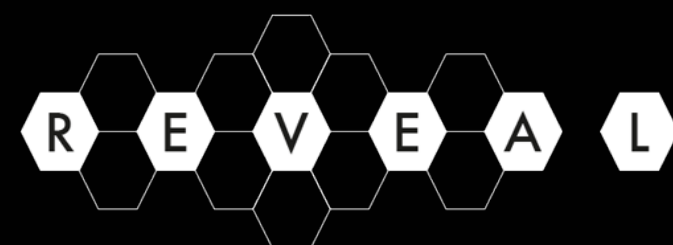


Software Sonification: Potential and Challenges

Carmen Armenti

REVEAL @ Software Institute — USI, Lugano



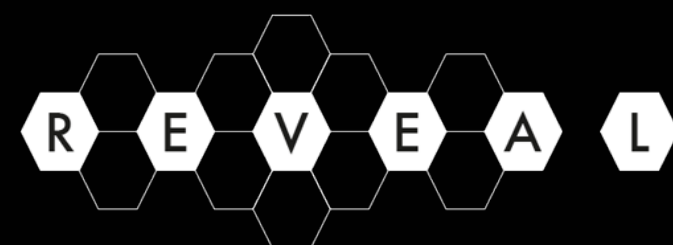
Università
della
Svizzera
italiana

Software
Institute

Software Sonification: Potential and Challenges

Carmen Armenti,
Marco Raglianti, and Michele Lanza

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Università
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Svizzera
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Hard-to-Answer Questions about Code

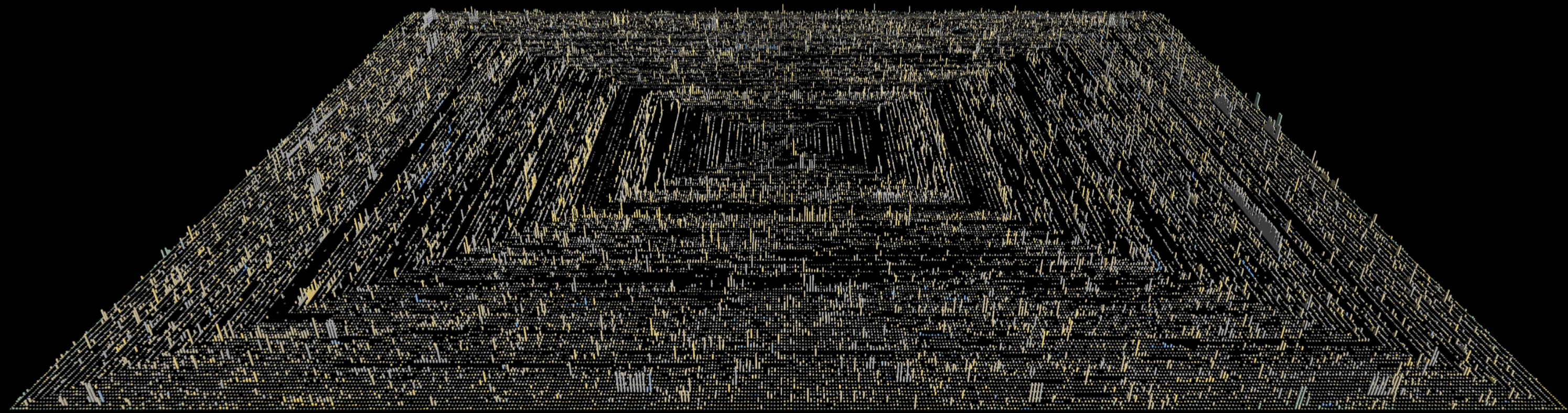
Thomas D. La Toza and Brad A. Mayers

In Proceedings of PLATEAU 2010

■ *“When, how, by whom and why was
this code changed or inserted?”*

■ *“Has this code always been this
way?”*

■ *“How has it changed
over time?”*



Linux on April 17, 2022

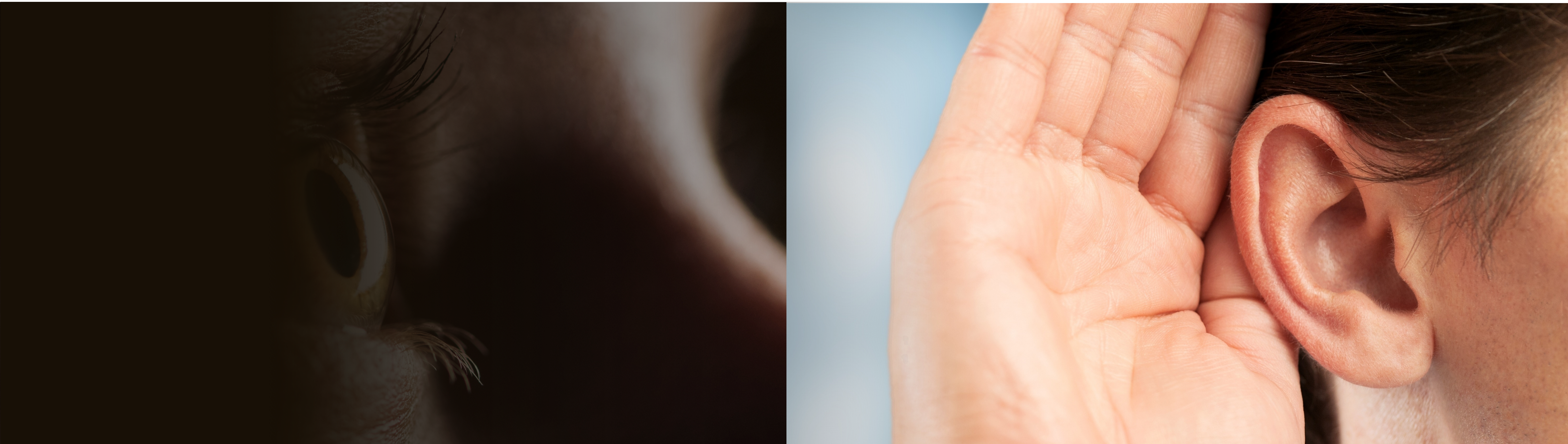


01/15/2009

To process temporal sequence of events, the sense humans rely on is...



To process temporal sequence of events, the sense humans rely on is...



...hearing

To process temporal sequence of events, the sense humans rely on is...

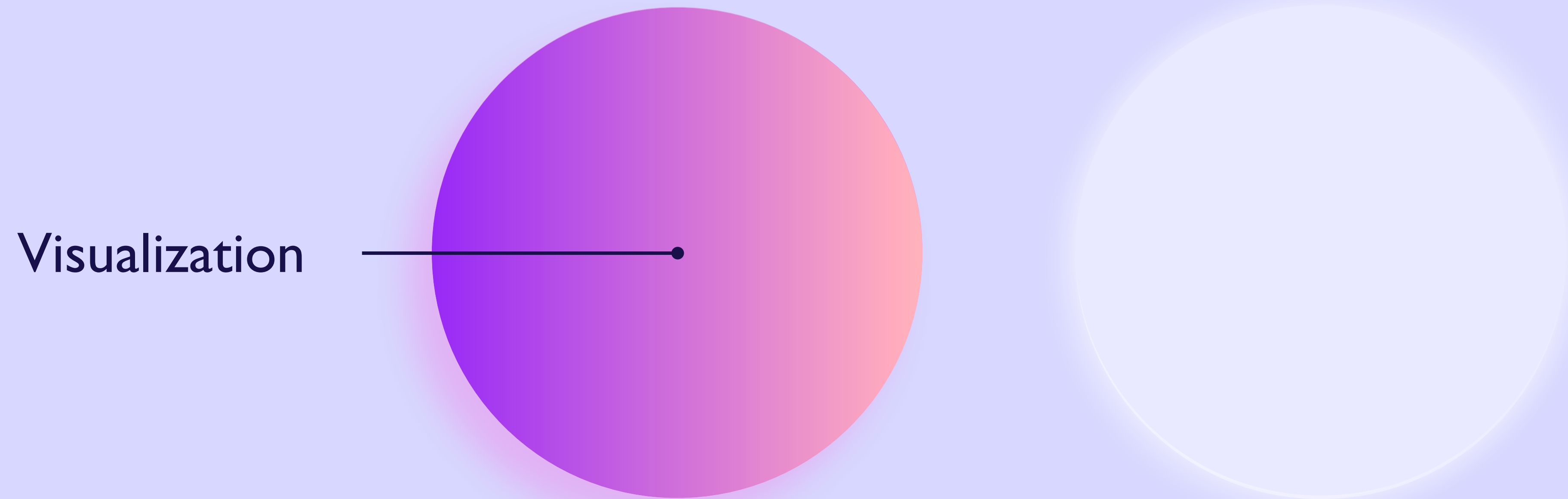


...hearing

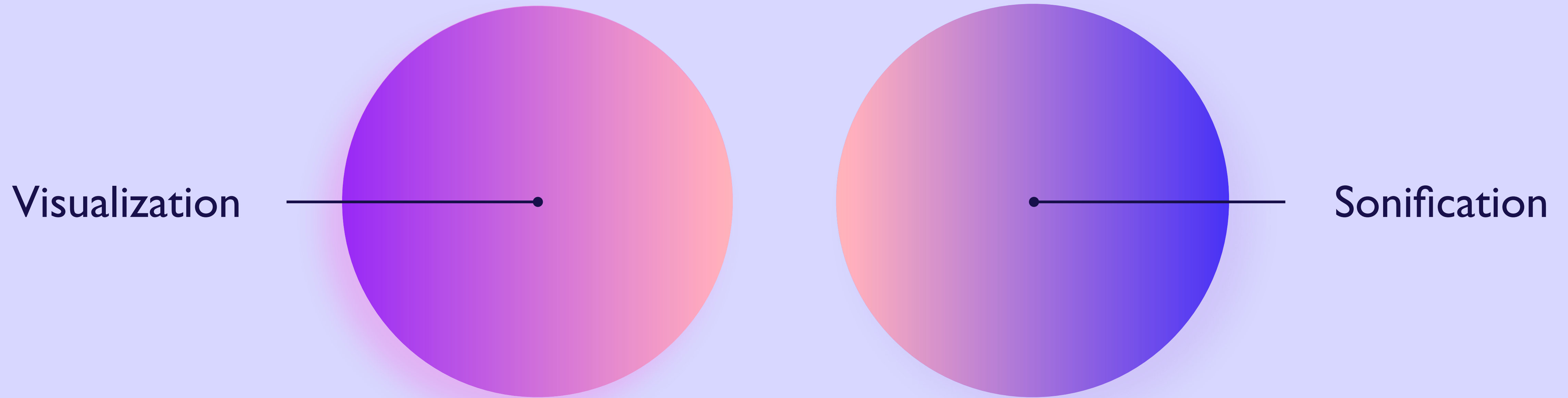
Information Display



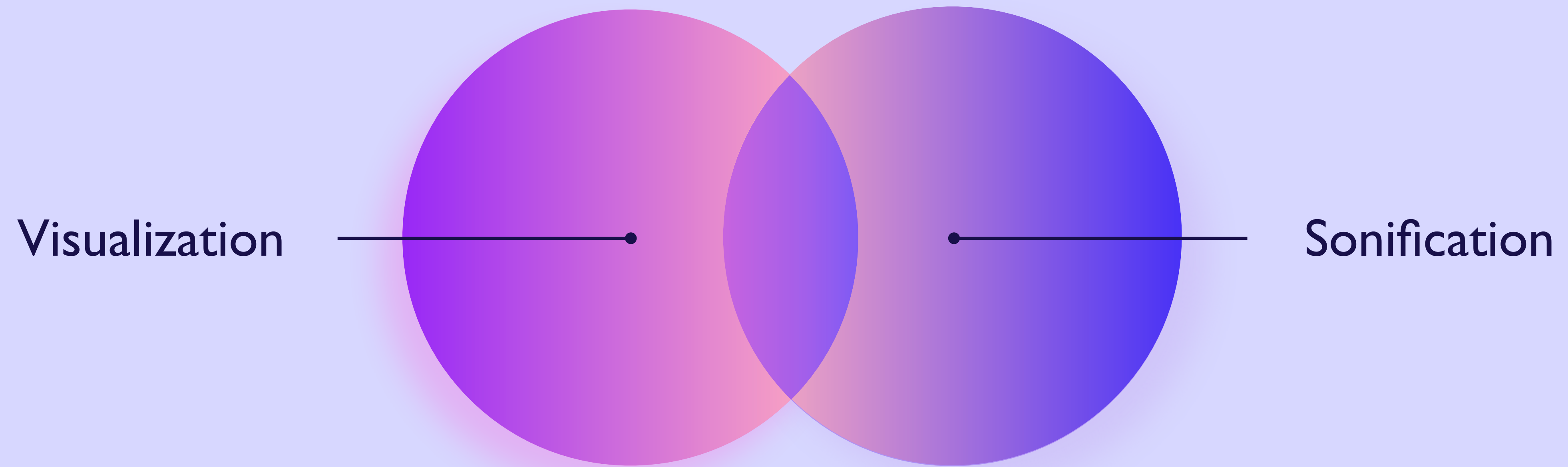
Information Display



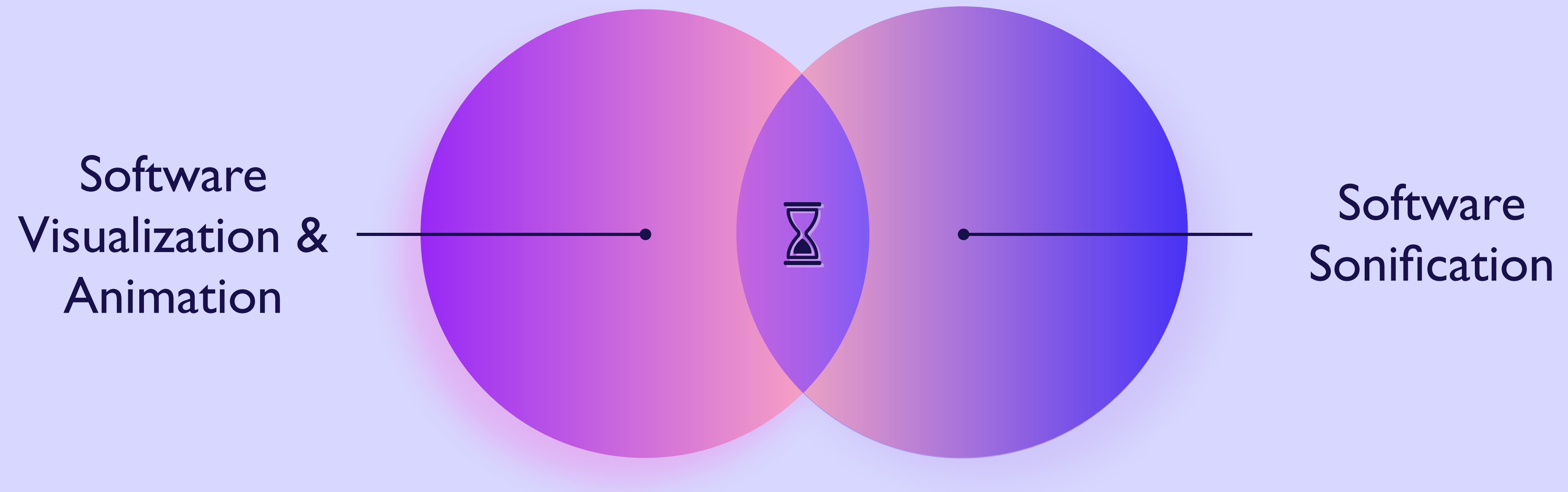
Information Display



Information Display

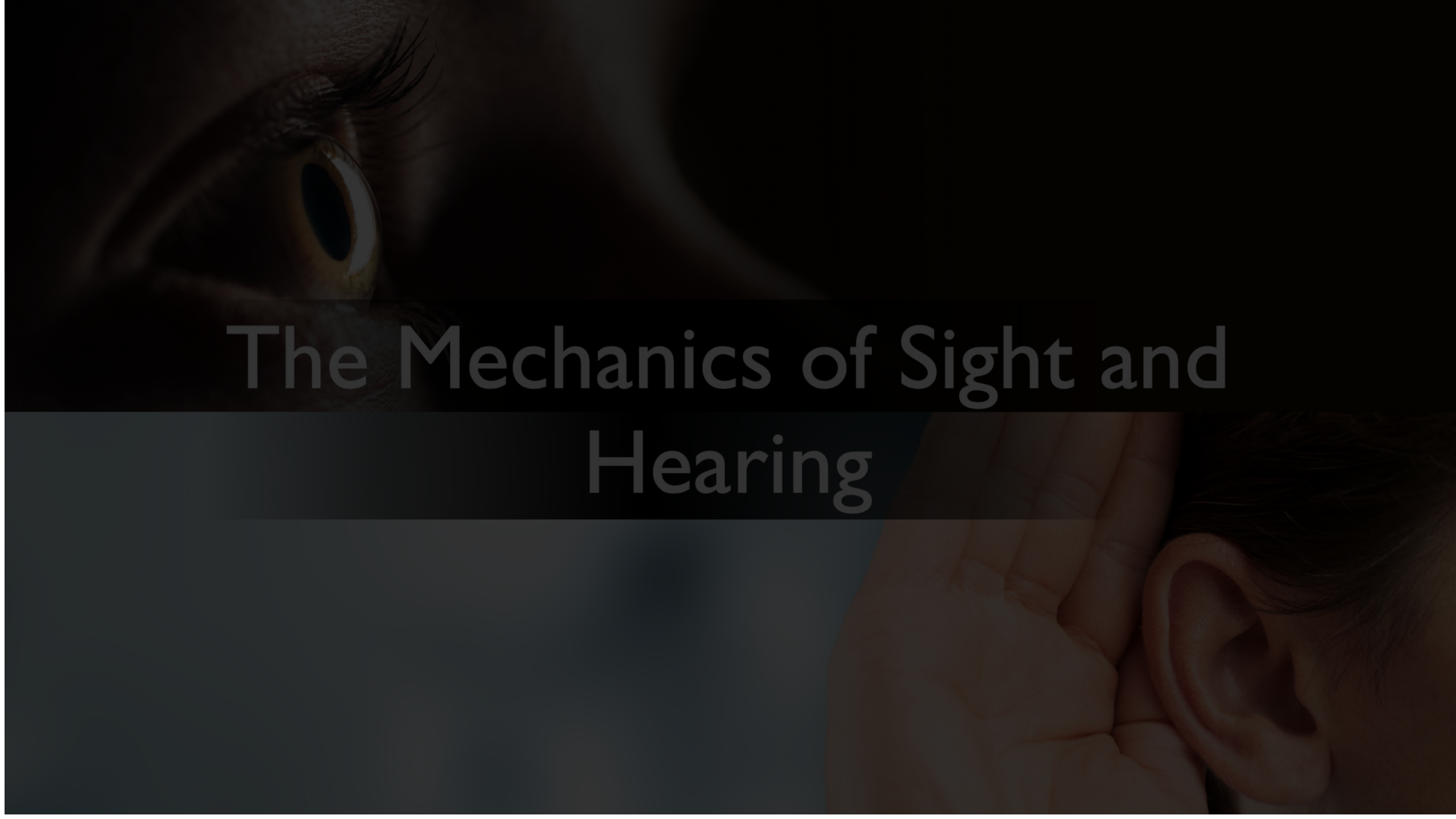


Information Display



An abstract graphic of a soundwave or waveform, rendered in white lines against a black background. The wave is complex, with many sharp peaks and valleys, suggesting a high-frequency or complex sound. The word "Sonification" is overlaid in white text.

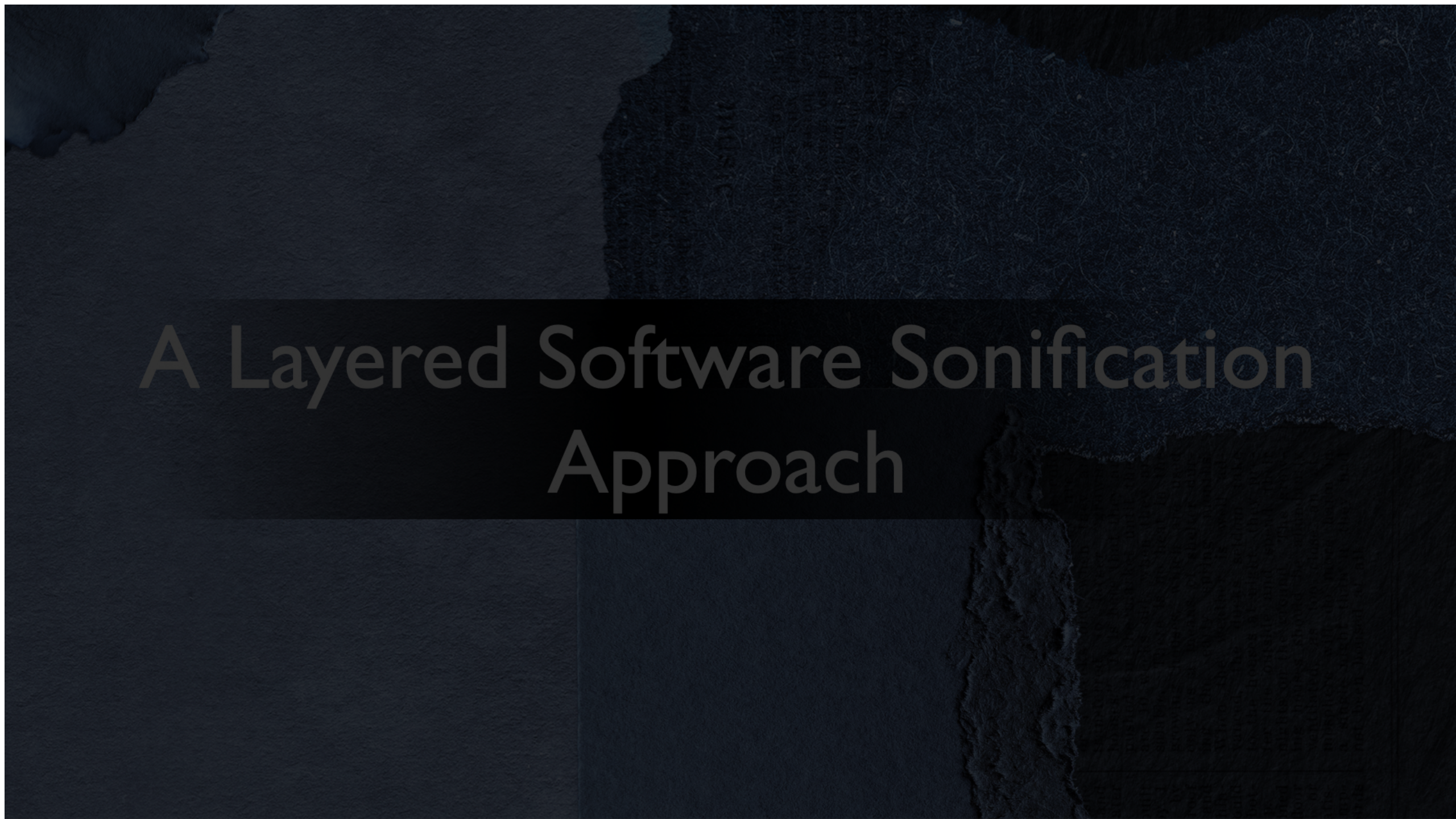
Sonification

A close-up photograph of a human eye and ear. The eye is looking towards the left, and the ear is visible on the right. The image is dark and moody, with a focus on the textures of the skin and the shape of the eye and ear.

The Mechanics of Sight and Hearing

An abstract geometric pattern consisting of dark, overlapping shapes that resemble stylized human profiles or architectural elements. The pattern is composed of various shades of brown and black, creating a complex, layered effect. The word "Gestalt Psychology" is overlaid in white text.

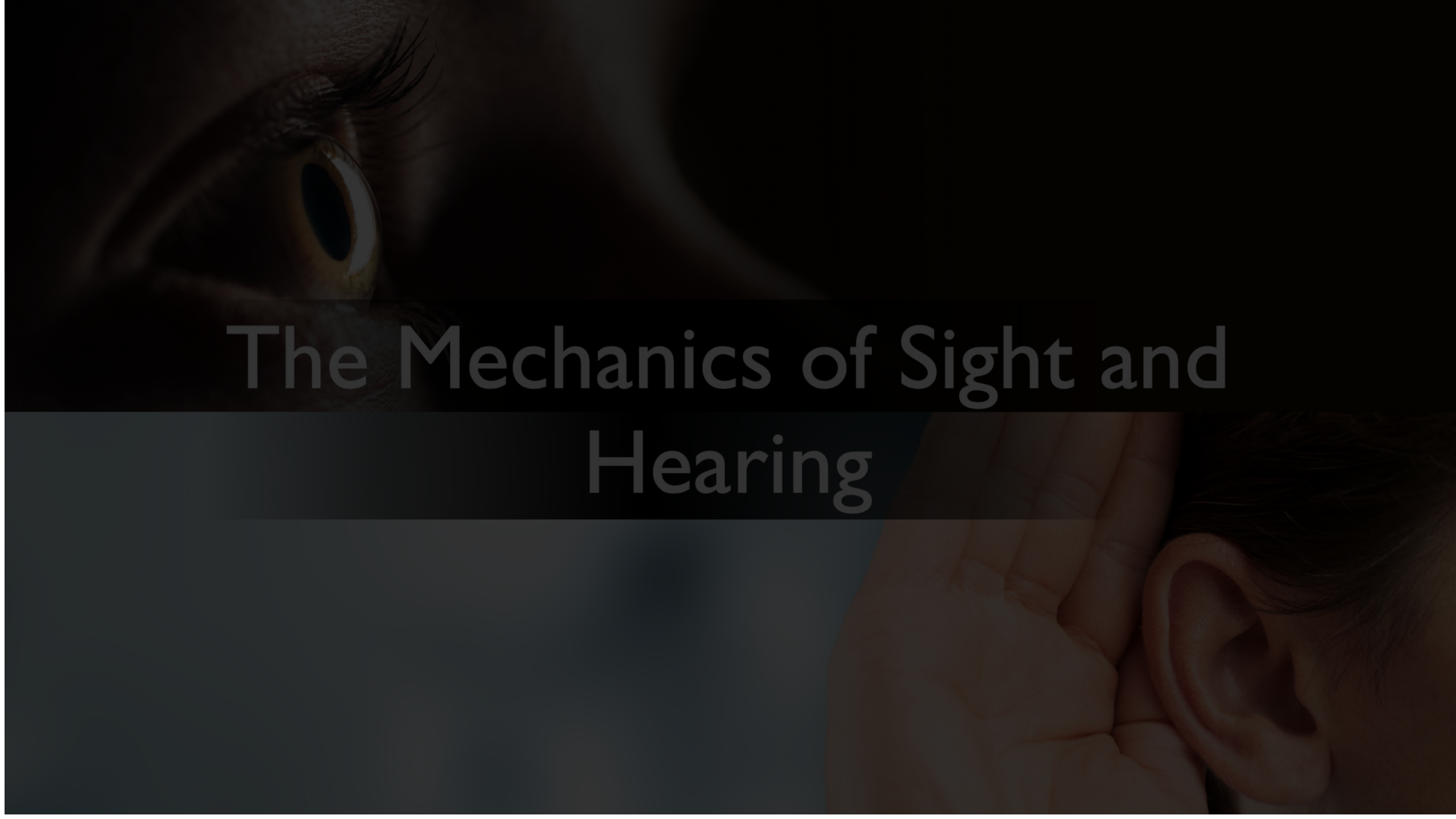
Gestalt Psychology

A dark, textured background with a mottled, almost marbled appearance. The colors range from deep black to dark grey, with some lighter, fibrous-looking areas that give it a tactile quality. The text "A Layered Software Sonification Approach" is overlaid in white.

A Layered Software Sonification Approach



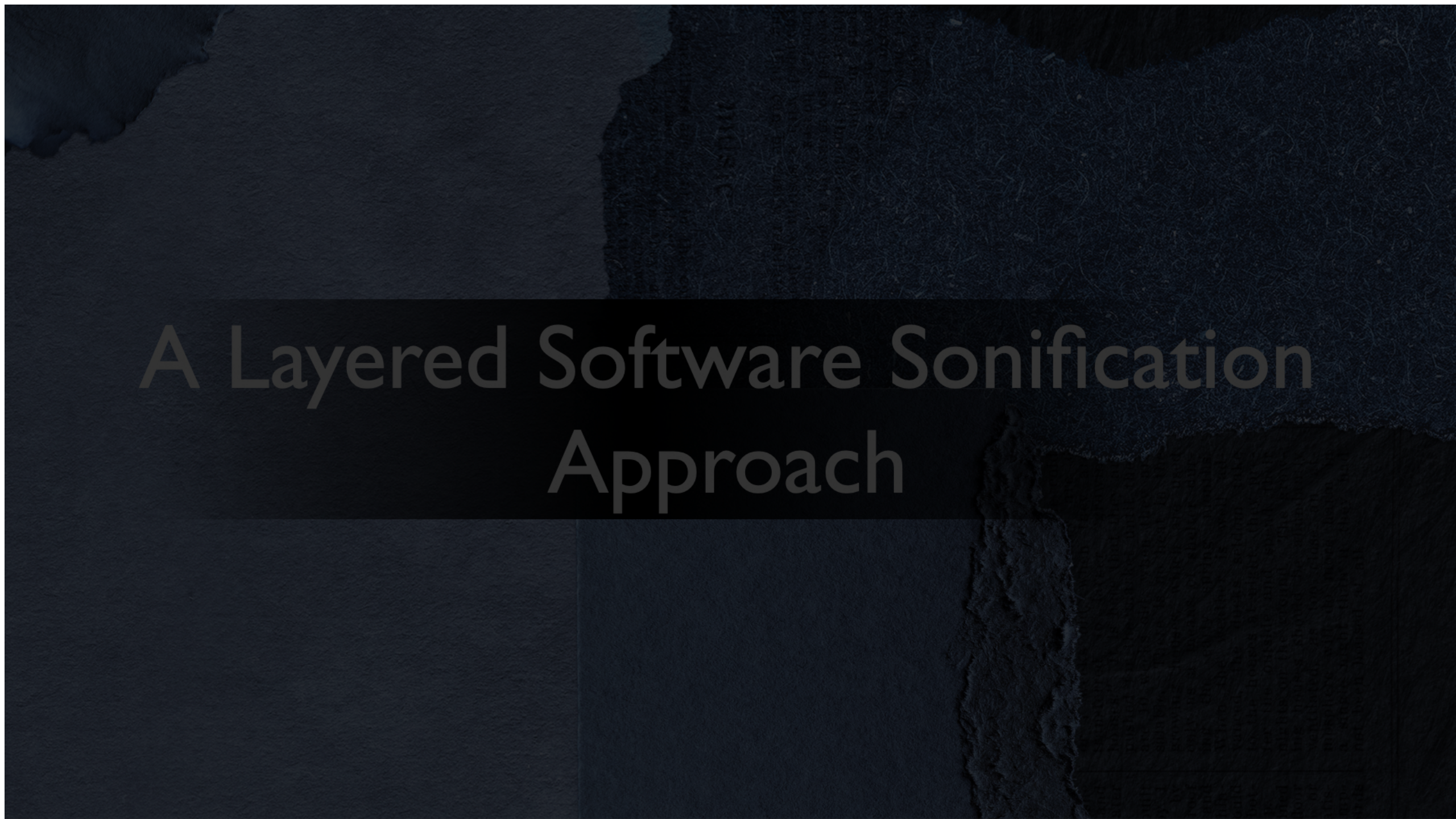
Visualization and Sonification as Complements



The Mechanics of Sight and Hearing



Gestalt Psychology



A Layered Software Sonification Approach



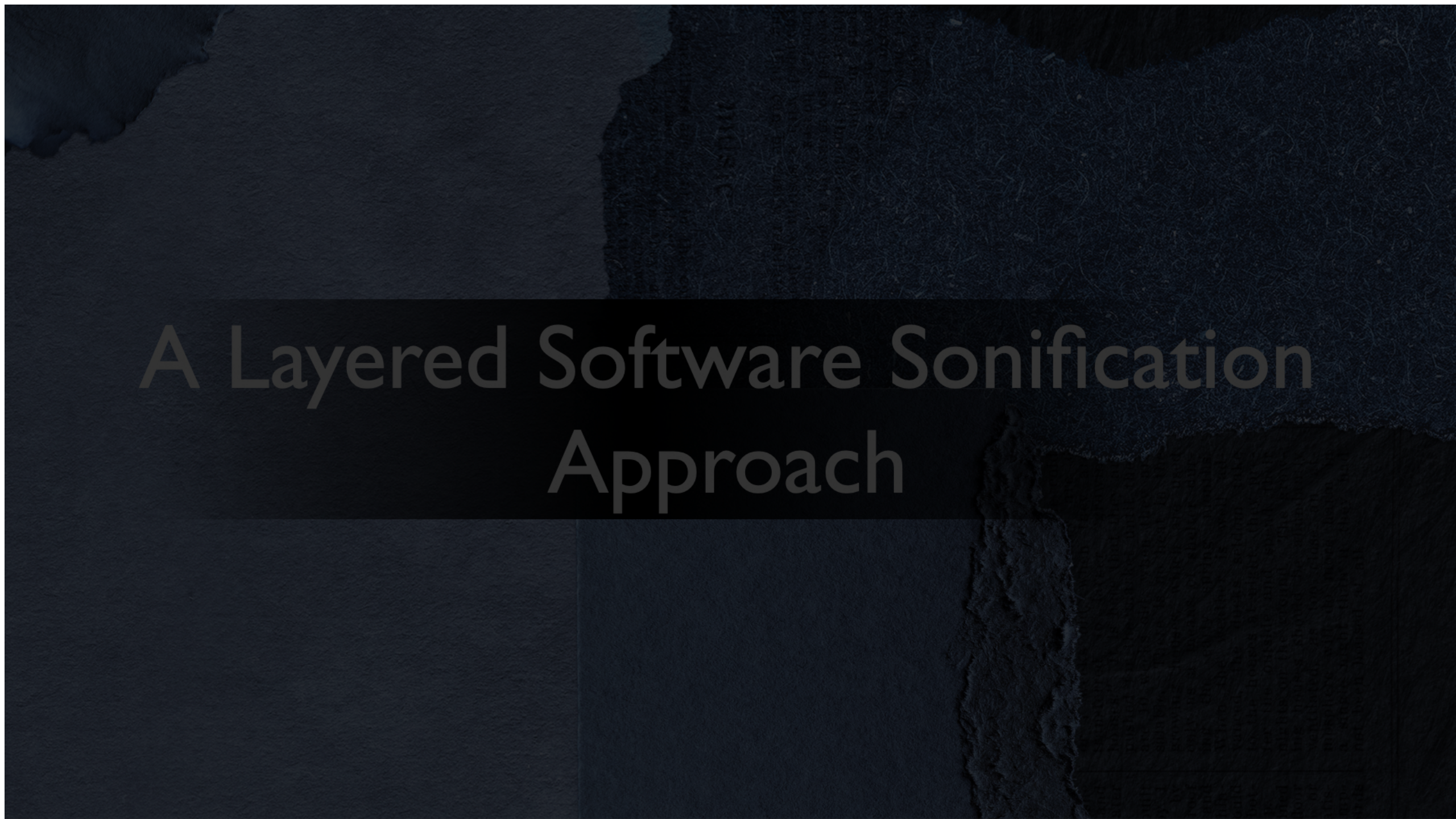
Visualization and Sonification as Complements



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A Layered Software Sonification Approach



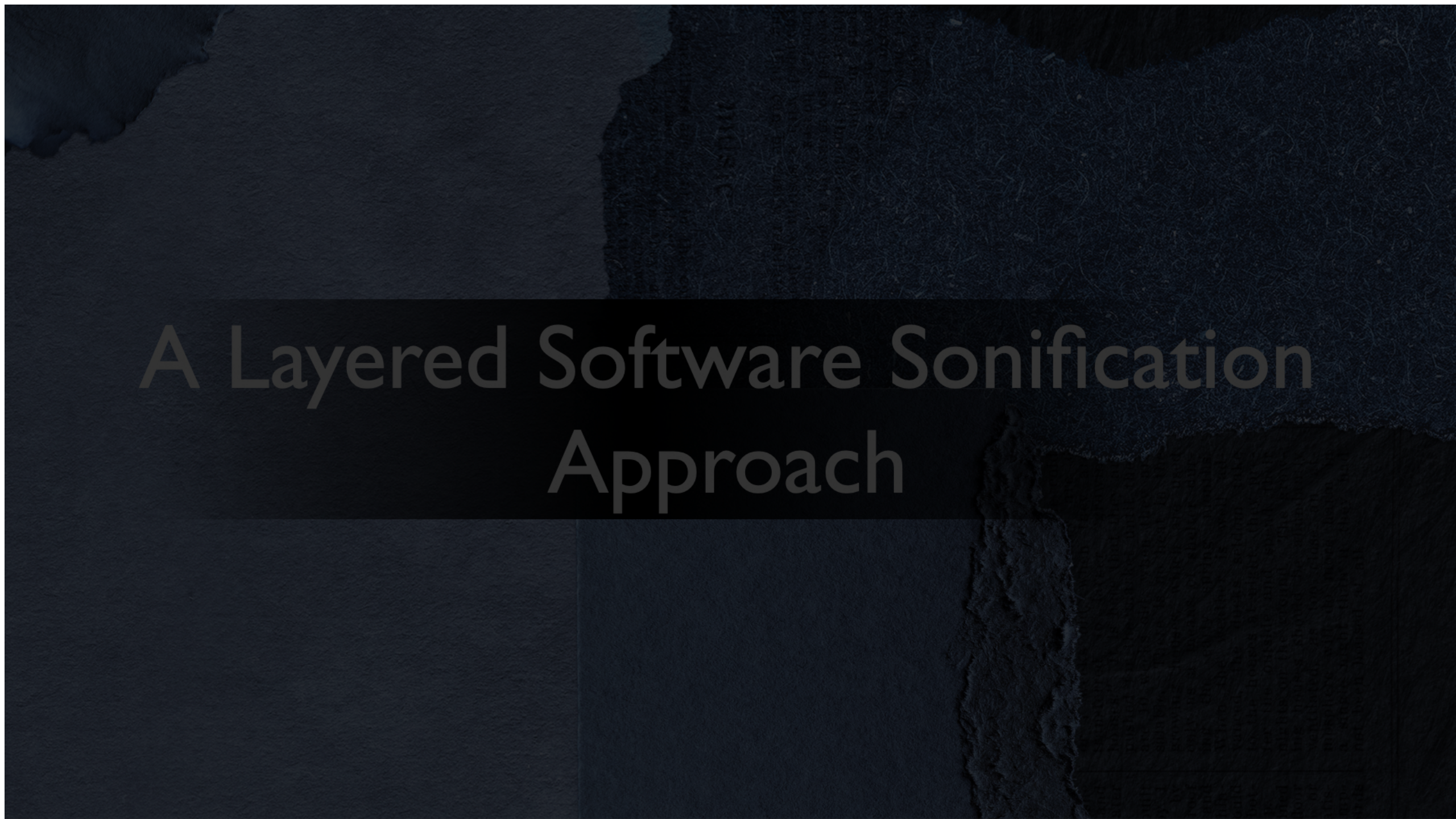
Visualization and Sonification as Complements



The Mechanics of Sight and Hearing



Gestalt Psychology



A Layered Software Sonification Approach



Visualization and Sonification as Complements



The Mechanics of Sight and Hearing



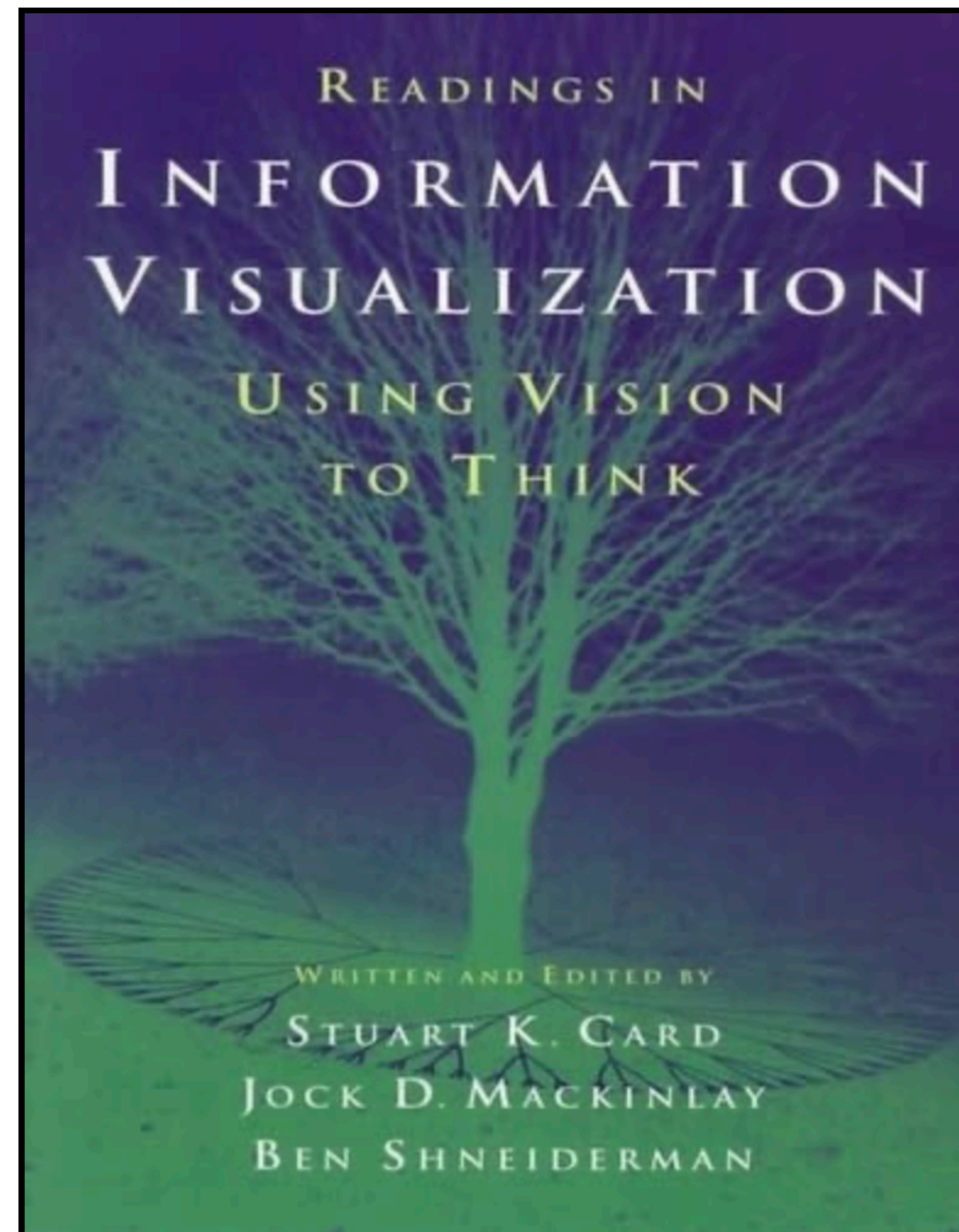
Gestalt Psychology



A Layered Software Sonification Approach

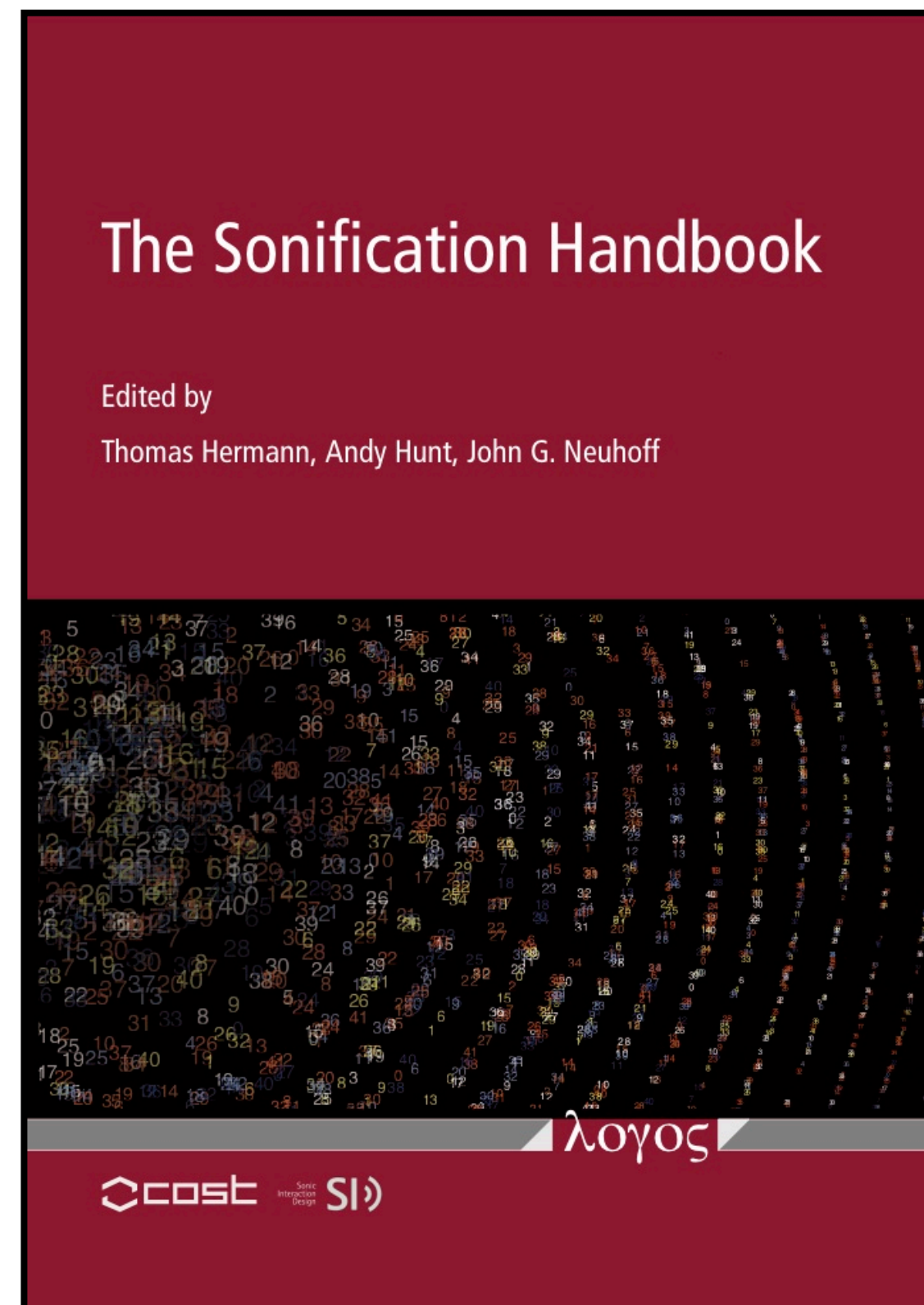
An abstract graphic of a soundwave or waveform, rendered in white lines against a black background. The waveform is complex, with many sharp peaks and valleys, suggesting a high-frequency or complex sound. It is centered horizontally and has a slight vertical spread.

Sonification



“If we can understand how perception works, our knowledge can be translated into rules for displaying information.”

Colin Ware



“Sonification is the mapping from data to one or more parameters of a sound synthesis model for the purpose of better understanding, communicating, or reasoning about the original model, experiment or system”.

Carla Scaletti



Existing since 1954, still
considered a “*fascinating
novelty*”

Display temporal information





Complement animations



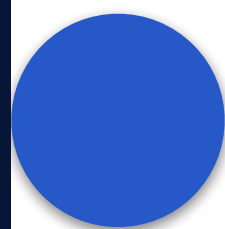
Deepen the understanding for
sighted and blind scientists

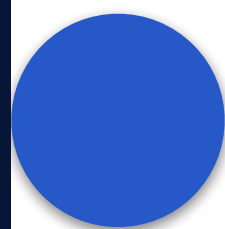


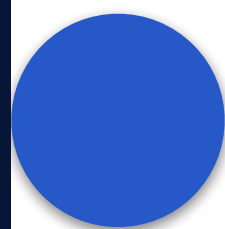
Apt to display multiple data
sources in parallel



Visualization and Sonification as Complements











The Mechanics of Sight and Hearing



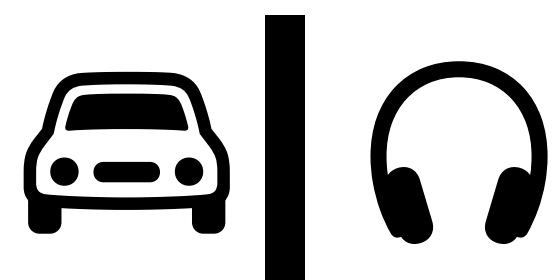
We see and hear with our brain



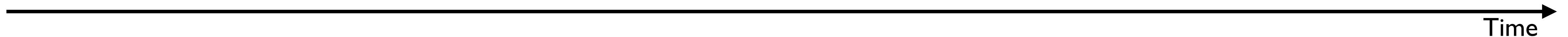
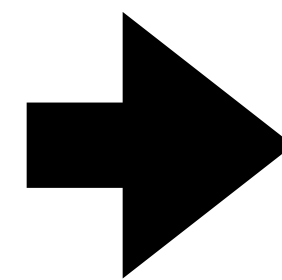
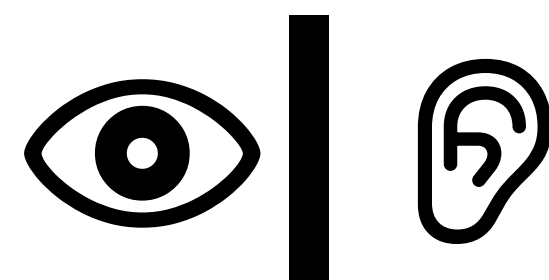
We see and hear with our brain

Sensation
(Physical Process)

External
Stimulus



Sensory
Organ





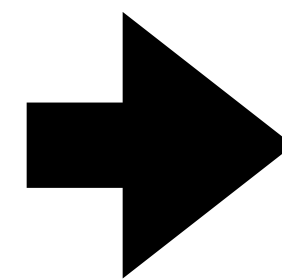
We see and hear with our brain

Sensation
(Physical Process)

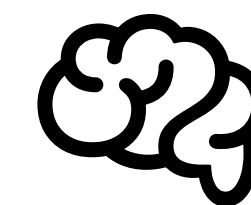
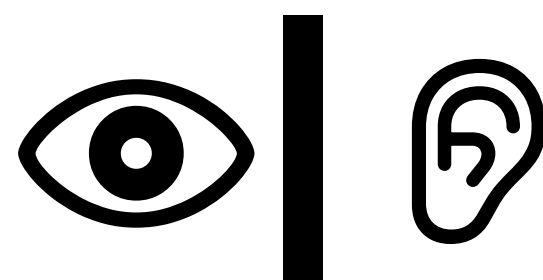
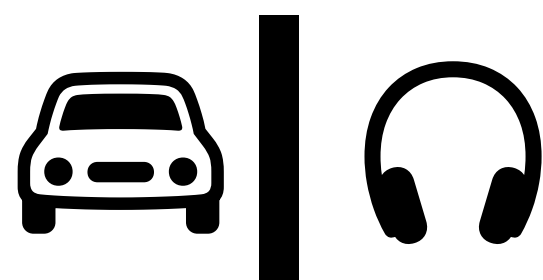
Perception
(Cognitive Process)

External
Stimulus

Sensory
Organ



Perceptual
Organ





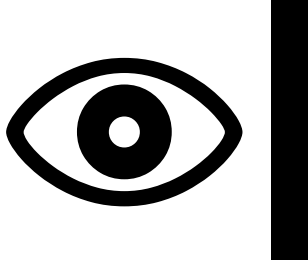
We have three types of memory that process
visual and auditory information



We have three types of memory that process
visual and auditory information

Iconic & Echoic Memory

50 to
250 ms



2 to 4
seconds

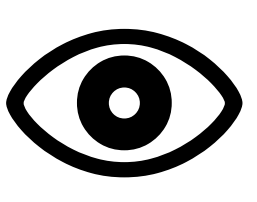
Time



We have three types of memory that process visual and auditory information

Iconic & Echoic
Memory

50 to
250 ms



2 to 4
seconds

Short-term Memory
(Working Register)

3 to 9 chunks of
information

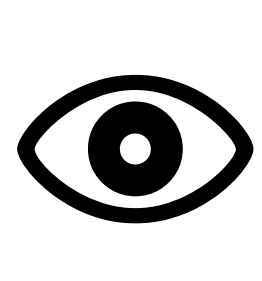
Time



We have three types of memory that process visual and auditory information

Iconic & Echoic
Memory

50 to
250 ms



2 to 4
seconds

Short-term Memory
(Working Register)

3 to 9 chunks of
information

Long-term Memory
(Storing Register)

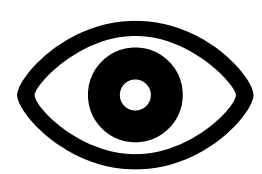
Time



We have three types of memory that process visual and auditory information

Iconic & Echoic
Memory

50 to
250 ms



2 to 4
seconds

Short-term Memory
(Working Register)

3 to 9 chunks of
information

Time

Pre-attemptive Processing

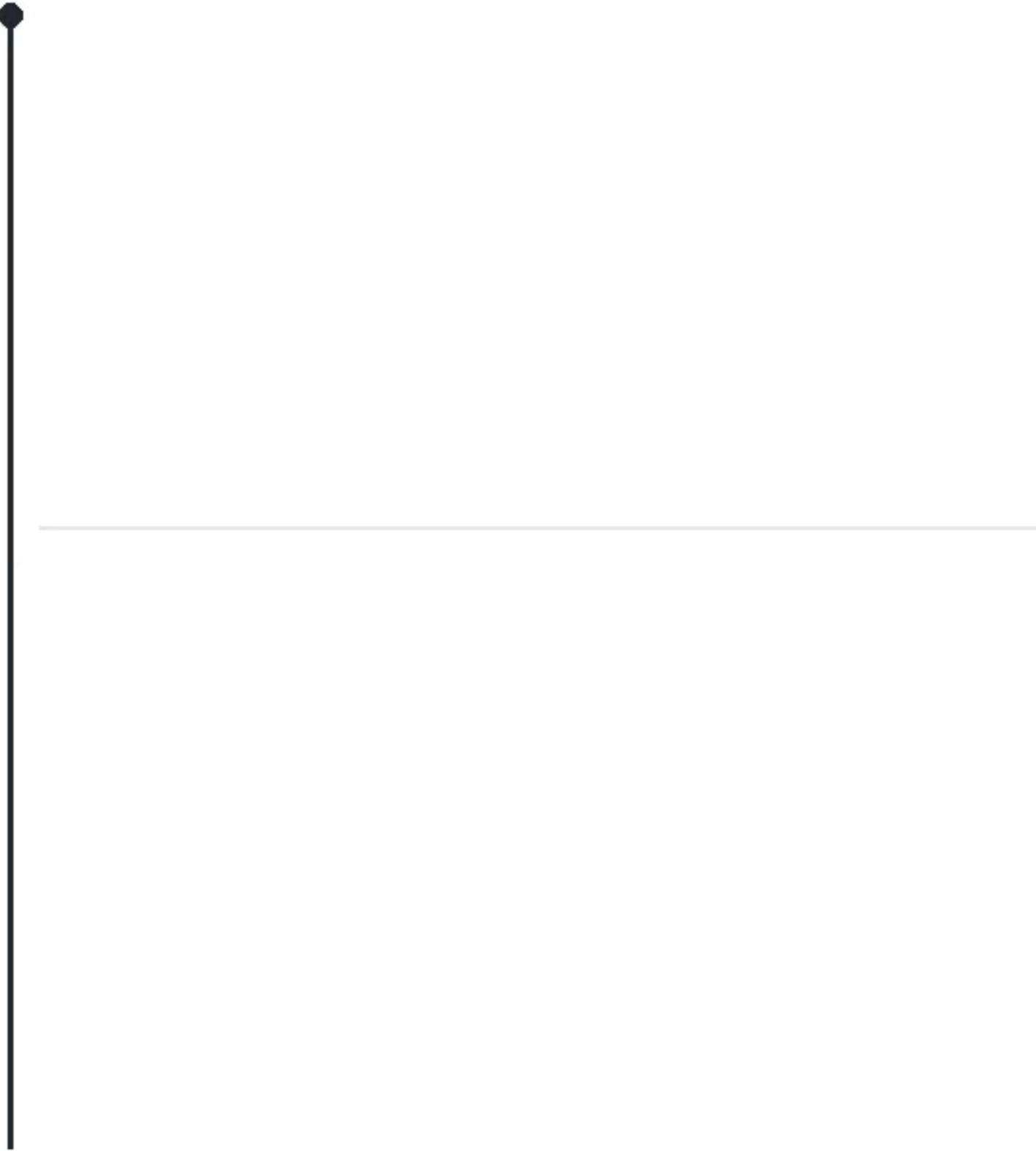
Auditory

Visual

Pre-attemptive Processing

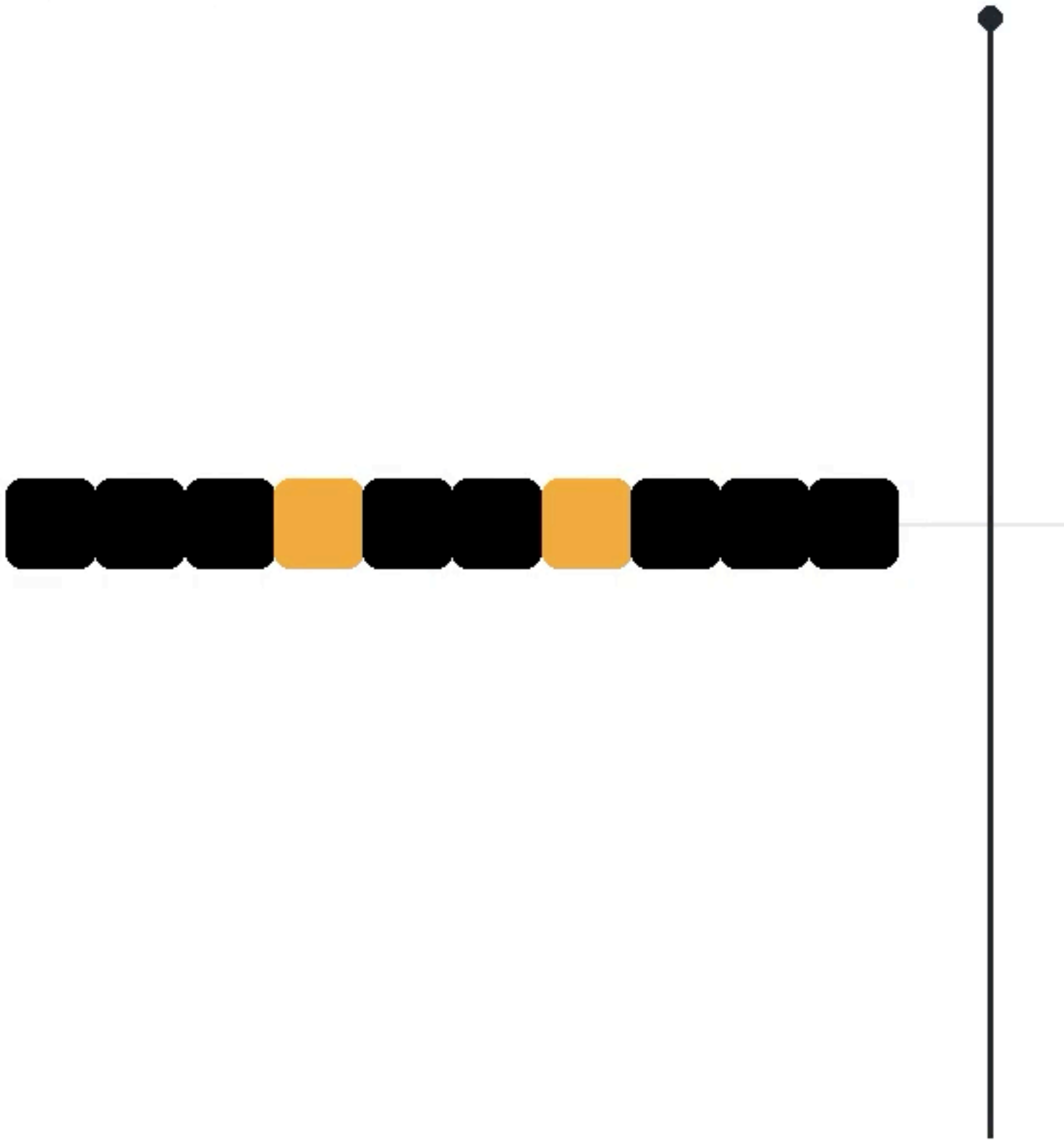
Auditory

Visual



Pre-attentive Processing

Auditory

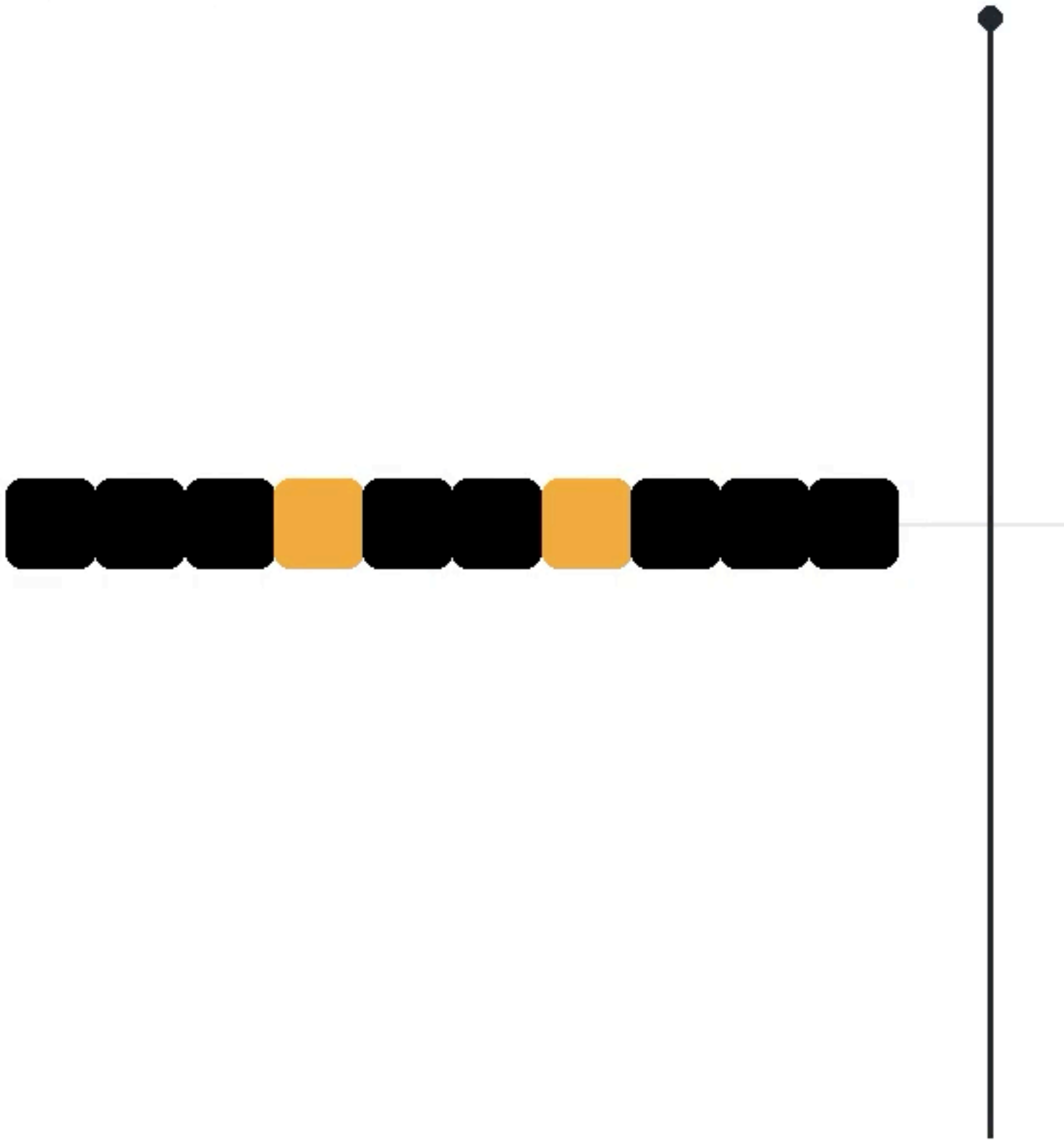


Visual

8789364082376403 | 2876453
298473298473209487329084
538927403298743287423 | 98
475098340983409832409832
049823098490328 | 45320948

Pre-attentive Processing

Auditory



Visual

8789364082376403 | 28764**5**3
298473298473209487329084
538927403298743287423 | 98
47**5**098340983409832409832
049823098490328 | 4**5**320948

Gestalt Psychology

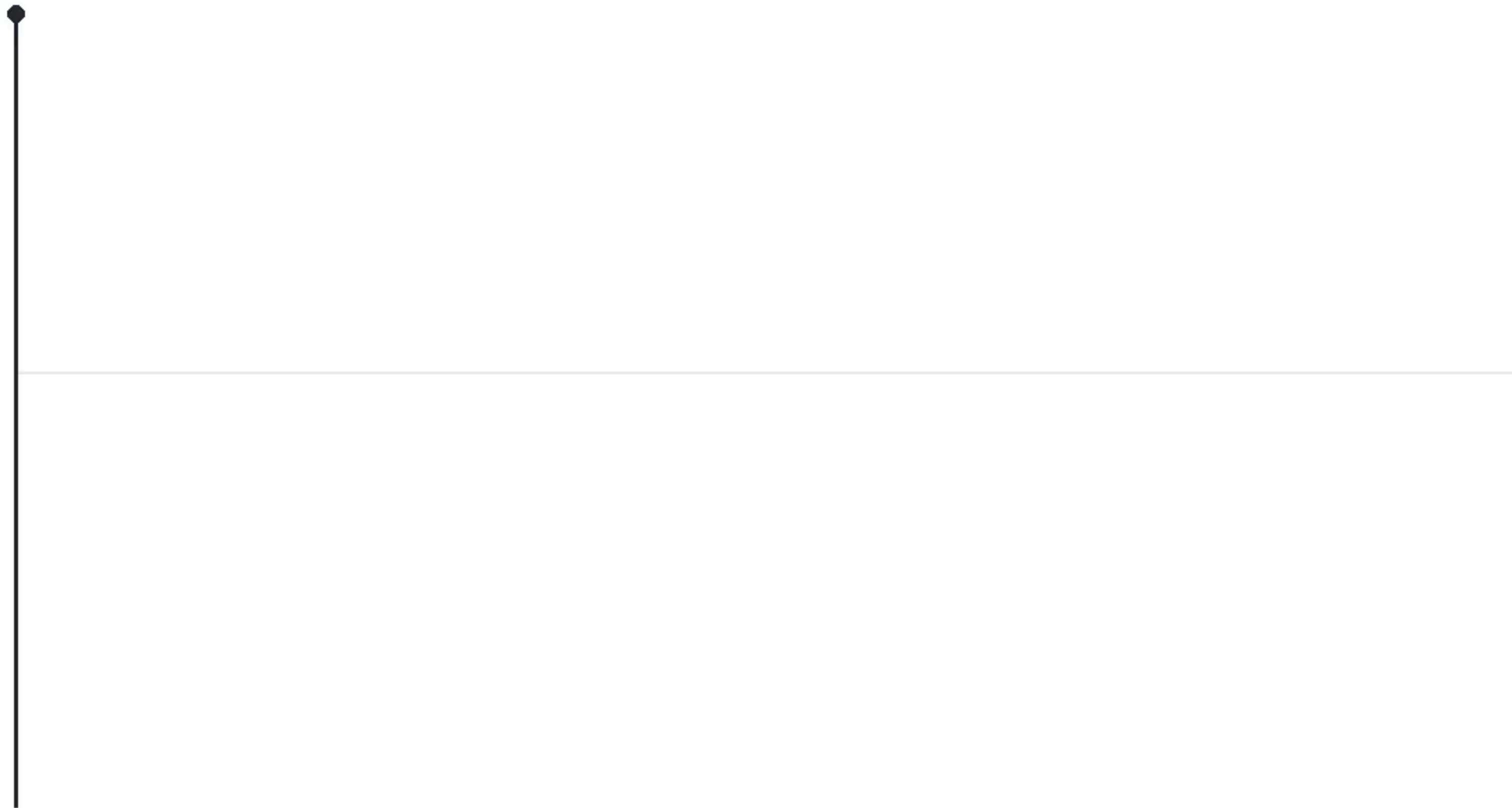
The background features a complex arrangement of organic, rounded shapes in orange, black, and light pink. A central horizontal band is filled with a purple-to-black gradient and overlaid with a white grid pattern. The title 'Gestalt Psychology' is centered within this band in a white, sans-serif font.

Proximity Principle

Elements that are close together are perceived as a single group or chunk, and are interpreted as being more related than elements farther apart.

Proximity Principle

Elements that are close together are perceived as a single group or chunk, and are interpreted as being more related than elements farther apart.

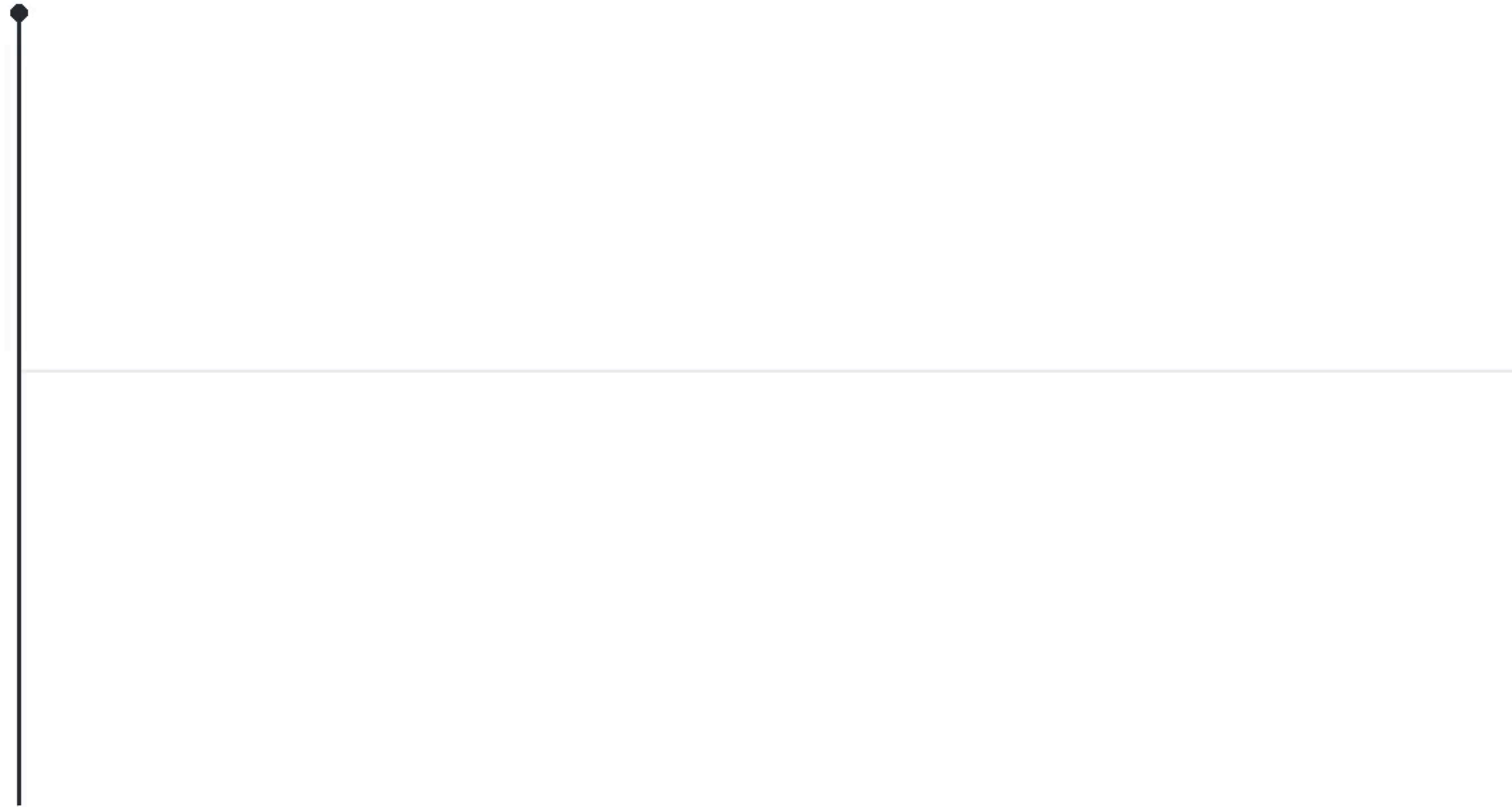


Similarity Principle

Elements that are similar are perceived to be more related than elements that are dissimilar.

Similarity Principle

Elements that are similar are perceived to be more related than elements that are dissimilar.



Visual and Aural Gestalts

Deal with spatial organization

Deal with temporal organization

Visual and Aural Gestalts

Deal with spatial organization

Govern how we look at the physical world and *instantly* perceive patterns

Deal with temporal organization

Govern how we listen to soundscapes as streams rather than isolated sounds

Visual and Aural Gestalts

Deal with spatial organization

Govern how we look at the physical world and *instantly* perceive patterns

Perceived simultaneously in an instant

Deal with temporal organization

Govern how we listen to soundscapes as streams rather than isolated sounds

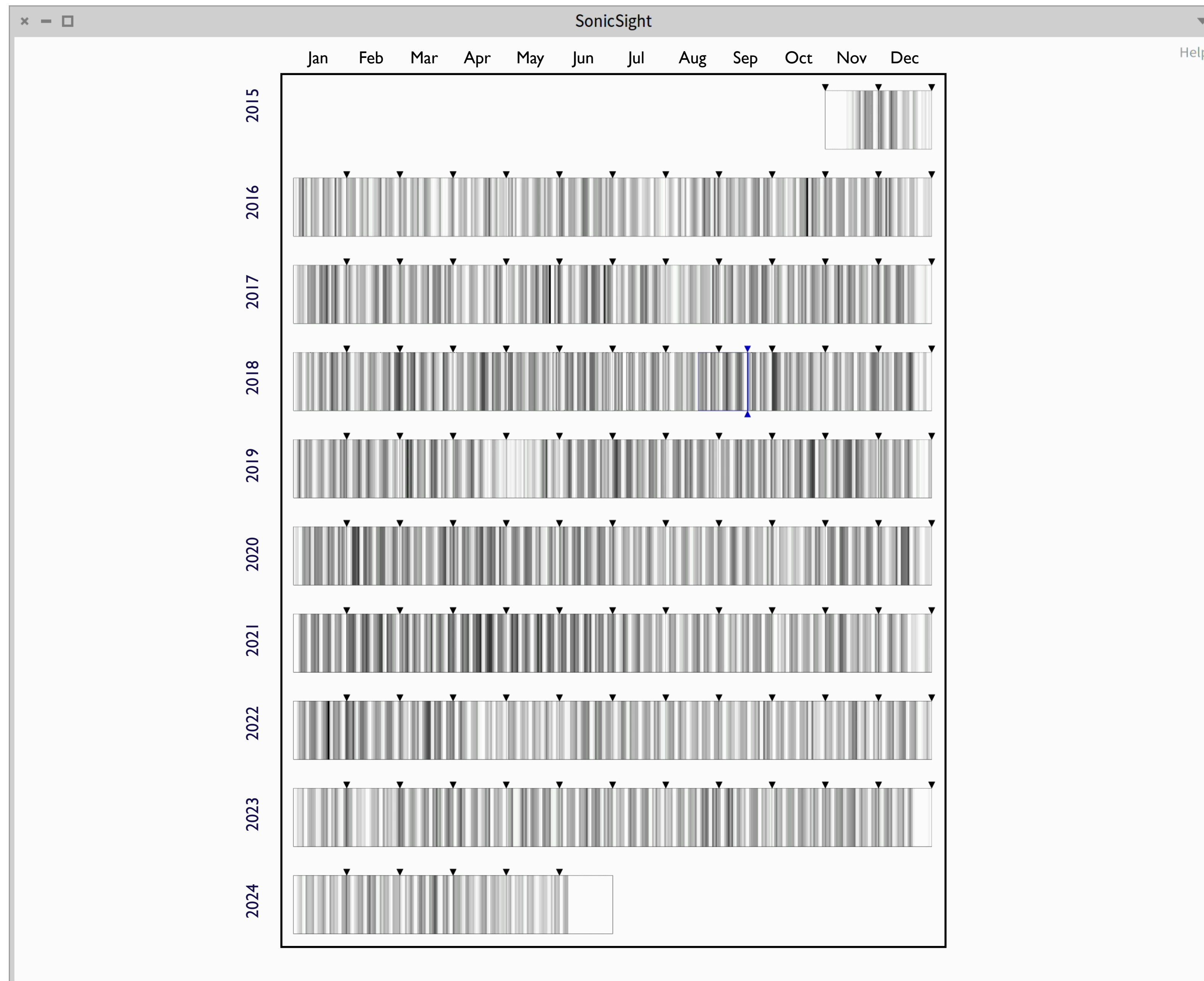
Require time to unfold

THE
MUSIC
BOOK

at 1 week's old, when they are transferred to larger growing houses. It is here that they are pushed to the market until they are 10 weeks old, when they are suitable. There is no heat in the growing houses, which are used only as a means of shelter during the early spring months. When the weather is well advanced, the decks seldom take to the houses at night, they prefer the outside and spend their nights on the ground. The growing houses should be abundantly ventilated, as too close an atmosphere will do more harm in a single night than if they had not been housed at all.

The background of the slide is a dark, textured surface with a blueish-grey color palette. It features a layered, torn-paper effect with irregular, jagged edges. The top layer is a lighter, fibrous material, while the bottom layer is a darker, more solid material. The overall appearance is that of a layered, textured surface, possibly representing the 'layered' nature of the software sonification approach.

A Layered Software Sonification Approach

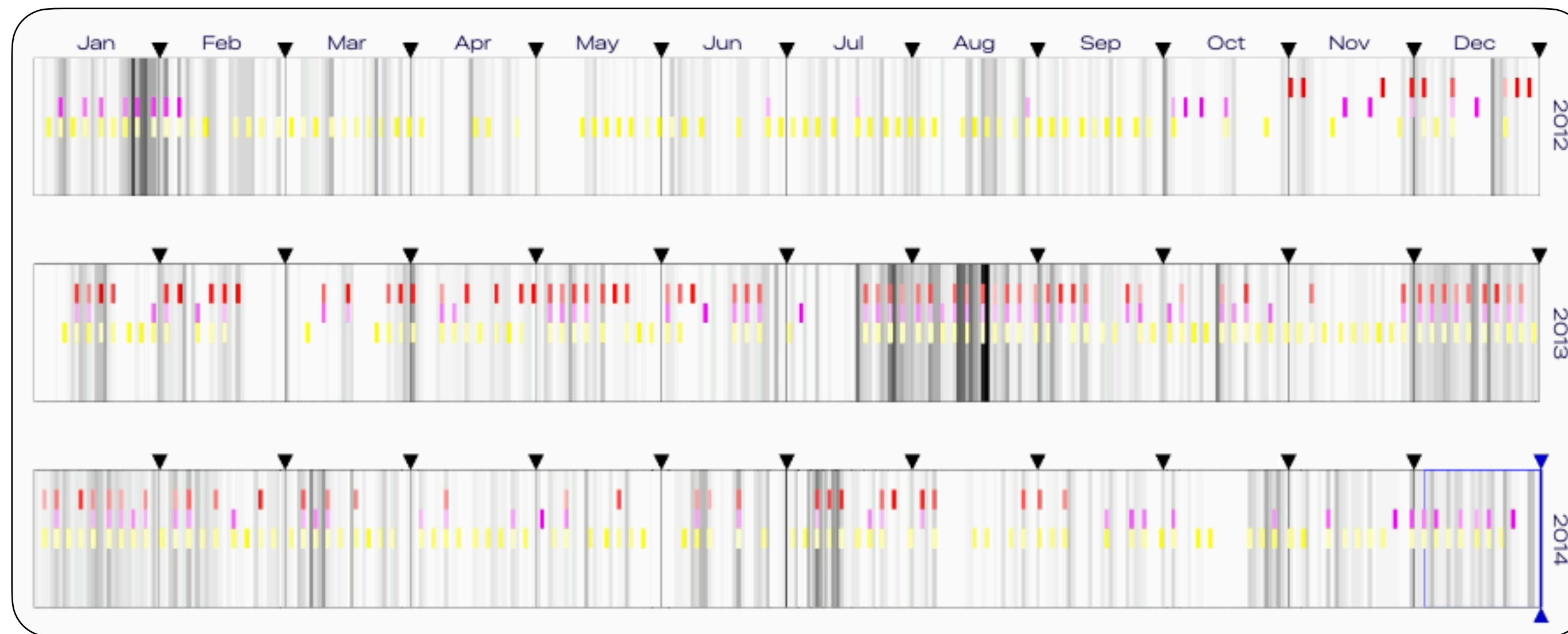


Visualizing And Sonifying The Heartbeat Of Software Systems. Carmen Armenti, Marco Ragianti, and Michele Lanza. In Proceedings of VISSOFT 2025.

Sonifying and Visualizing the Heartbeat of Evolving Software Systems

Carmen Armenti, Marco Raglianti, and Michele Lanza

In Proceedings of VISSOFT 2025

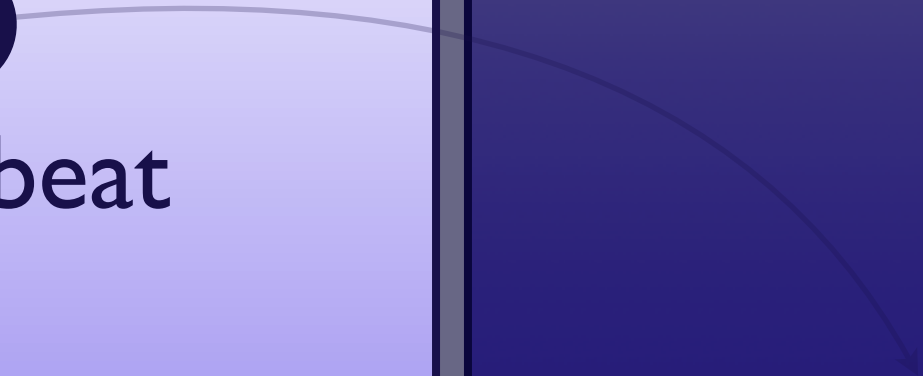


Layer 1

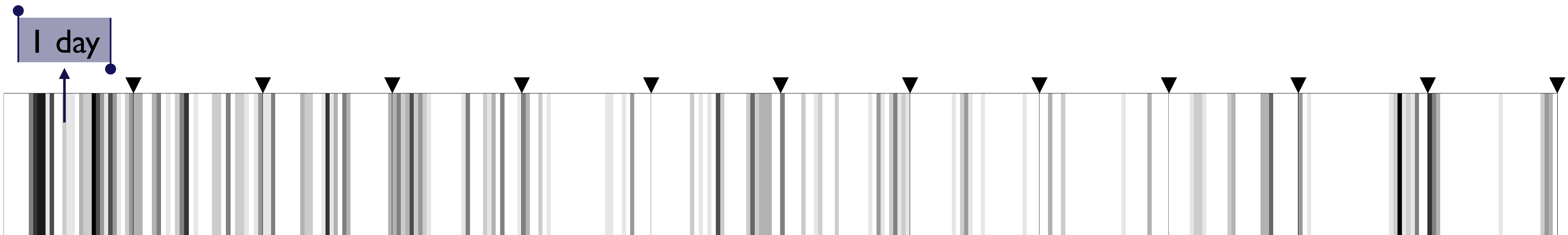
●
Heartbeat

Layer 2

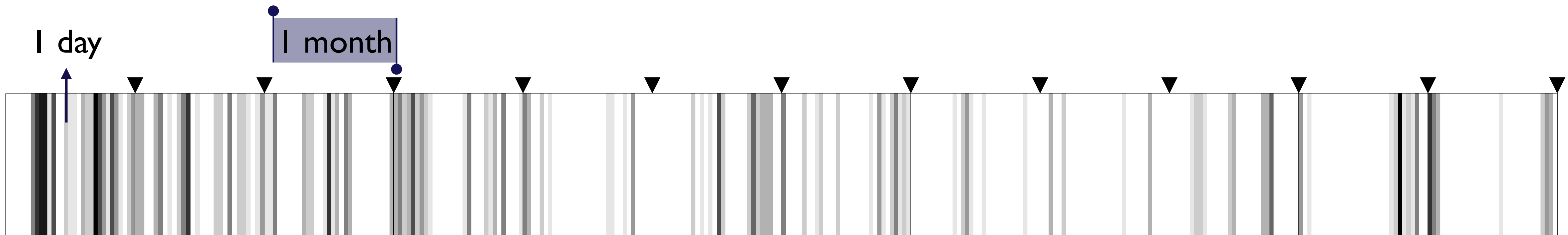
Developers
●



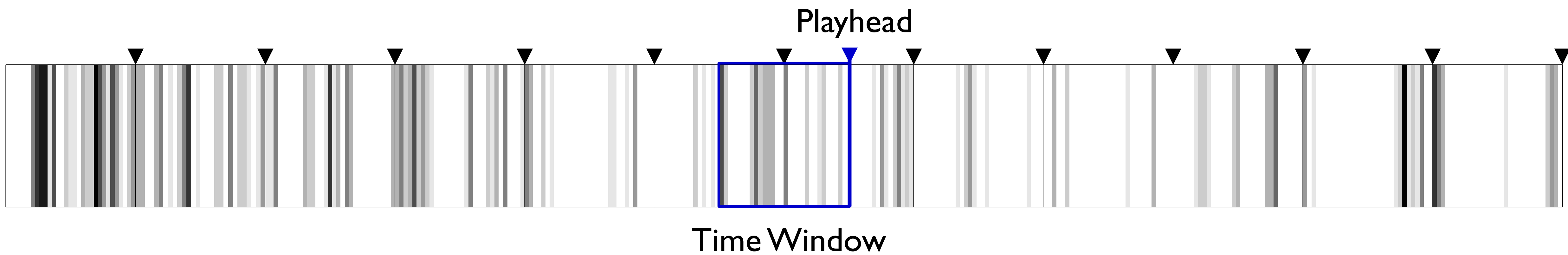
The Heartbeat Layer



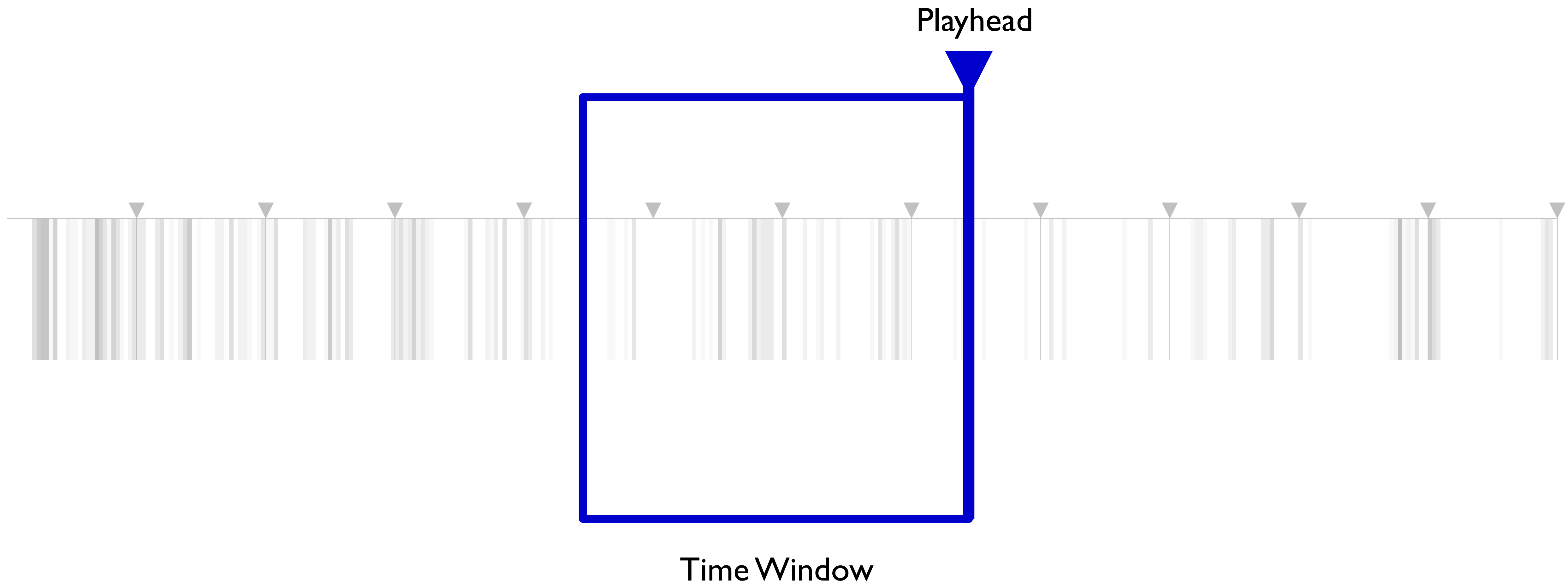
The Heartbeat Layer



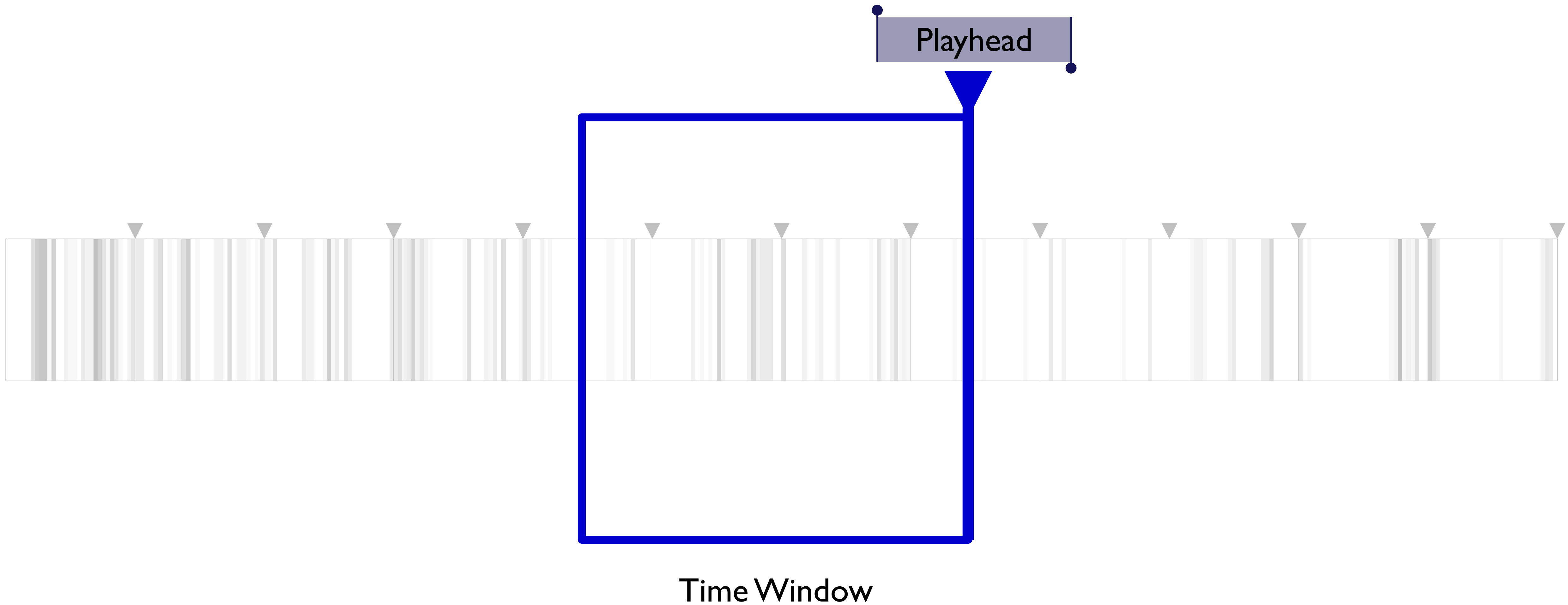
The Heartbeat Layer



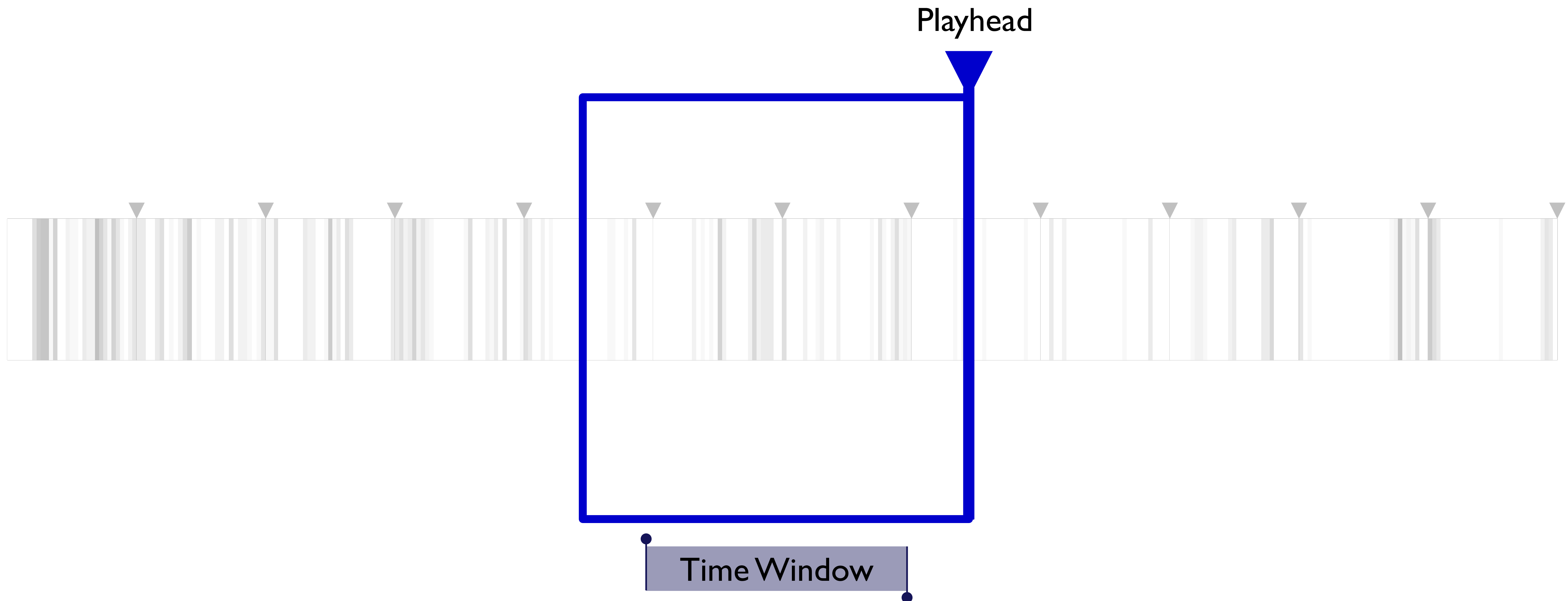
The Heartbeat Layer



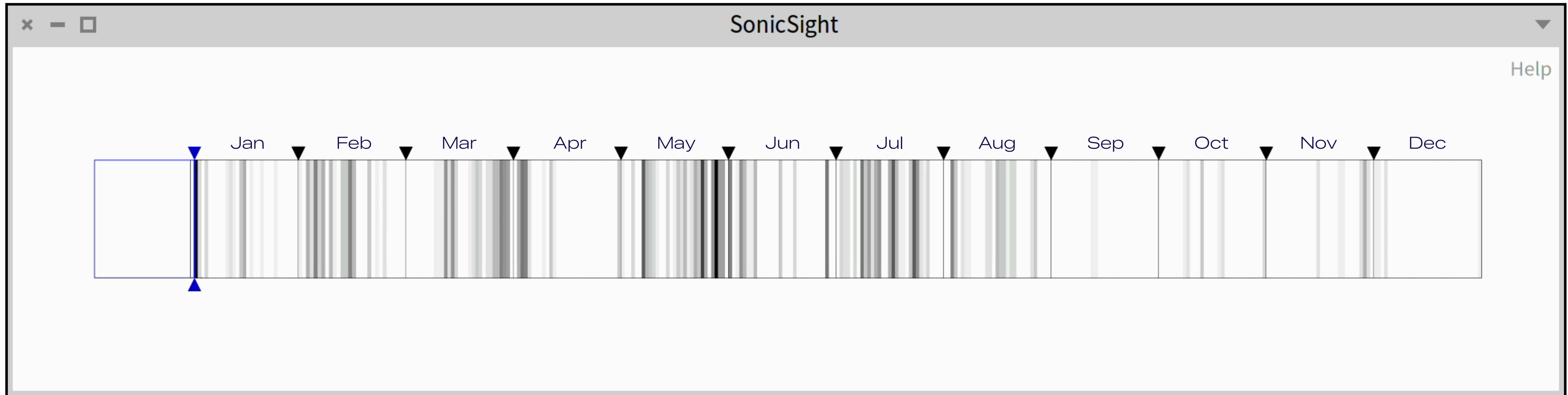
The Heartbeat Layer

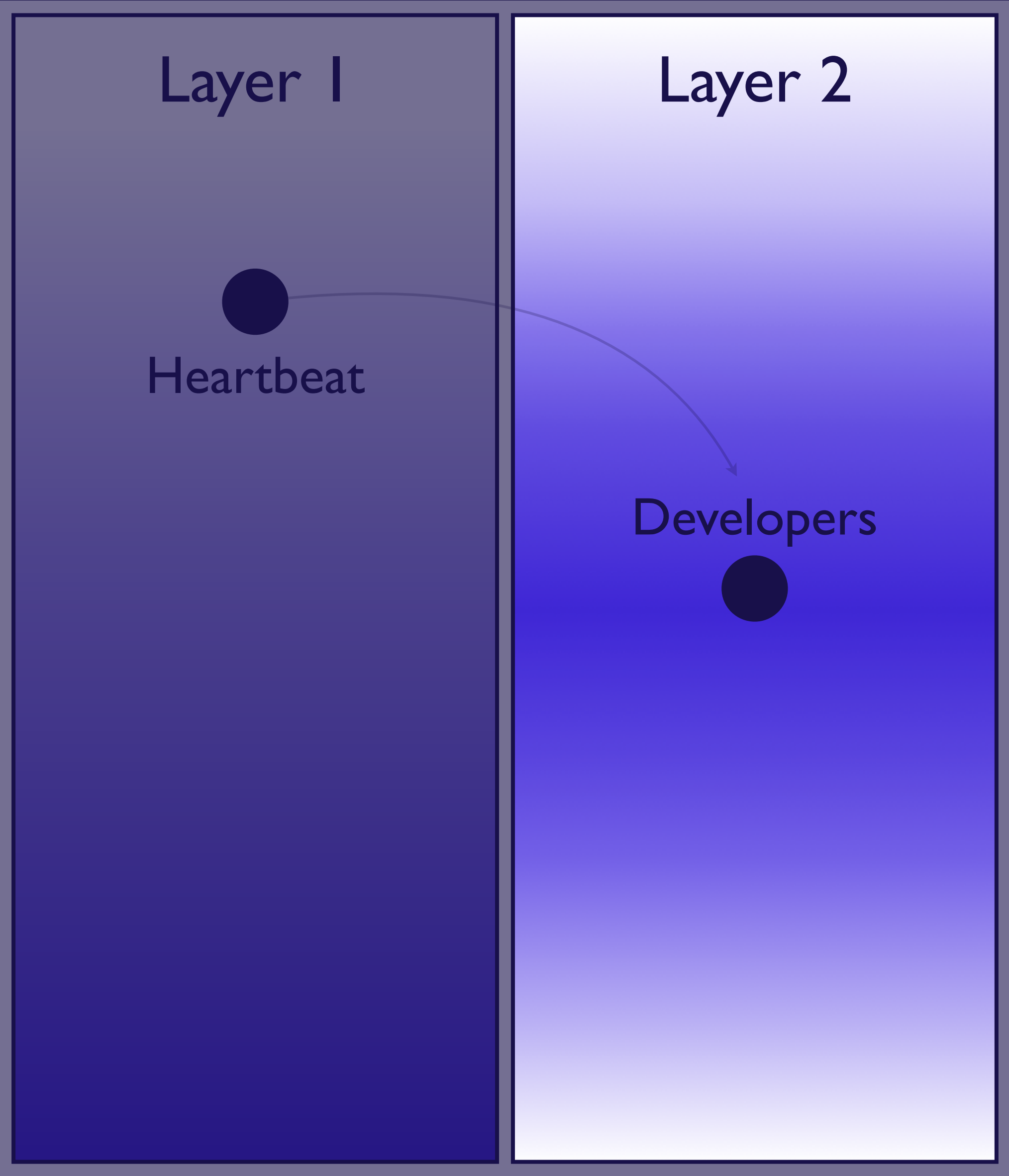


The Heartbeat Layer

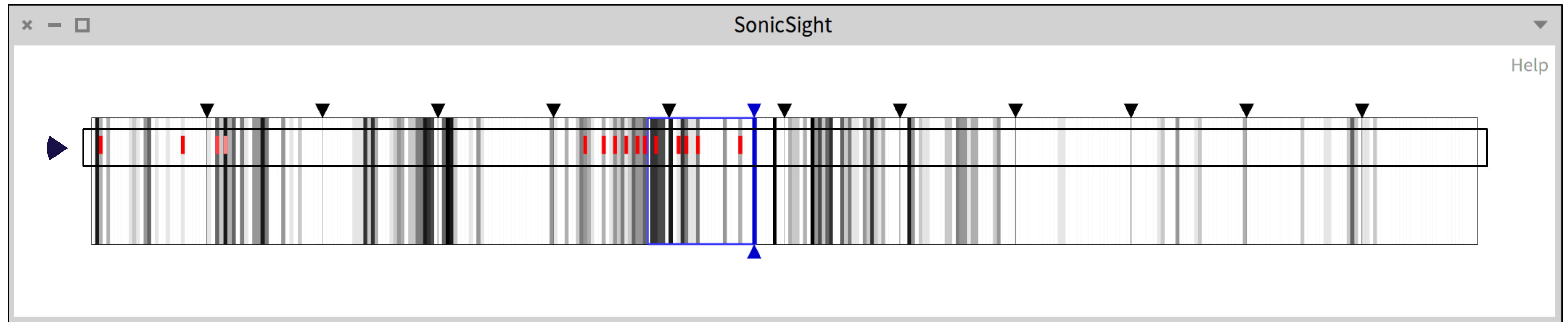


JetUML: Activity in 2018

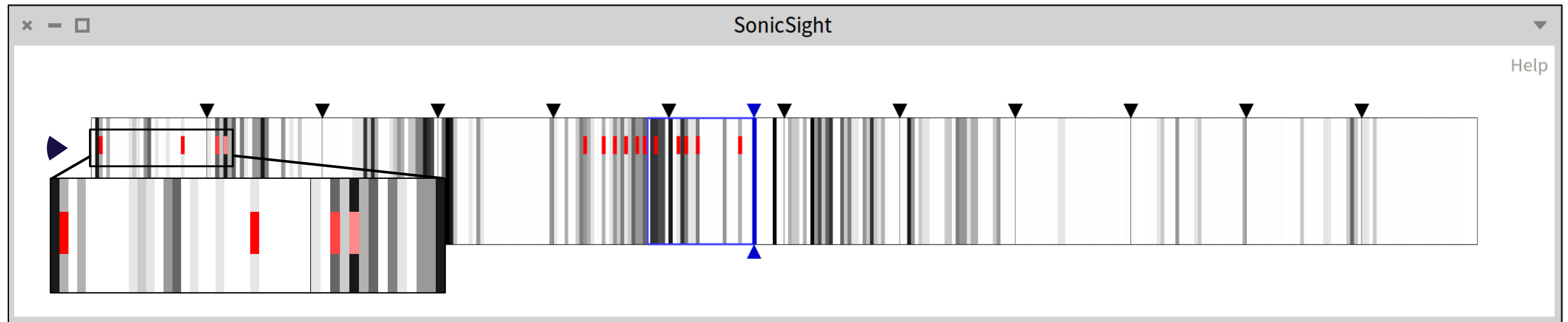




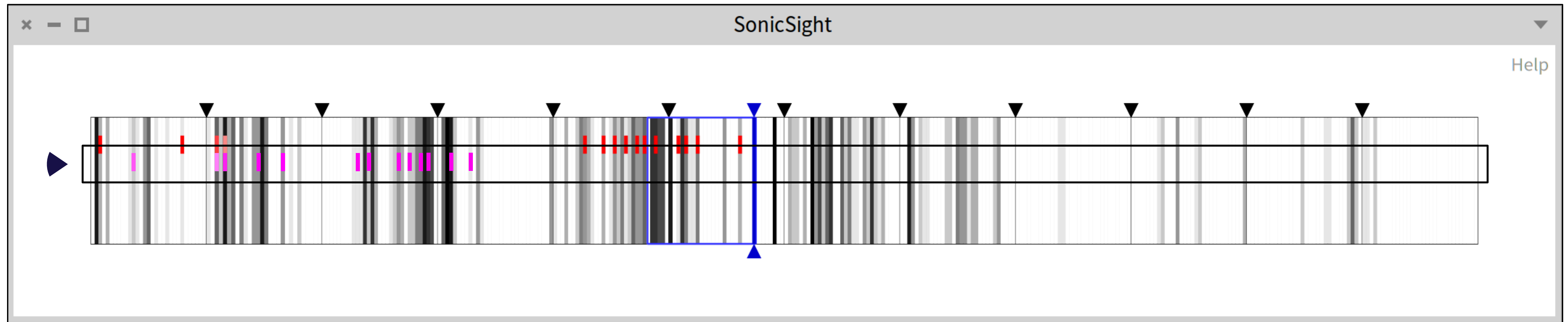
The Developers' Layer



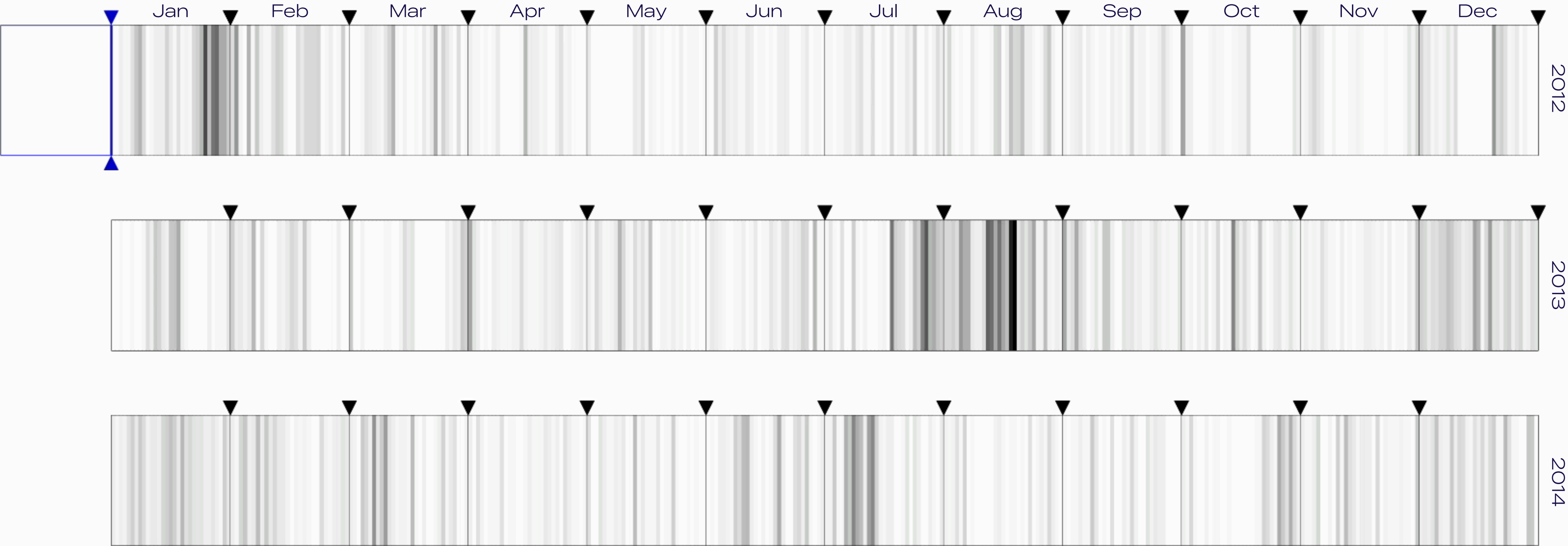
The Developers' Layer



The Developers' Layer



Bootstrap: 2012-2014



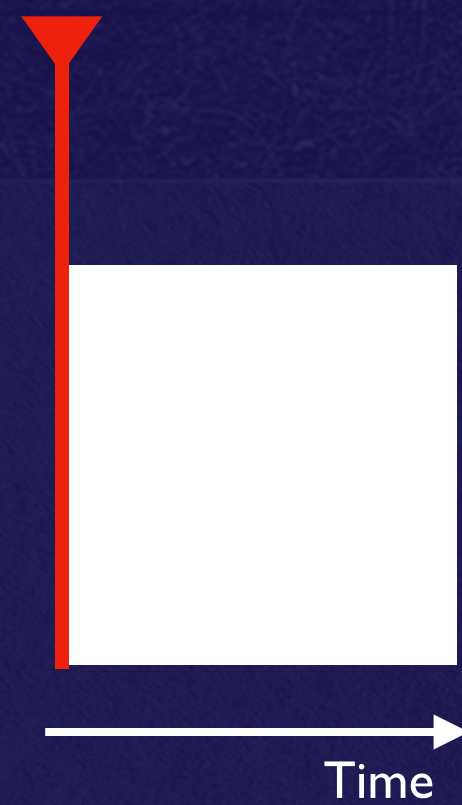
The background of the slide is a dark, textured surface with a blueish-grey color palette. It features a layered, torn-paper effect with various textures and colors. A central black horizontal band contains the title text in white. The overall aesthetic is artistic and abstract, suggesting a layered or multi-dimensional concept.

A Layered Software Sonification Approach through “Aural Glyphs”

What is a Glyph?



Building an Aural Glyph



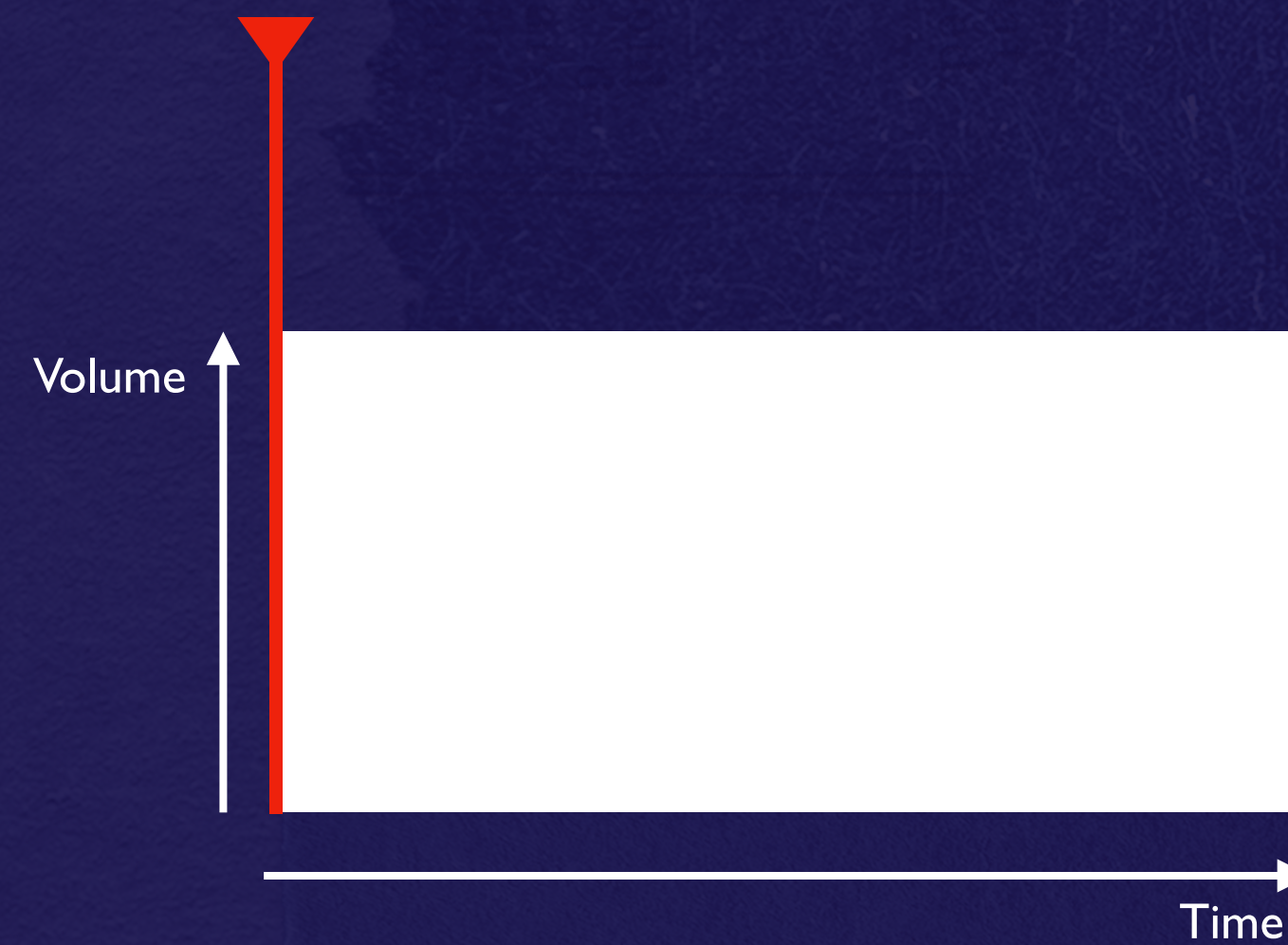
Building an Aural Glyph



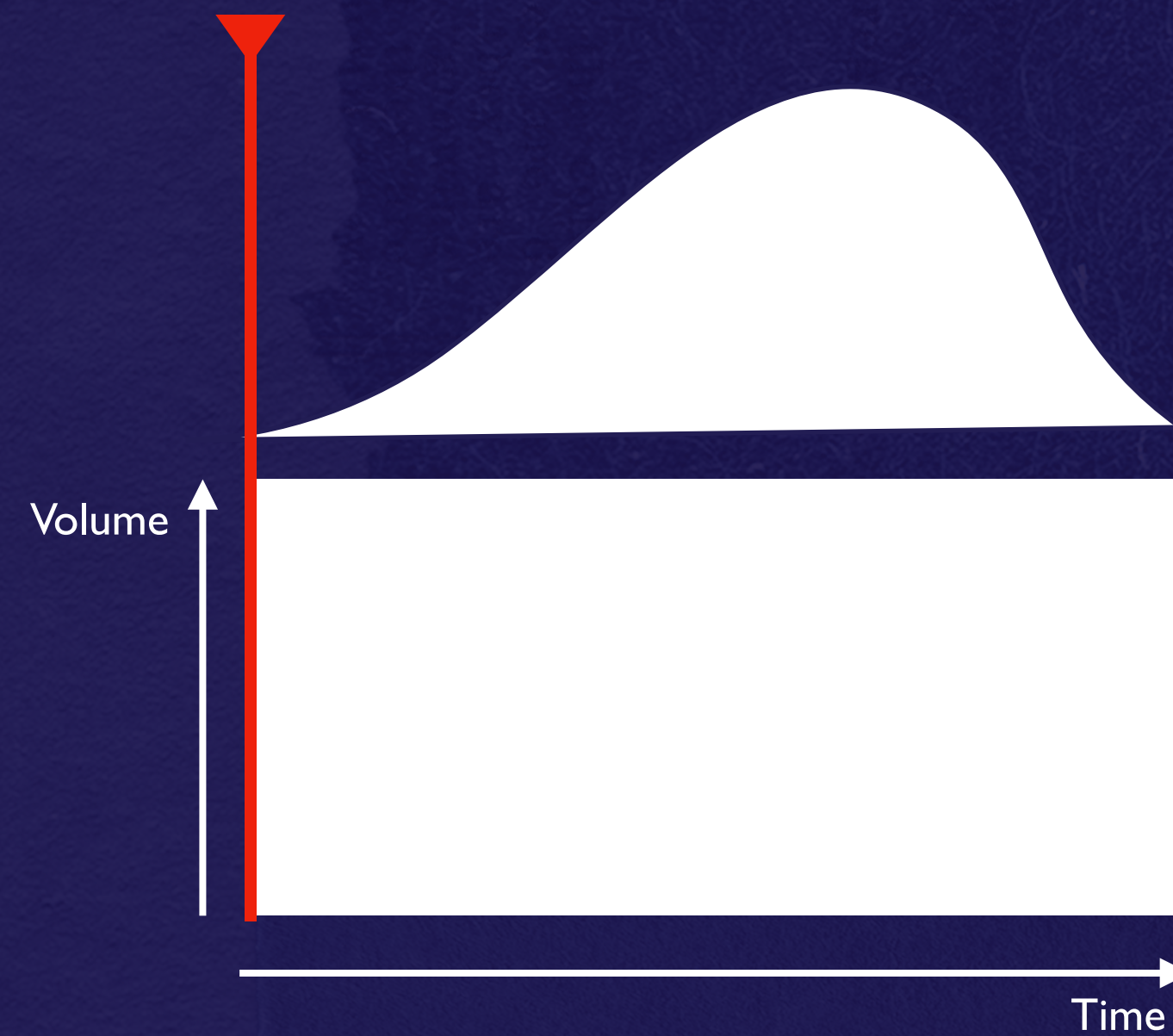
Building an Aural Glyph



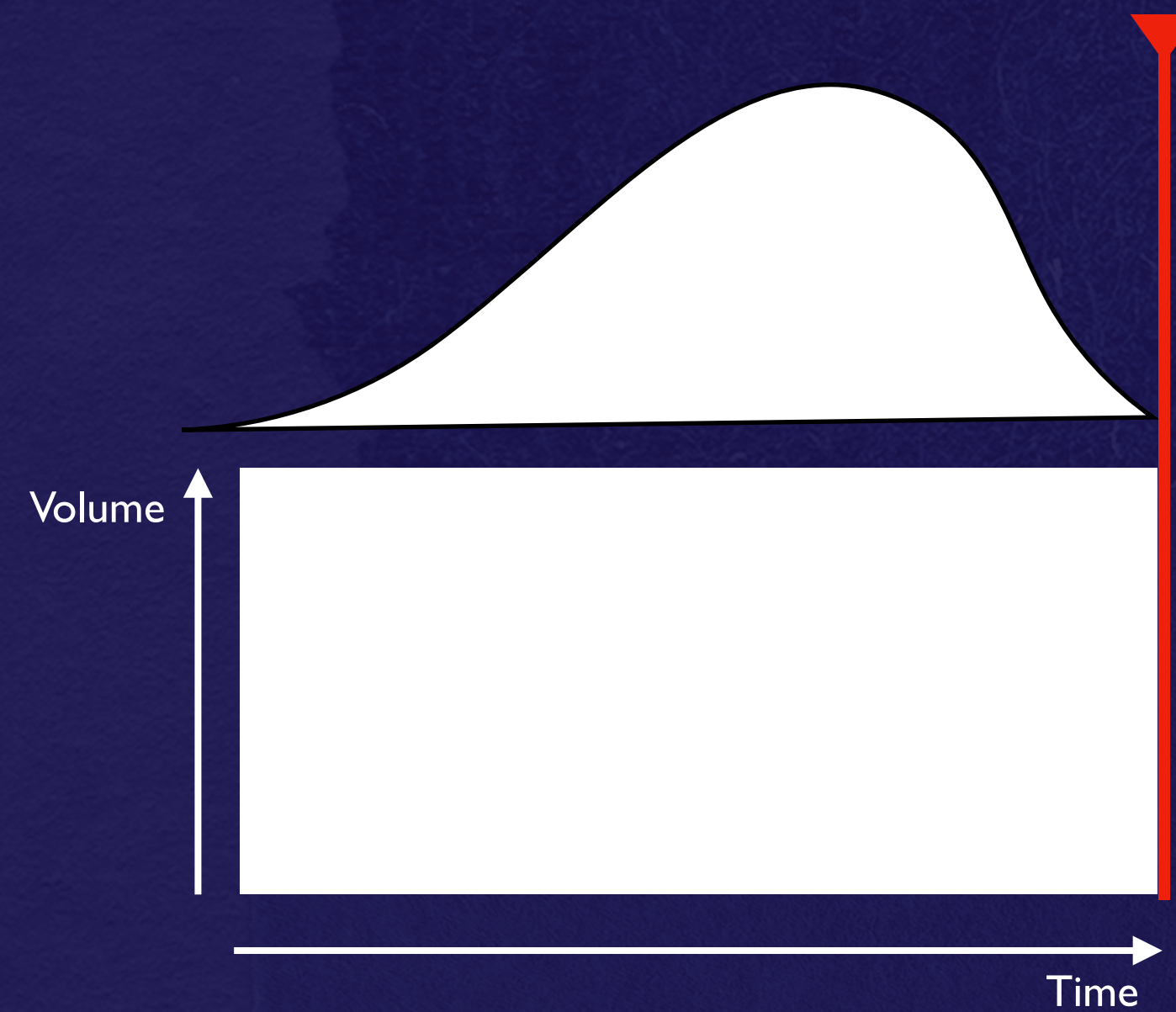
Building an Aural Glyph



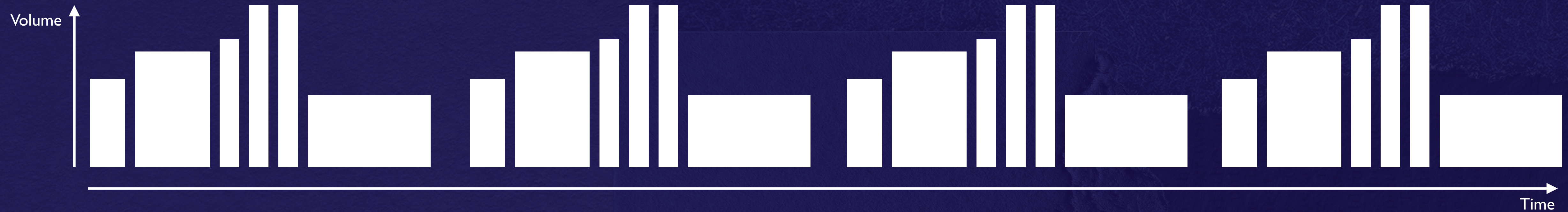
Building an Aural Glyph



Building an Aural Glyph



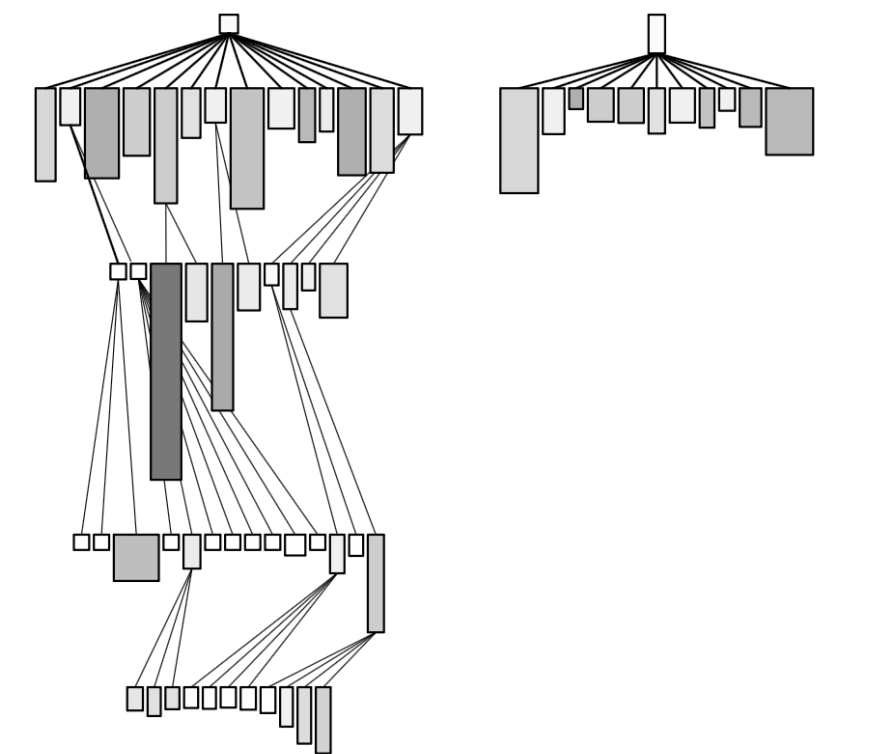
Towards a Grammar of Aural Glyphs



Polymetric Views—A Lightweight Visual Approach to Reverse Engineering

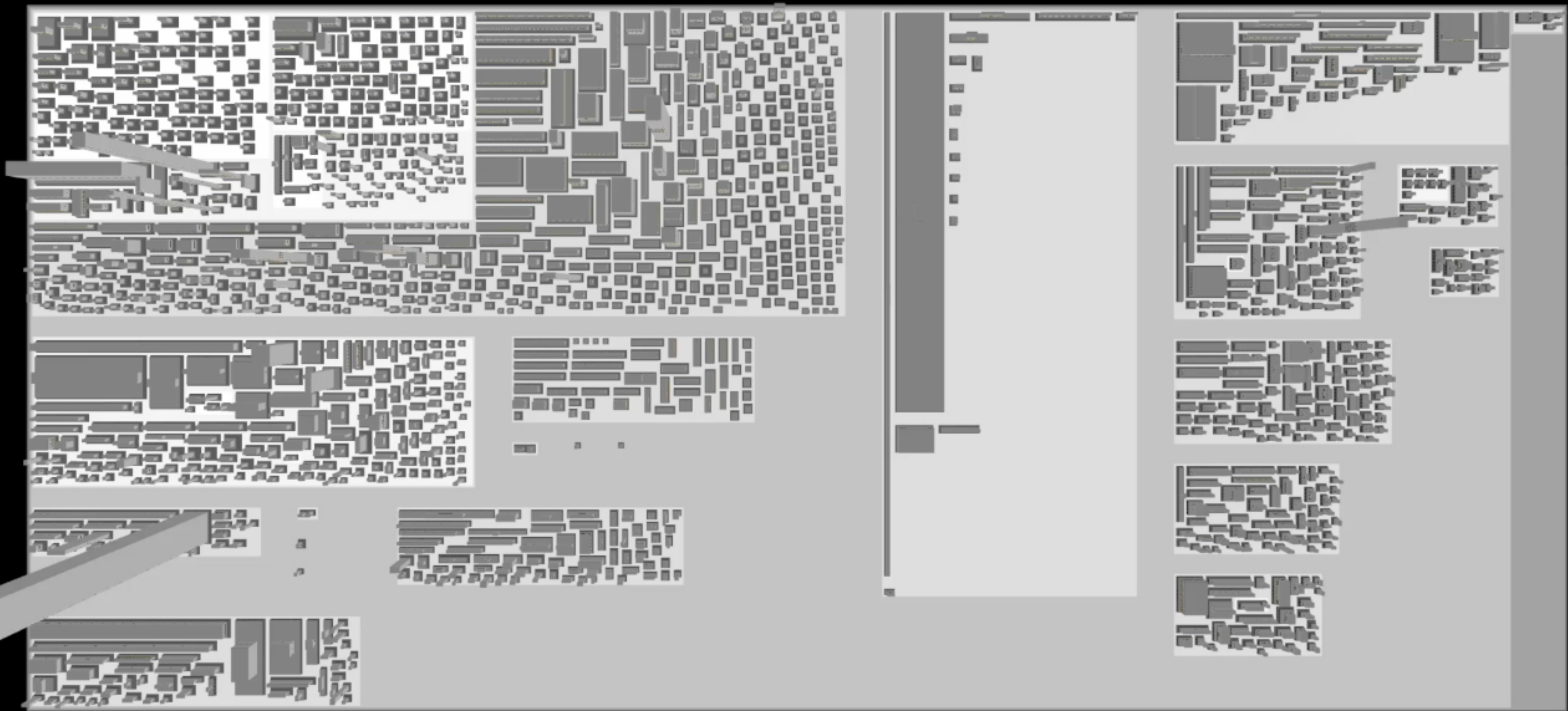
Michele Lanza and Stéphane Ducasse

In Proceedings of IEEE Transactions on Software Engineering, 2003.



Where Do We Go from Here?



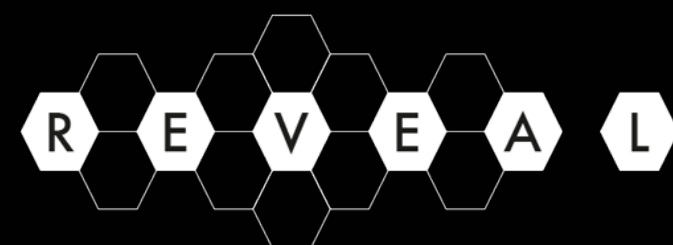




01/15/2009

Software Sonification: Potential and Challenges

Carmen Armenti



Università
della
Svizzera
italiana

Software
Institute