamic time warping
- a **blueprint** for studying perceptual morphs with criteria and experiments
- an **extendable, online tool** to create morphs and develop new algorithms





design ecosystem



Current work

modalities:



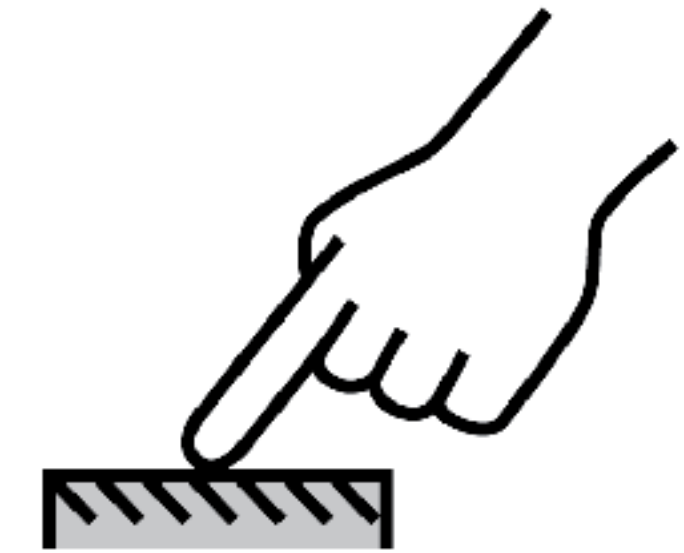
tactile actuators



motion profiles

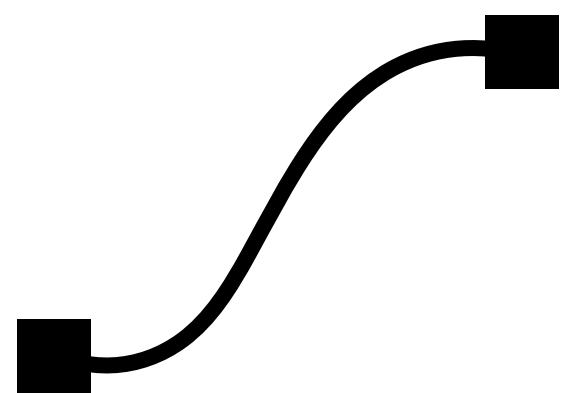


force feedback

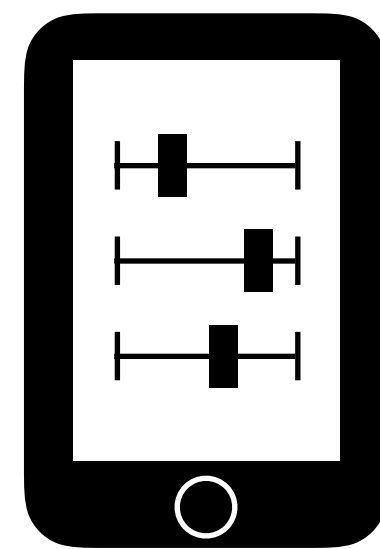


shape/texture

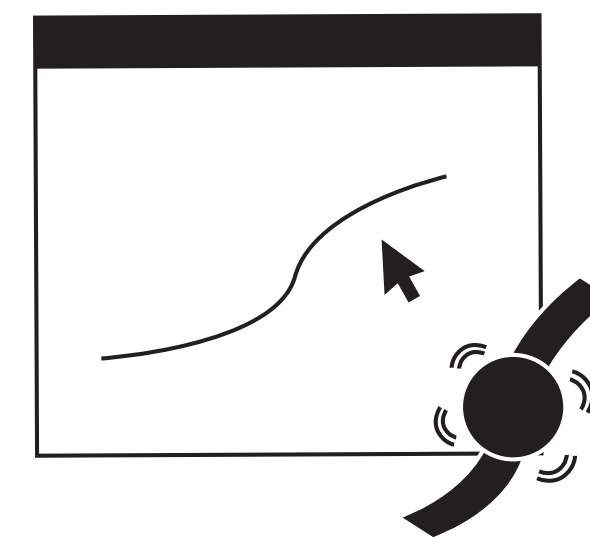
applications:



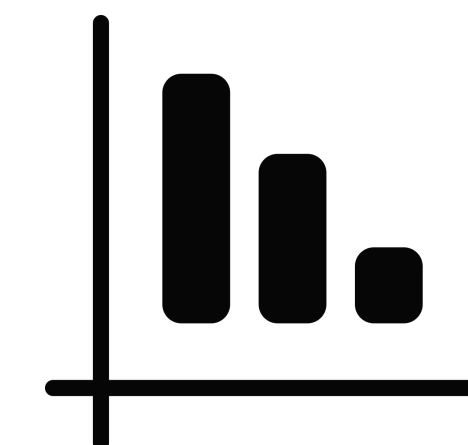
animation



customization



design tools



research



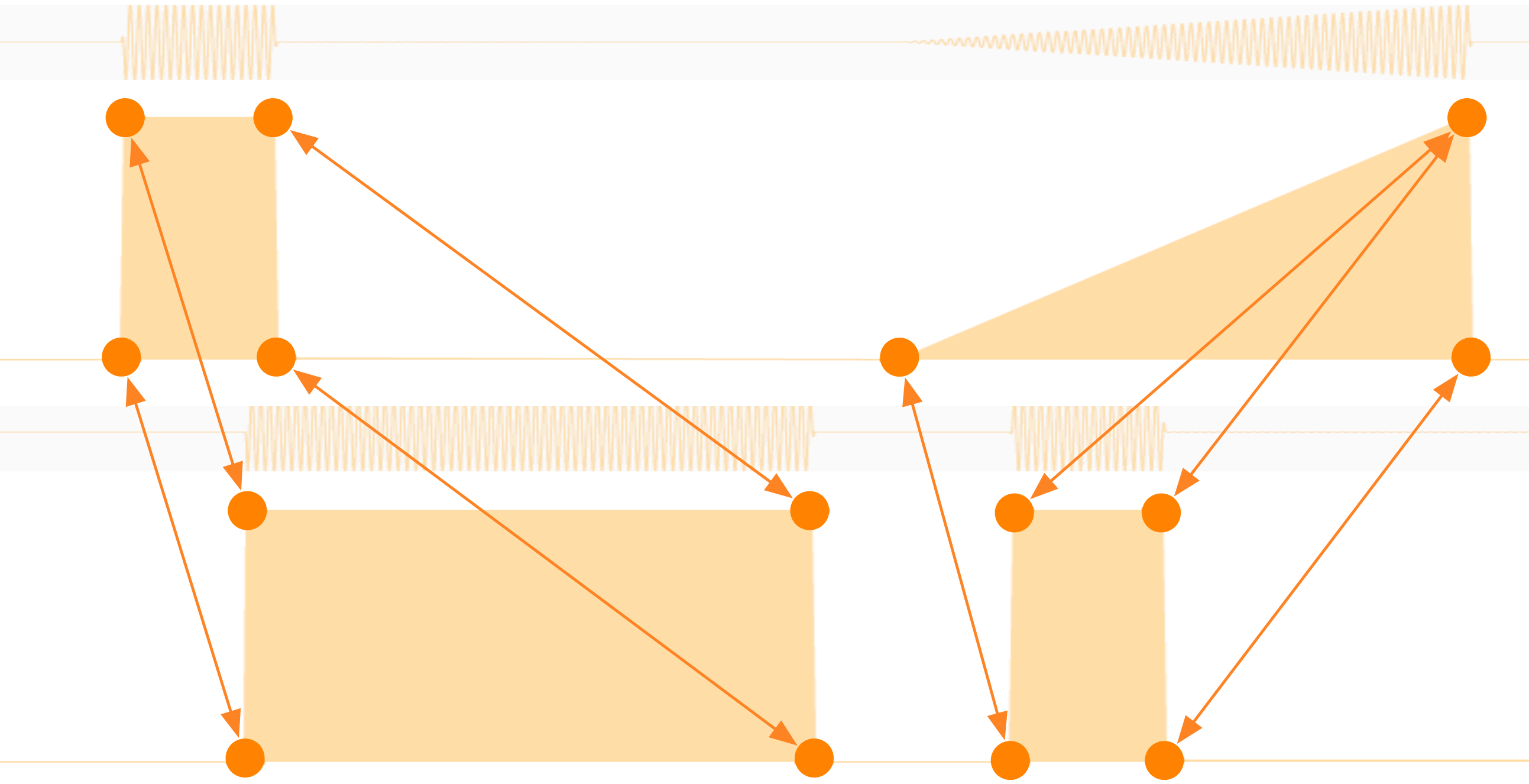
thanks!



Predictable and distinguishable **morphing** of vibrotactile rhythm



THE UNIVERSITY OF BRITISH COLUMBIA



oliverschneider.ca/macaronmix

Ben Clark,
Oliver Schneider,
 Karon E. MacLean,
 Hong Z. Tan

