Detailed Description of the Audio Patches' Behavior[1]

1 Lightness

Lightness is sonified by integrating two components: one for the sonification of the low Weight Index, and the other one for the sonification of the high Weight Index. These two methods use different sonification models, described below.
In intermediate cases (e.g., in continuous transitions from high to low Weight Index, and vice-versa), traces of one of the sonifications might be faintly heard in the background.

1.1 Sonification of low Weight Index

The engine for the sonification of low Weight Index is a chain of 32 audio synthesis small patches, which we call "agents".
Each agent has an input receiving integers from the outside, and two outputs: one for sending sounds to the mixing section, and another one for sending out an integer. The 32 agents are connected to exchange integer values: the output of the n-th agent is connected to the input of the (n+1)th agent. The 32-nd agent sends its output to the first agent of the chain, creating a feedback loop.

Each agent contains a filtered white noise generator and a triangular wave playback engine, mixed together (see below, point 7).
When an integer is received through the agent's input, the agent is activated: if no values are received, the agent will be idle and silent.
One activation of an agent consists of three stages:

a) the generation of a series of parameters settings controlling the amplitude of the white noise generator and the triangular wave playback engine, to create one sonic event with certain attack, sustain, release times (e.g., 9000 ms, 300 ms, 3000 ms - see below for further specifications, points 1, 2, 3),
b) the generation of a new integer output, calculated on the received input integer (i.e., randomly adding 0, 5 or -5 to it),
c) the action of sending out the new integer after a certain a delay (e.g., 600 ms - see below for further specifications, point 4), to avoid that all agents output events too quickly.

The integer controls the audio events' pitch: it is considered as a MIDI note, and quantized on a harmonic grid based on a pentatonic set. Converted in Hertz, it becomes the frequency of the triangular wave playback engine and the center frequency of the resonant filter applied to the white noise generator.
If no other parameters were involved, the result of this chain would be a sequence of very low-pitched sounds, following one after the other at regular intervals, with the same ADSR, and pitches randomly moving by steps of 5 semitones around the bottom of the pitch range allowed by the patch (i.e., MIDI note 24).

The Weight Index parameter influences a series of parameters in each agent:

1) the attack time of the agent, from 1000 ms (high Weight Index) to 10000 ms (low Weight Index)

[1] This document is a part of Supplementary Material of the paper: Niewiadomski, R., Mancini, M., Cera, A., Piana, S., Canepa, C., Camurri, A. "Does embodied training improve the recognition of mid-level expressive movement qualities sonication?"

2) the sustain time of the agent, from 100 ms (high Weight Index) to 300 ms (low Weight Index)
3) the release time of the agent, from 1000 ms (high Weight Index) to 3000 ms (low Weight Index)
4) waiting time before sending the new integer to the output, from 200 ms (high Weight Index) to 600 ms (low Weight Index)
5) a transposition factor for the MIDI note derived from the received integer, from 1 semitone (high Weight Index) to 91 semitones (low Weight Index)
6) Weight Index is used to control each agents' amplitude production, multiplied by 0.0 (high Weight Index) to 1.0 (low Weight Index)
7) Weight Index subtly controls the mix ratio between the filtered white noise generator and the triangular wave playback engine (low Weight Index causes the output of the triangular wave to be multiplied by 0.7 – high Weight Index causes the output of the triangular wave to be multiplied by 1.0). Low Weight Index will produce noisier, whispery, airy sounds.

To sum up:

in the case of constant maximum value of Weight Index, the agents will have these features:

- 1000 ms attack, 100 ms sustain, 1000 ms release
- each event separated by 200 ms
- pitches random-walking around extremely low range
- amplitude = 0 (non-audible)

in constant minimum value of Weight Index, the agents will have these features:

- 10000 ms attack, 300 ms sustain, 3000 ms release
- each event separated by 600 ms
- pitches random-walking around extremely high range
- amplitude = 1 (maximum audibility)

In real-life conditions, Weight Index is always (sometimes dramatically) moving between high and low values, and it is never constant. This natural feature, coupled with the described mappings and the autonomous behavior inherent in the agents' architecture, translates the idea of floating light objects surrounding the dancer. A light movement (= low Weight Index) will push up the agents' pitches, make them slowly evolving, and audible. When Weight Index increases, it will fade out the agents, while they gently descend in pitch and become denser.

The Lightness parameter is used to control a further, final amplitude stage for this module: when Lightness is at its maximum (1.0), the module is fully audible (its output is multiplied by 1.0), when at its minimum (0.0), the module will not be heard (its output is multiplied by 0.0).

1.2 Sonification of high Weight Index

To sonify high values of Weight Index we used a granulator. 16 modules play short fragments (grains) of a source sound file, applying a fade-in/fade-out window (made from a triangular waveform). The players are synchronized in order to create a continuous sound by overlapping grains. The source sound file used in this case is a continuous, low-pitched sound, slightly varying in amplitude and timbral color. It was created by reverberating, transposing and compressing some recordings of slamming doors.
The granulators' window size slightly changes according to the Weight Index parameter: high Weight Index will set it at 100 ms, low Weight Index will set it to 90 ms. This gives the sound some natural

instability and variability.
Weight Index causes also changes in the playback rate (i.e., pitch) of the grains. Low Weight Index causes random transpositions by a factor of 0.8 / 1.2 (where 1.0 means no transposition, 2.0 means double speed, 1 octave higher, 0.5 means half speed, 1 octave lower). High Weight Index does not add any random transposition.
The Weight Index parameter also controls the overall output level of this module: high Weight Index multiplies the output level by 1.0, low Weight Index multiplies the output level by 0.0.
The Motion Index controls which parts of the source sound file are going to be played back. A high value of Motion Index will cause the players to reproduce the louder parts of the sound file. A low value of Motion Index will cause the players to reproduce the softer parts of the sound file.

The overall output volume of the high Weight Index sonification is controlled by the Lightness parameter as well, in the same way as the sonification of low Weight Index.

2 Fragility

When the value of Fragility changes from 0 to 1, a clock is started, when it goes back to 0, the clock is stopped. While it is running, the clock generates events (i.e., "bangs") at a 5 ms rate.
Every time a clock event is generated it causes the random selection of one out of 4 players: the player starts to play a section of a pre-recorded sample. The samples contain recorded fragments of physical objects on the verge of breaking). Samples last between 500 and 1000 ms, and have a peculiar morphology: they contain significant events (e.g., loud cracks, lasting between 50 and 100 ms) and less important small cracklings in other points, interleaved with silence.
The selected player randomly selects a section of the sample to be played, with a duration randomly set between 100 and 200 ms, and starts playing it back.
Being the clock's rate very fast, when Fragility is at 1, several clock events will cause the 4 players to trigger several overlapping events in the range 100-200 ms, resulting in the production of a series of short superposed cracklings. The interaction between the samples' morphology and the playback settings provides variability and, then, the communication of Fragility.
When a series of fragile movements is detected, usually the value of Fragility is not constant but changes frequently, causing the clock to start and stop several times. Since the playback parameters setting is optimized for the pre-recorded sample described above, each clock activation / deactivation causes the playback of 2 or 3 sample fragments: according to the sequence of input values, the sonic result can range from a series of sparse cracklings, with lots of interleaved silences, to a denser sonification.