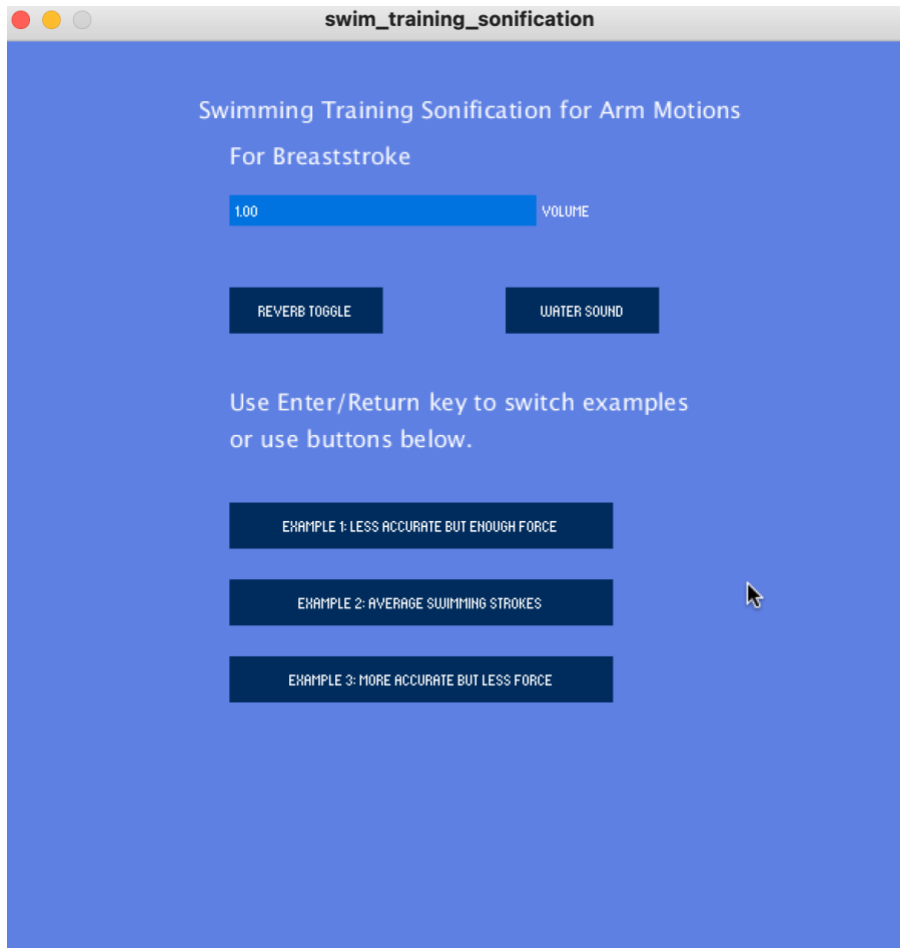


## User Manual of Swimming Training Sonification for Arm Motion in Breaststroke

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The Swimming Training Sonification for Arm Motion includes changing the volume through the slider, a reverb toggle button to mimic the underwater experience, a water-sound button to turn on/off the water sound, and switching three example data using both buttons and the keyboard.



The volume slider changes the volume of the master gain. The slider is ranged from 0 to 1 and was set to 1 initially. It is used when the users feel the sonification is too loud and annoying, and then they can turn down the sound. The change of the master gain glide will not influence the patterns of the sonification. It modifies the overall volume of the sonification.

The reverb toggle will toggle on/off the reverb effect to the sonification. The initial sonification is without the reverb effect. If you click odd times, you turn on the reverb effect. For even times of clicks, you turn off the reverb effect. The reverb effect is to mimic the underwater environment.

The reverb effect is created by adding the sound reflections of a space to a dry audio signal, simulating the way sound waves bounce off surfaces in a room or environment. When sound travels through water, it also reflects off the surfaces, and the reflections can create a sense of space and depth. That is why the reverb effect can mimic the sound of being underwater.

Another Water Sound button uses the sample player to add or turn off the water sound. The sonification is initially with the water sound. If you click an odd number of times, you turn off the water sound. If you click even times, you turn on the sound effect. The water sound mimics the sound of the paddle heard by the swimmer while swimming. You could apply the water and reverb sound effects together or either of them or neither.

The three buttons for each example will let the users implement different JSON data into the sonification and hear the sound differences. Each JSON data document includes an array of arm motion objects. Each object contains phase, timestamp, force, duration, oxygen, and accuracy features. In breaststroke, the arm motions are divided into five phases: glide, out-sweep, catch, in-sweep, and recovery. The following figure shows each phase's usual range of force and duration.

Range of force and duration

phase	force (N)	duration (ms)
glide	$\leq 10$	1000 ~ 2000
outsweep	50 ~ 150	200 ~ 400
catch	100 ~ 300	500 ~ 700
insweep	150 ~ 400	500 ~ 700
recovery	20 ~ 50	200 ~ 400

The oxygen level range should be above 94 percent for trained swimmers, or it could cause danger. If under 94%, a "D, D" sound will alarm the users. The accuracy of arm motions is usually above 0.6 to maintain swimming. The data objects in the data documents are usually taken in the given ranges of features.

The first button of "Example 1: less accurate but enough force" will load data in swimmer\_data1.json and start the Example 1 event every time you click. Example 1 has data that is lower in accuracy but higher in force. The second button of "Example 2: average swimming strokes" will load data in swimmer\_data2.json and start the Example 2 event every time you click. Example 2 has data that are average in the range. The third button of "Example 3: more accurate but less force" will load data in swimmer\_data3.json and start the Example 3 event every time you click. Example 3 has the data objects that have higher accuracy, but a lower force is given.

The users can also use the Enter/Return Key to switch between examples. The examples loop from 1 to 3, wrap to 1 and loop again. When every example begins, a text-to-speech sound announces the current example number.

The timestamp is the cumulative duration of the swimming and is used to schedule tasks. A sin wave is controlled by force and duration. The duration and force/350 as gain value are passed in the amplitude/gain envelope to manipulate the gain of the sin wave. The oxygen level is detected to protect the swimmers' safety. If the oxygen level is under 94%, there raised an alarm sound from "alarm.wav." The accuracy controls another square wave in the sonification. The accuracy \* 440 gives the frequency of the square wave. As mentioned before, a sample player of water sound in "water\_sound.mp3" can be turned on and off by the "water sound" button.