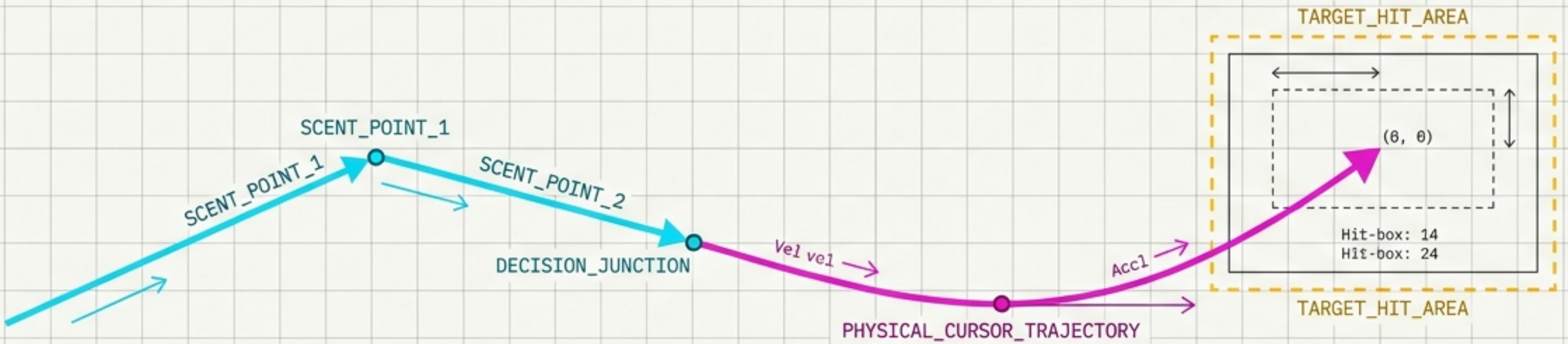
How People Act: Targets, Movement and Control

Designed for Product Designers, UI/Mobile Engineers, DS Architects & AI-Assisted Builders



Opening Recap: Whereas S11E01 optimized what users choose by shaping choice architecture and information scent, S11E02 governs how they physically execute those choices through biomechanical motor control.

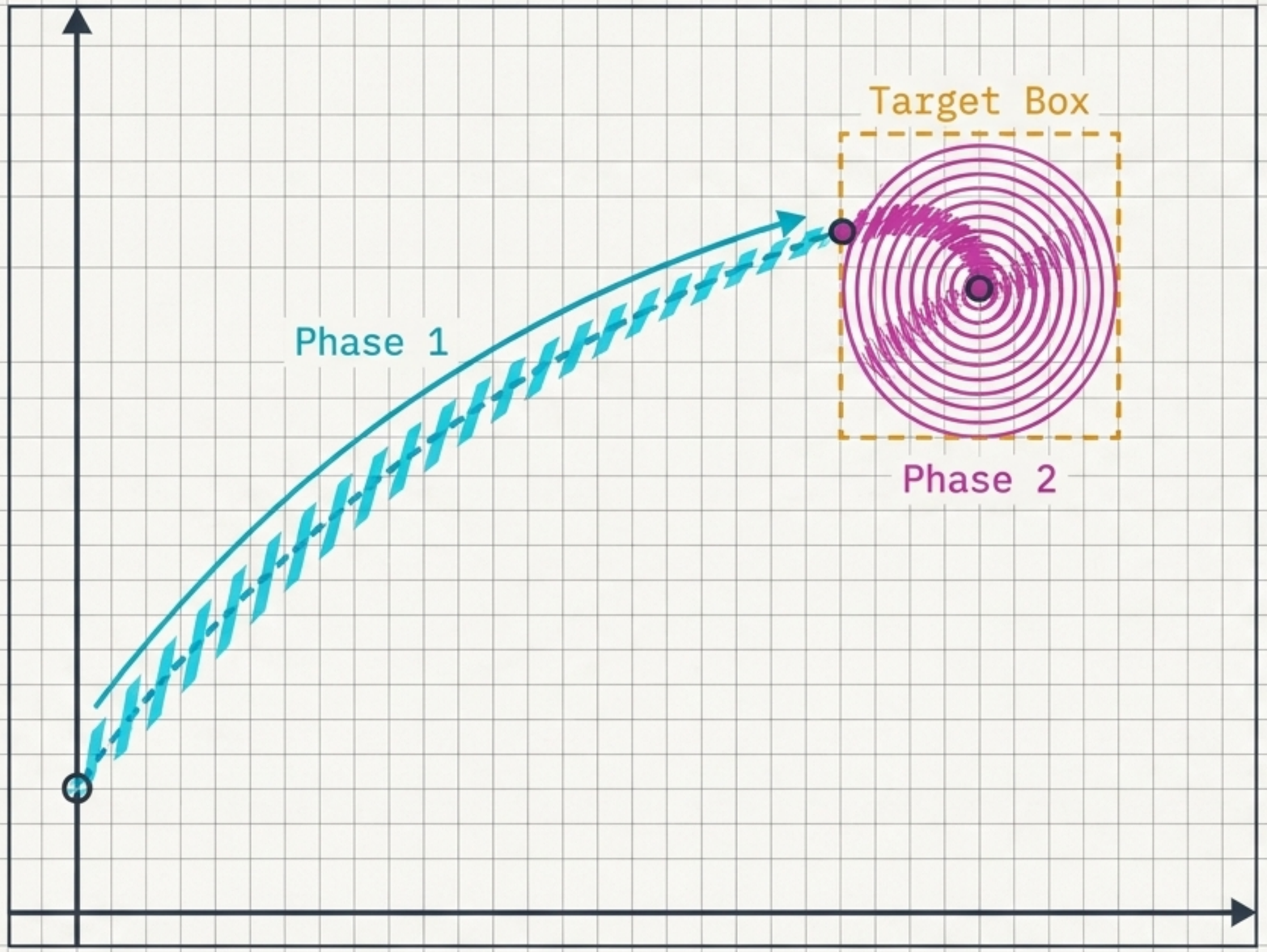
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SECTION 1 // Epistemic Grounding: Laws vs. Effects vs. Heuristics

 **Predictive Motor Models** (Physics)	 **Behavioral Effects** (Psychology)	 **Design Heuristics** (Best Practices)
• e.g., Fitts's Law (1954), Accot-Zhai Steering Law. • Falsifiable mathematical equations predicting movement time in milliseconds based on geometry.	• e.g., Confirmation Habituation. • Predictable human cognitive and physical reactions observed in aggregate user data.	• e.g., Undo over Friction. • Engineered UI patterns specifically designed to mitigate the biome-cha constraints of the first two categories.

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SECTION 1 // Two-Phase Human Motor Control



Phase 1: Open-Loop Ballistic Movement

- Initial rapid impulse driven by overall distance (D).
- Central nervous system fires blindly toward the general target area. No time for visual feedback.

Phase 2: Closed-Loop Visual-Feedback Homing

- Corrective micro-movements near the target driven by target width (W).
- The eye communicates with the hand in real-time to prevent overshooting. Small targets exponentially increase Phase 2 time.

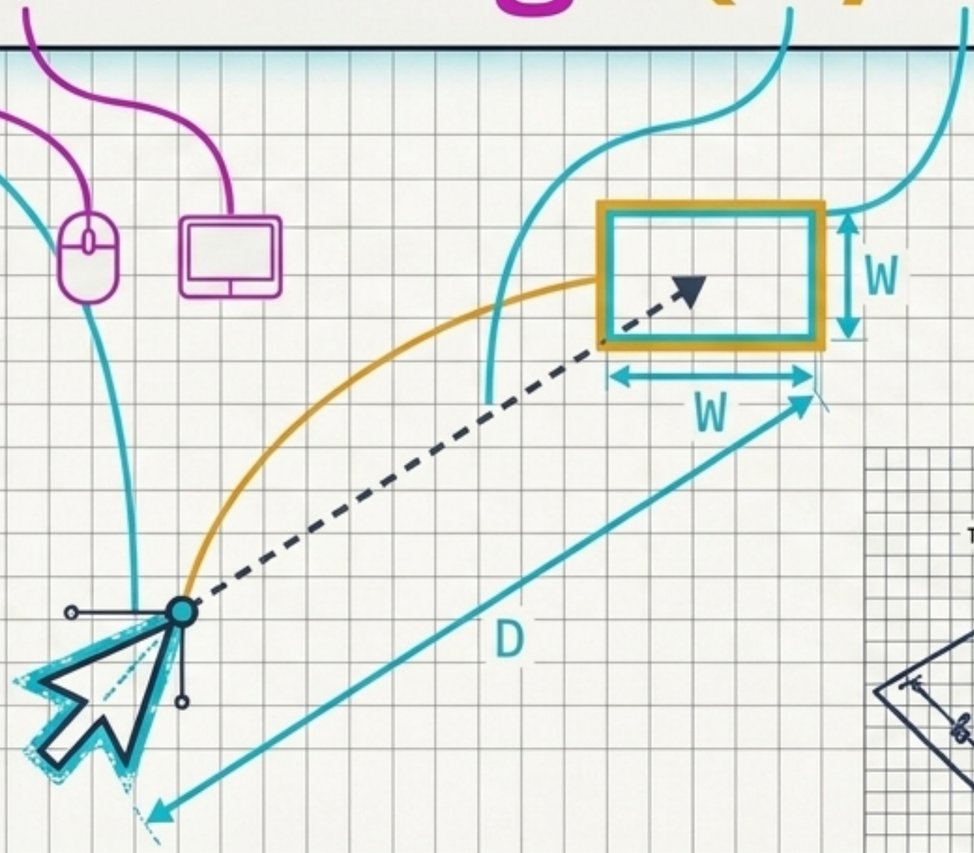
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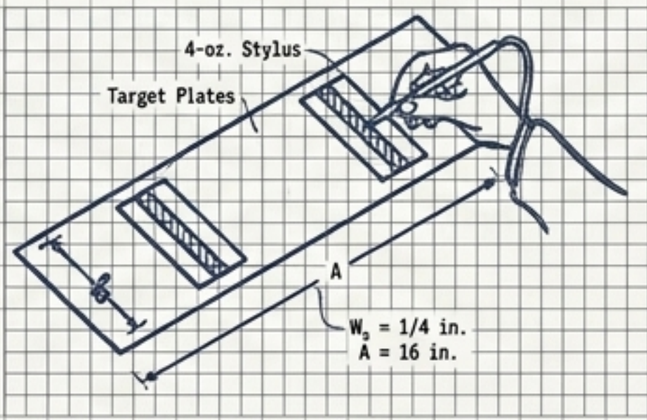
The Shannon Formulation (MacKenzie, 1992):

$$MT = a + b * \log_2(D/W + 1)$$

Variables:

- Index of Difficulty (ID): log2(D/W + 1) measured in bits. The +1 mathematically guarantees ID cannot be negative.
- MT: Total Movement Time (ms).
- a, b: Empirically derived device constants (e.g., mouse vs. trackpad).
- D: Distance to target center.
- W: Width of target along the axis of approach.

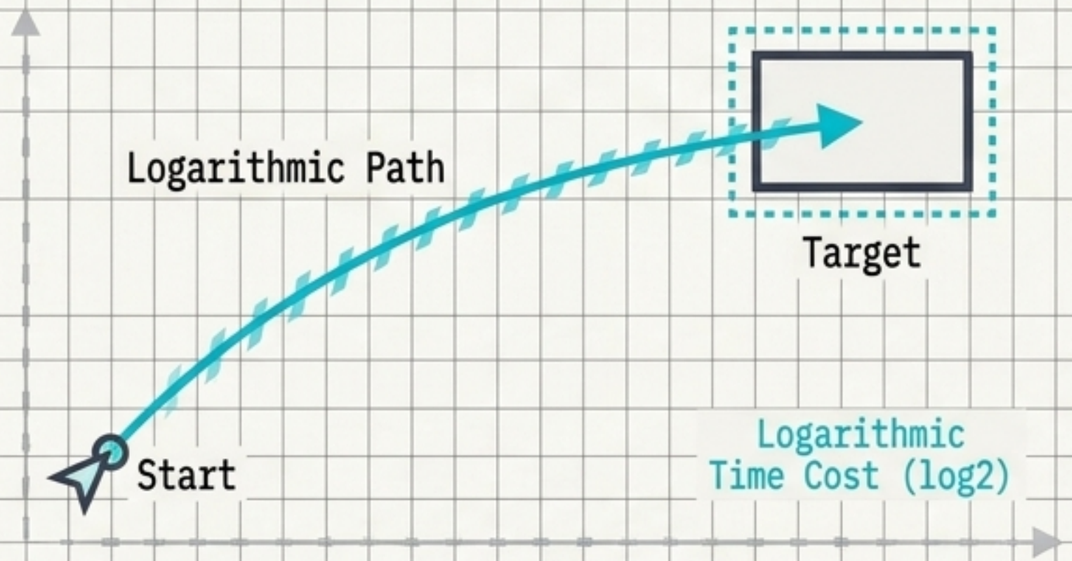




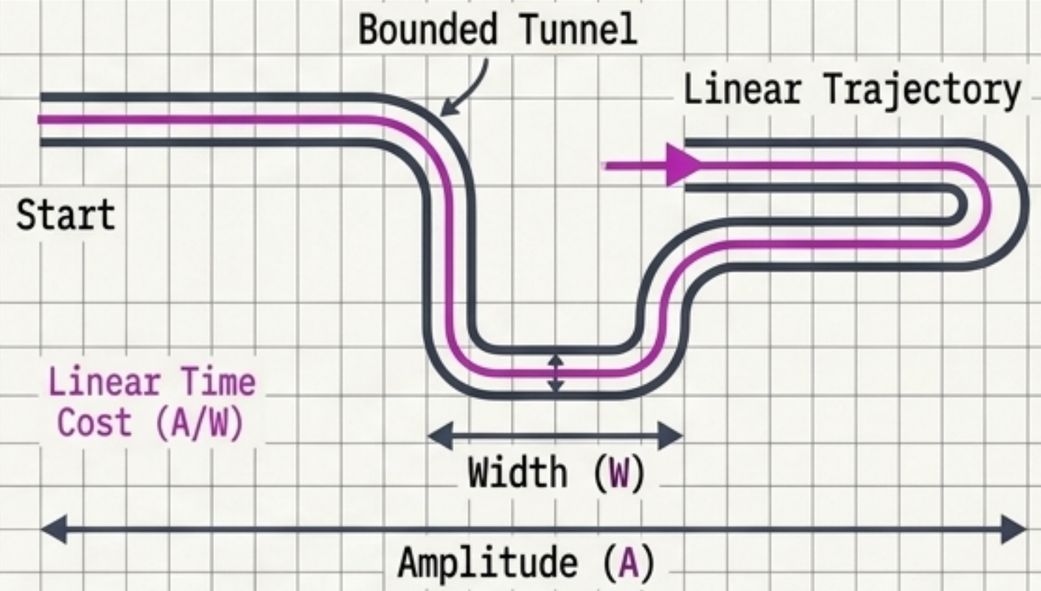
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SECTION 2 // The Steering Law: Bounded Tunnels vs. Open Targets

Open Target Pointing (Fitts's Law)



Bounded Tunnel Steering (Accot-Zhai Law)



The Shift

Contrast Fitts's logarithmic pointing (log2) against linear trajectory steering.

The Accot-Zhai Equation

$$T = a + b * (A/W)$$

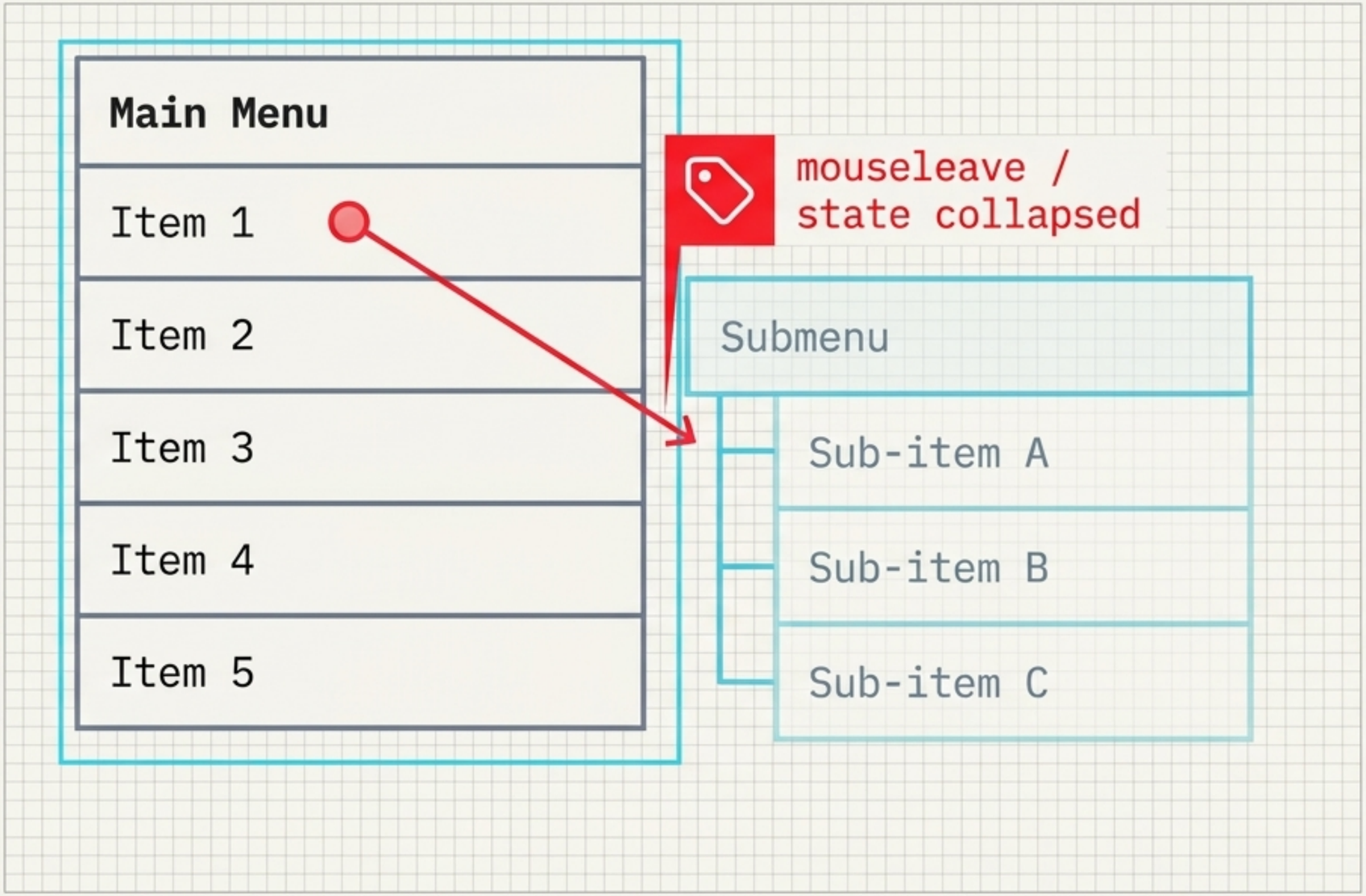
T: Total Steering Time
A: Amplitude of Path
W: Width of Path
a, b: Device Constants

Mechanics & Penalty

1. **Mechanics:** Moving through bounded tunnels (sliders, nested hover menus) strips away Phase-1 ballistic speed, forcing the user into constant Phase-2 closed-loop corrective control.
2. **Penalty:** The time cost scales linearly with the Amplitude of the path (A) divided by the tunnel Width (W).

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SECTION 2 // Submenu Geometry & The Diagonal Dropout



The Problem:
Standard CSS :hover states assume grid-based orthogonal movement (traveling straight down, then straight right).

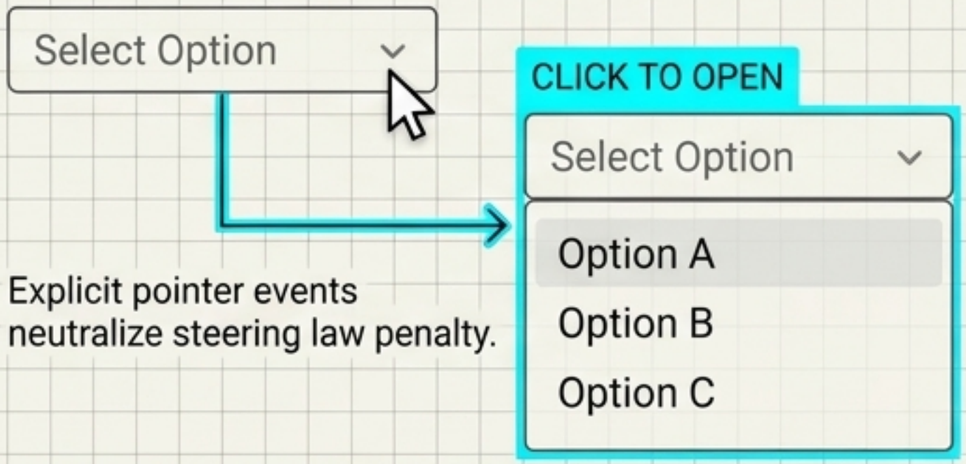
The Human Reality:
Humans take the shortest path. They move diagonally.

The Penalty:
Stepping even 1px outside the narrow orthogonal corridor triggers a mouseleave event. This heavily penalizes normal fine-moto collapsing the submenu instantly and frustrating the user.

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SECTION 2 // Engineering Fixes: Click-Toggle vs. Safe Cone

Fix 1: Explicit Click-Toggle (The Simple Path)




```
// EVENT HANDLER SNIPPET
const toggleMenu = (event) => {
  event.preventDefault(); // Stop propagation
  menu.classList.toggle('is-open');
};

// ATTACH LISTENER (CLICK)
button.addEventListener('click', toggleMenu);

// DO NOT USE (HOVER)
// button.addEventListener('mouseover', toggleMenu);
```

- Ditch hover entirely. Require explicit pointer events (click) to open/close popovers. This completely neutralizes the Steering Law penalty.

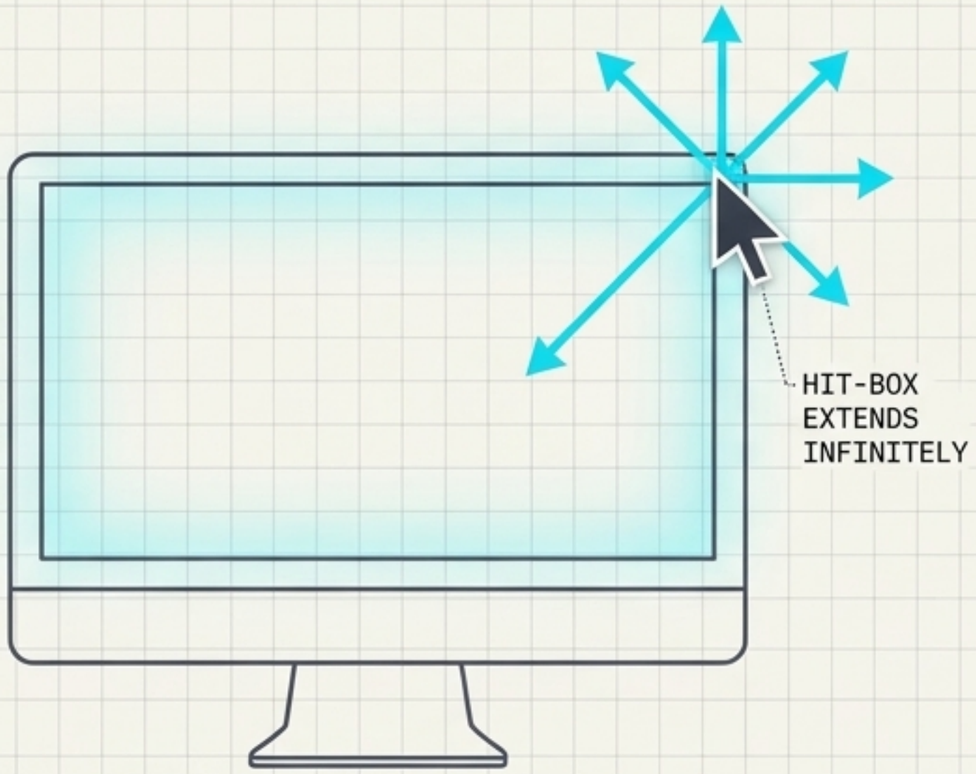
Fix 2: Trajectory Directional Aim (The Amazon Approach)



- **Vector Math:** Calculate a triangle between the current mouse position and the upper/lower corners of the submenu.
- Introduce a timeout delay only if the mouse trajectory stays within this blue safe cone.

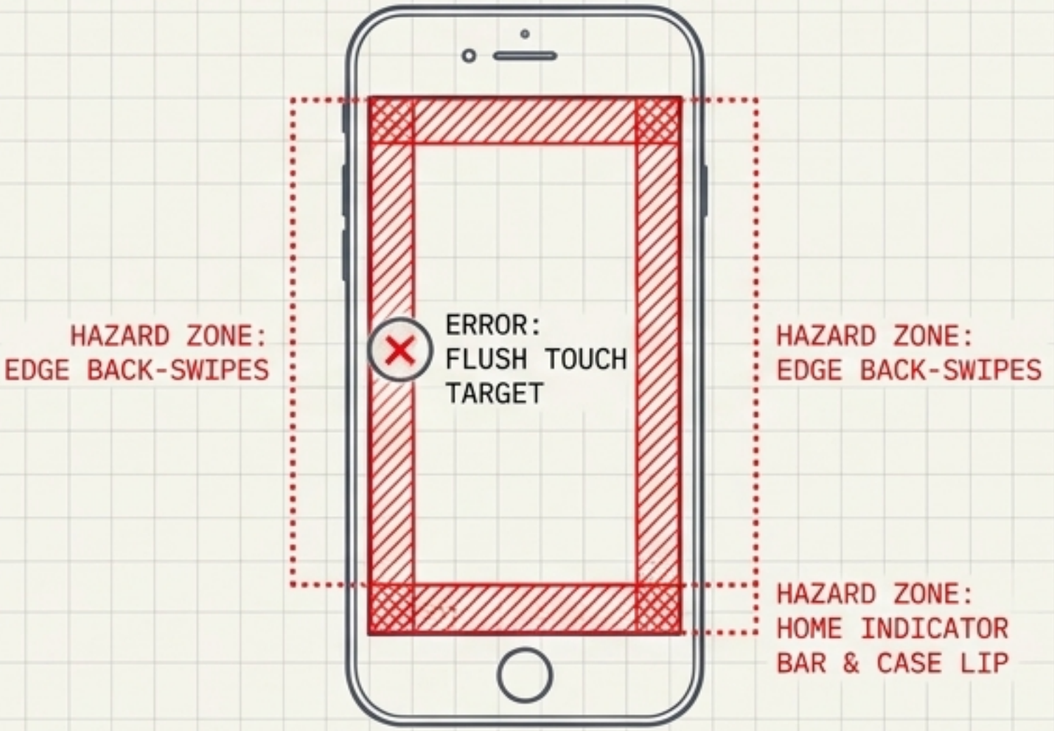
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Desktop: Bruce Tognazzini's Infinite Edges



- On a desktop, hardware boundaries physically trap the cursor. For elements pinned to corners/edges, W -> ∞, driving the Index of Difficulty to 0.

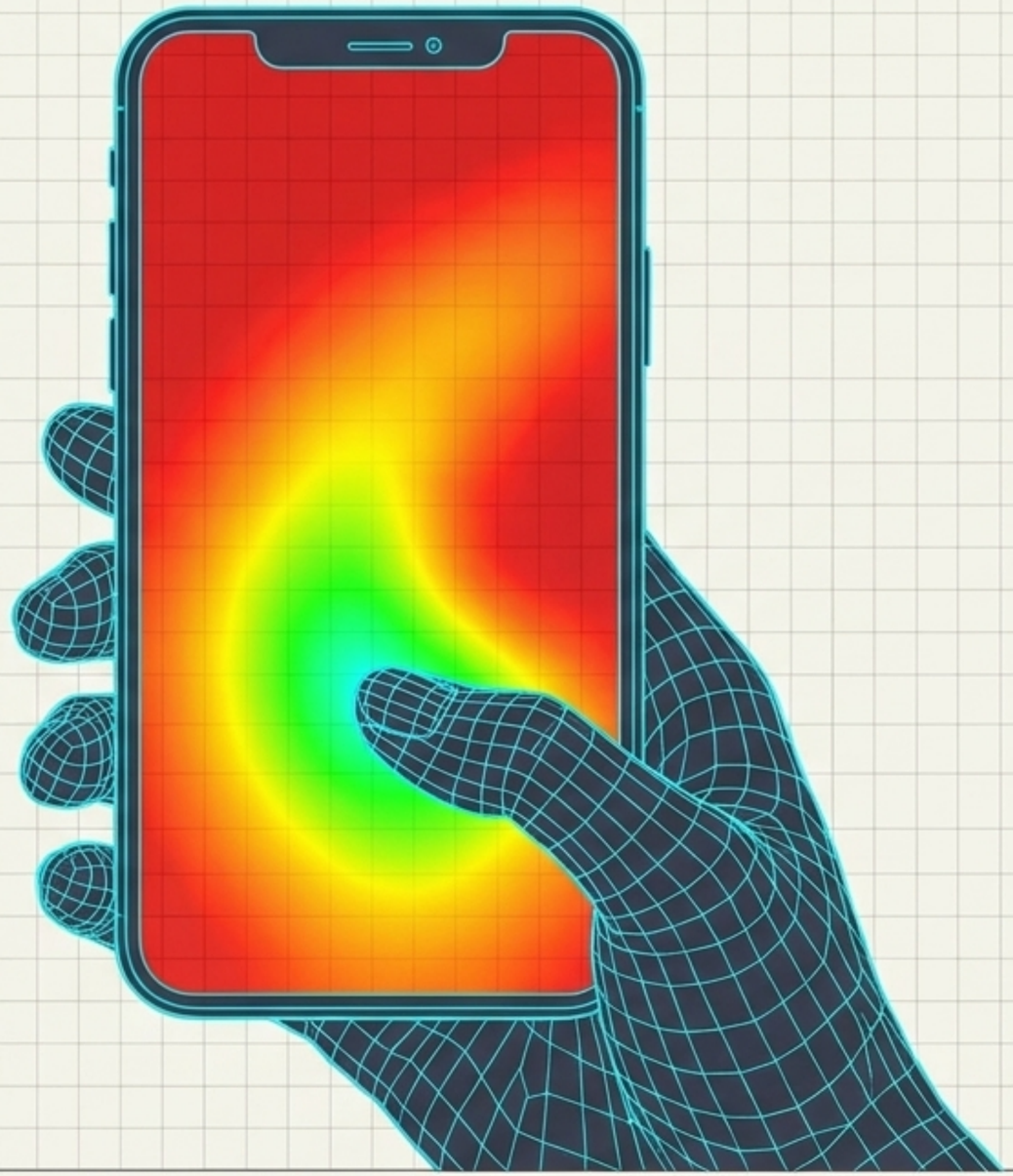
Mobile: The Edge is Lava



- On touchscreens, edges are dangerous. Users fight iOS/Android edge back-swipes, the bottom Home Indicator bar, and the physical lip of protective phone cases. Pinning touch targets flush to the edge increases error rates.

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SECTION 3 // Mobile Ergonomics: The Thumb Arc



The Reality:

N=1,333 field study. 49% of users rely primarily on a one-handed, single-thumb posture.

Optimal Placement:

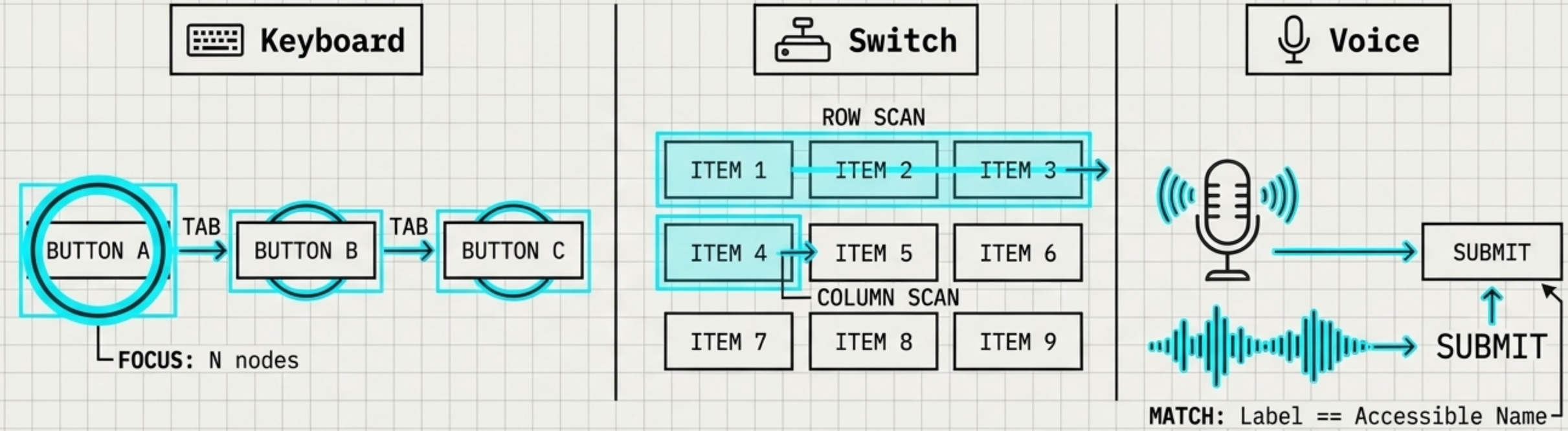
The bottom-center natural thumb arc is the lowest-friction zone for Phase-2 targeting.

The Insight:

The geometric center of the screen is not the ergonomic center of the device. Crucial interactive elements should anchor to the bottom.

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SECTION 3 // Non-Pointer Modalities (Keyboard, Switch, Voice)



Why Fitts's Law Fails Here: Distance (D) and Width (W) are irrelevant without an analog spatial pointer.

Keyboard/Switch Scanning (WCAG 2.1.1):

- Interaction cost scales linearly with the focus-stop count (N).
- Equation: Cost = ∑ (Focus Stops).

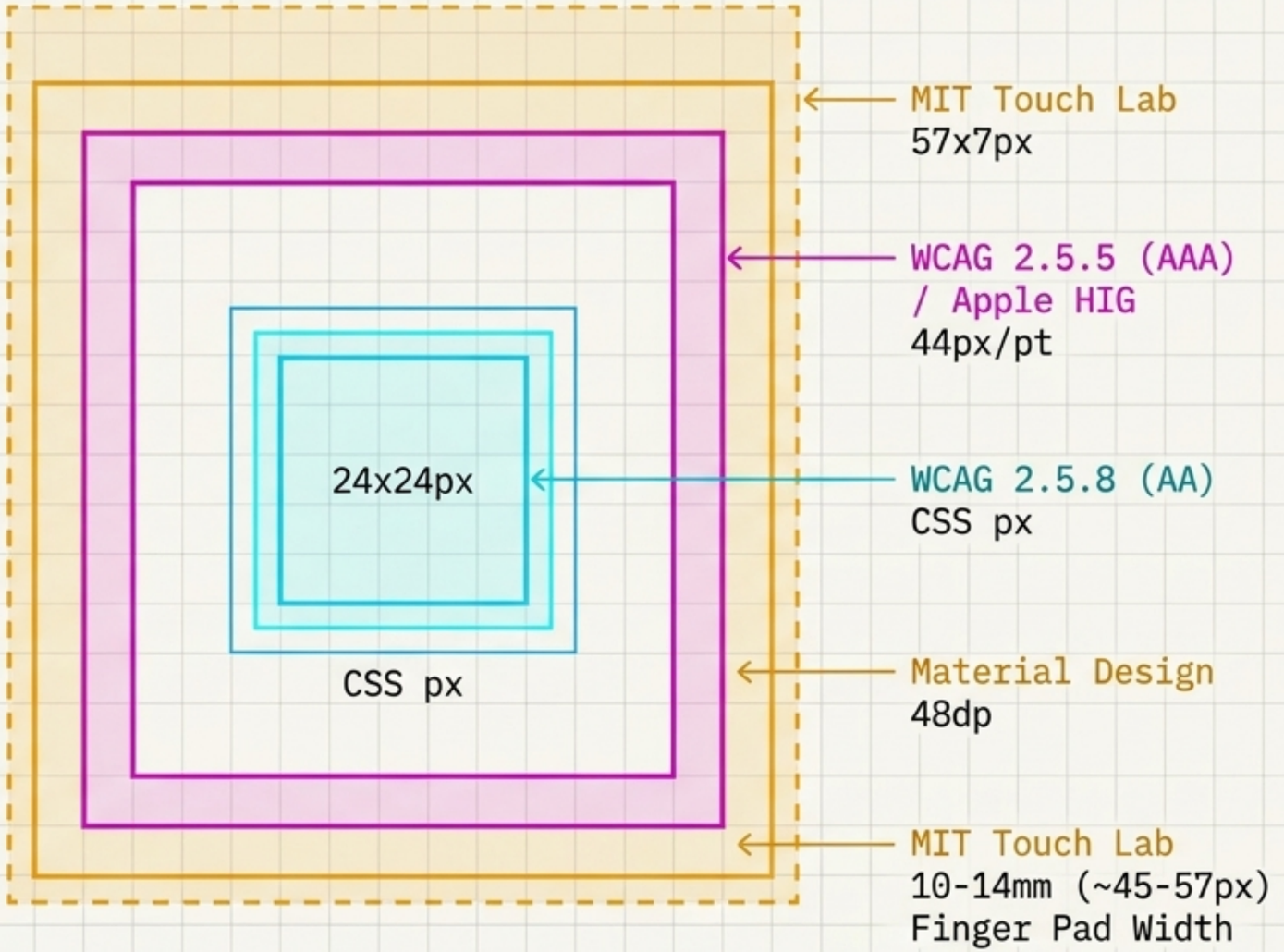
Voice Control (WCAG 2.5.3):

- Cost scales with cognitive label clarity. The visible text must perfectly match the underlying accessible name, otherwise voice-target mismatch causes failure.

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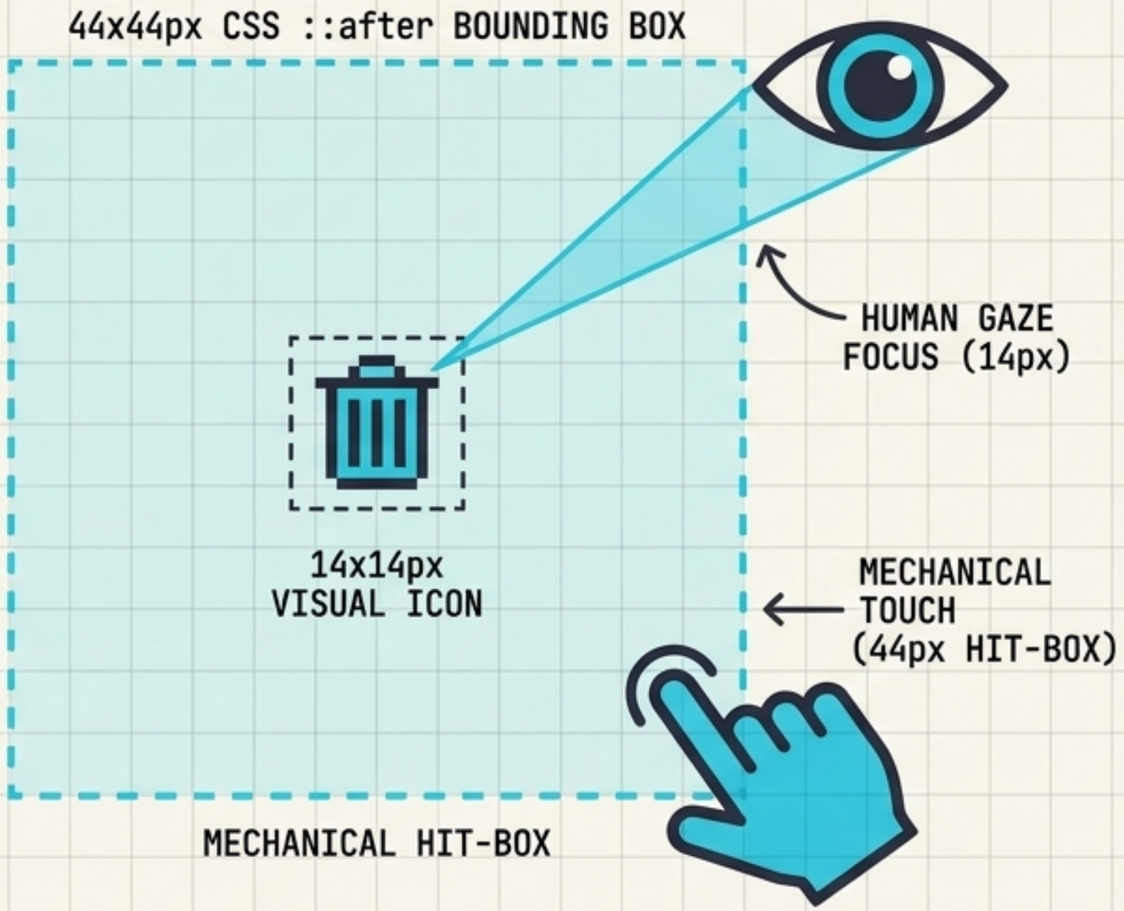
SECTION 4 // Cross-Platform Target-Sizing Standards (Reference)

- **WCAG 2.5.8 (AA):** 24x24 CSS px (Allows for spacing exception).
- **WCAG 2.5.5 (AAA):** 44x44 CSS px (The gold standard for inclusivity).
- **Apple HIG:** 44x44 pt.
- **Material Design:** 48x48 dp.
- **MIT Touch Lab:** 10–14mm biomechanical finger pad width (approx 45-57px).



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SECTION 4 // The Invisible Hit-Box Paradox



TECHNICAL SPECIFICATION

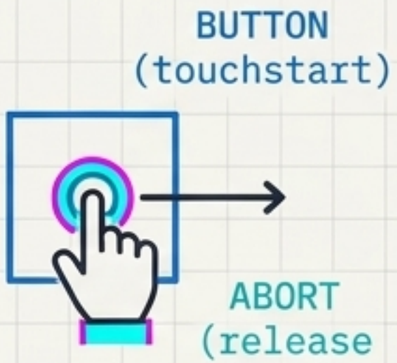
- **THE PARADOX:**
  Passing a mechanical accessibility audit (using invisible CSS padding) does not equal human accessibility.
- **VISUAL HOMING DELAY:**
  Because the user cannot see the 44px hit-box, their Phase-2 closed-loop motor system still decelerates drastically to target the microscopic 14px visual element.
- **THE RISK:**
  Invisible padding masks adjacent destructive slips. If hidden boxes overlap or sit too close, users trigger actions they never visually aimed for.

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SECTION 5 // Motor Slips vs. Cognitive Mistakes

Slips (Motor): The user had the correct intention, but physical execution failed (e.g., bumped screen, hand tremor).

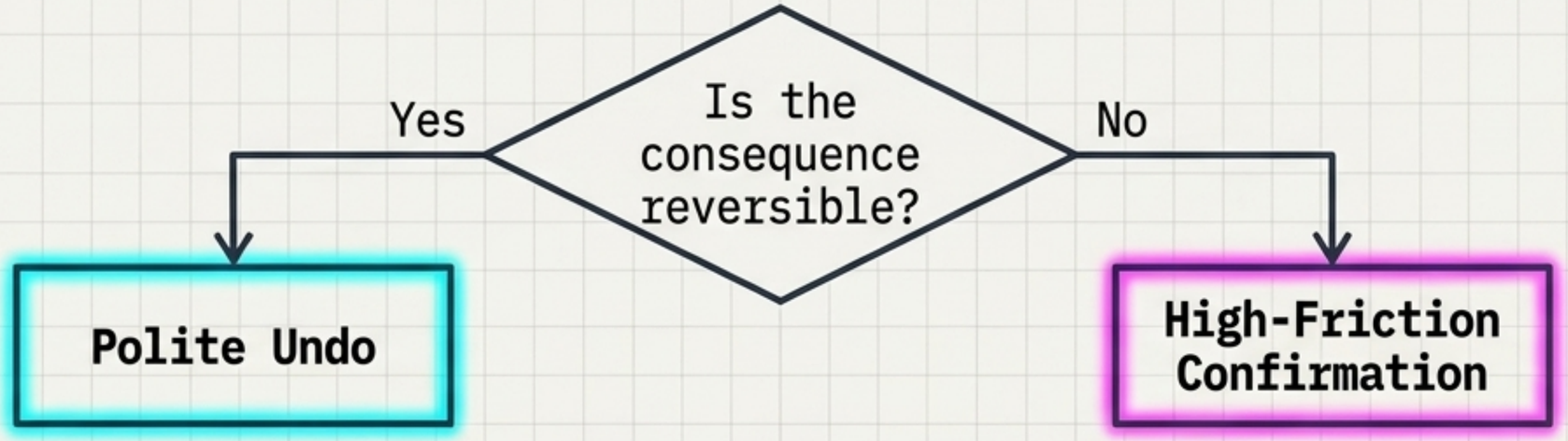
Pointer Cancellation (WCAG 2.5.2)	**Pointer Gestures** (WCAG 2.5.1 / 2.5.7)
• Never execute destructive actions on mousedown/touchstart. • Always fire on pointerup. • Allow a slide-off abort before release.	• Complex pathing (drag-and-drop, pinch-zoom) causes high slip rates. • Always provide single-pointer button fallbacks (e.g., Tap-to-move).





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SECTION 5 // Habituation & The Undo vs. Friction Decision Matrix



Confirmation Habituation:
Prompting 'Are you sure?' for routine actions breeds muscle memory. Users click 'Yes' blindly, rendering the friction useless (Aza Raskin).

Reversible Actions (The Standard):

- Use a 10-second polite Undo (ARIA role='status', W3C COGA recovery pattern). Let the user execute instantly and fix slips post-execution.

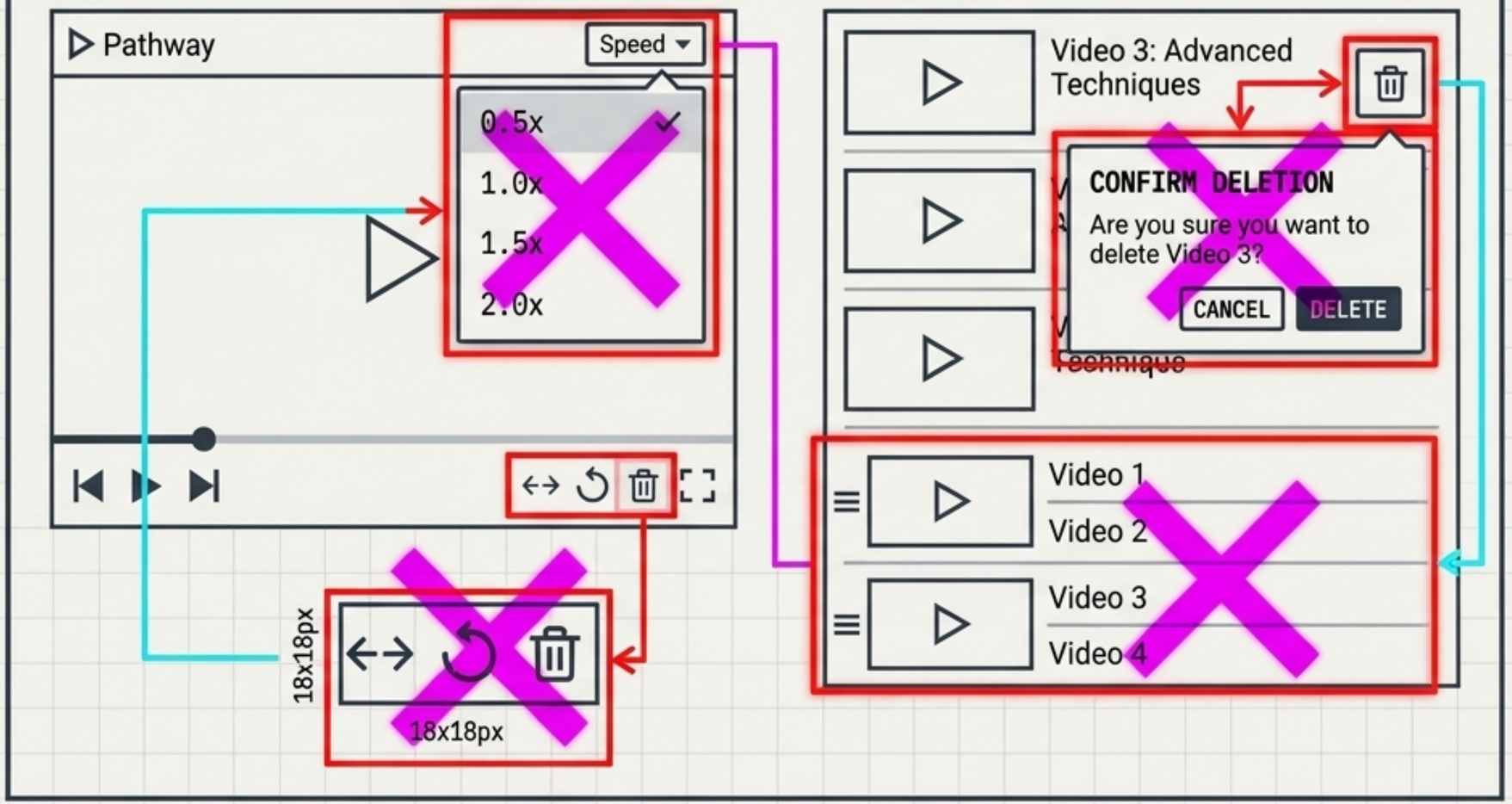
Irreversible Consequences (The Exception):

- Use high-friction, non-standard interactions (e.g., typing 'DELETE' to drop a database) strictly for catastrophic data loss.

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SECTION 6 // Vibe-Coder Anti-Patterns (Pathway Audit)

BLUEPRINT AUDIT



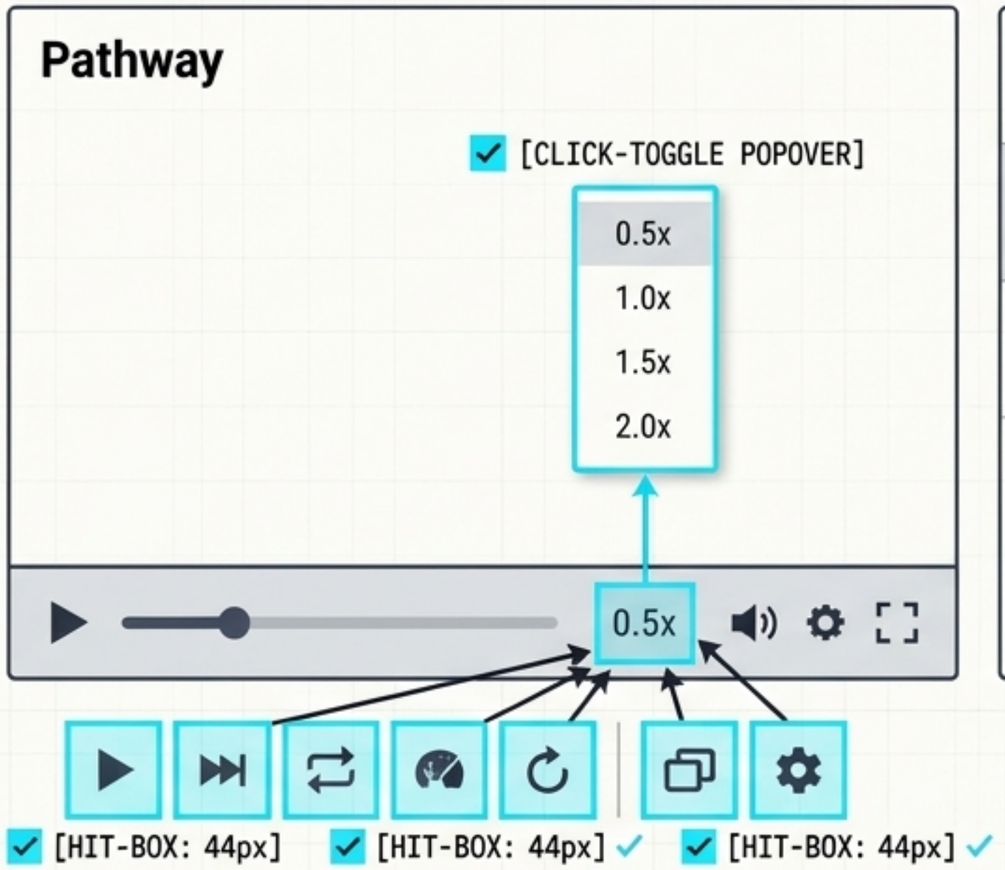
DIAGNOSTIC LIST // FAILURES & ANTI-PATTERNS

1. **Speed Menu:** CSS hover triggers diagonal dropout on the playback-speed submenu.
2. **Toolbar Icons:** 18x18px packed scrub/reset/delete icons. Fails WCAG 24x24 minimum; guarantees adjacent slips.
3. **Deletion:** Destructive action triggers immediately on mousedown, followed by an over-used, annoying confirm() popup.
4. **Playlist Sorter:** Drag-only reordering blocks Keyboard and Switch users entirely.

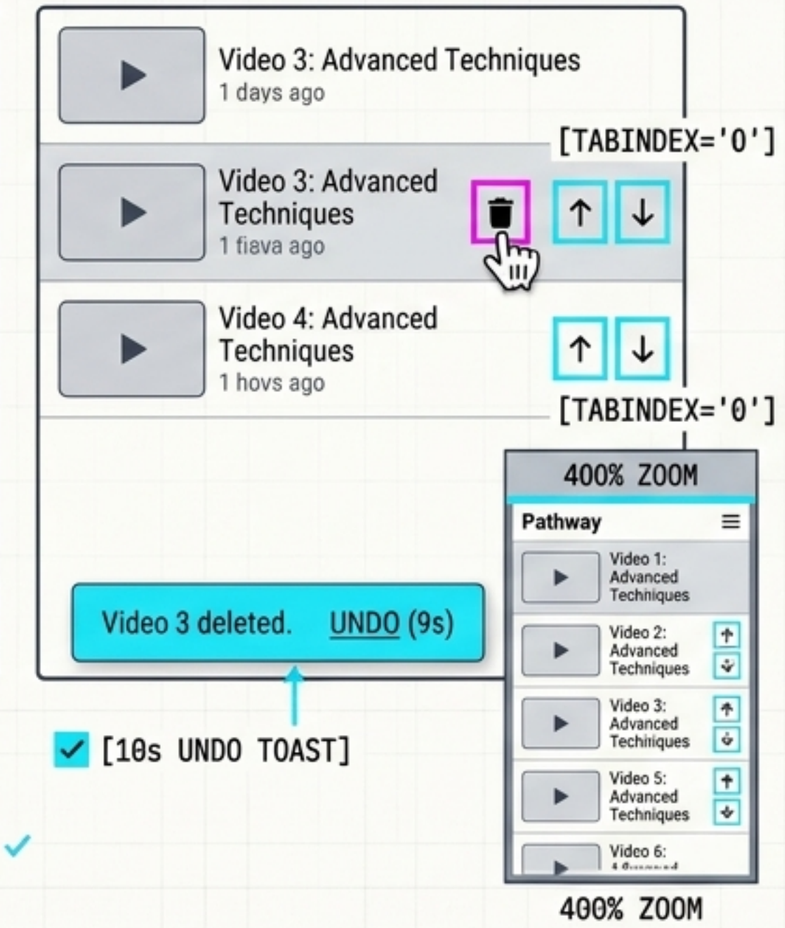
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SECTION 6 // Pathway Multi-Modal Repairs

PATHWAY VIDEO PLAYER // CONTROLS & TOOLBAR



PATHWAY PLAYLIST // SORTING & ACTIONS



DIAGNOSTIC LIST // SOLUTION PATCHES

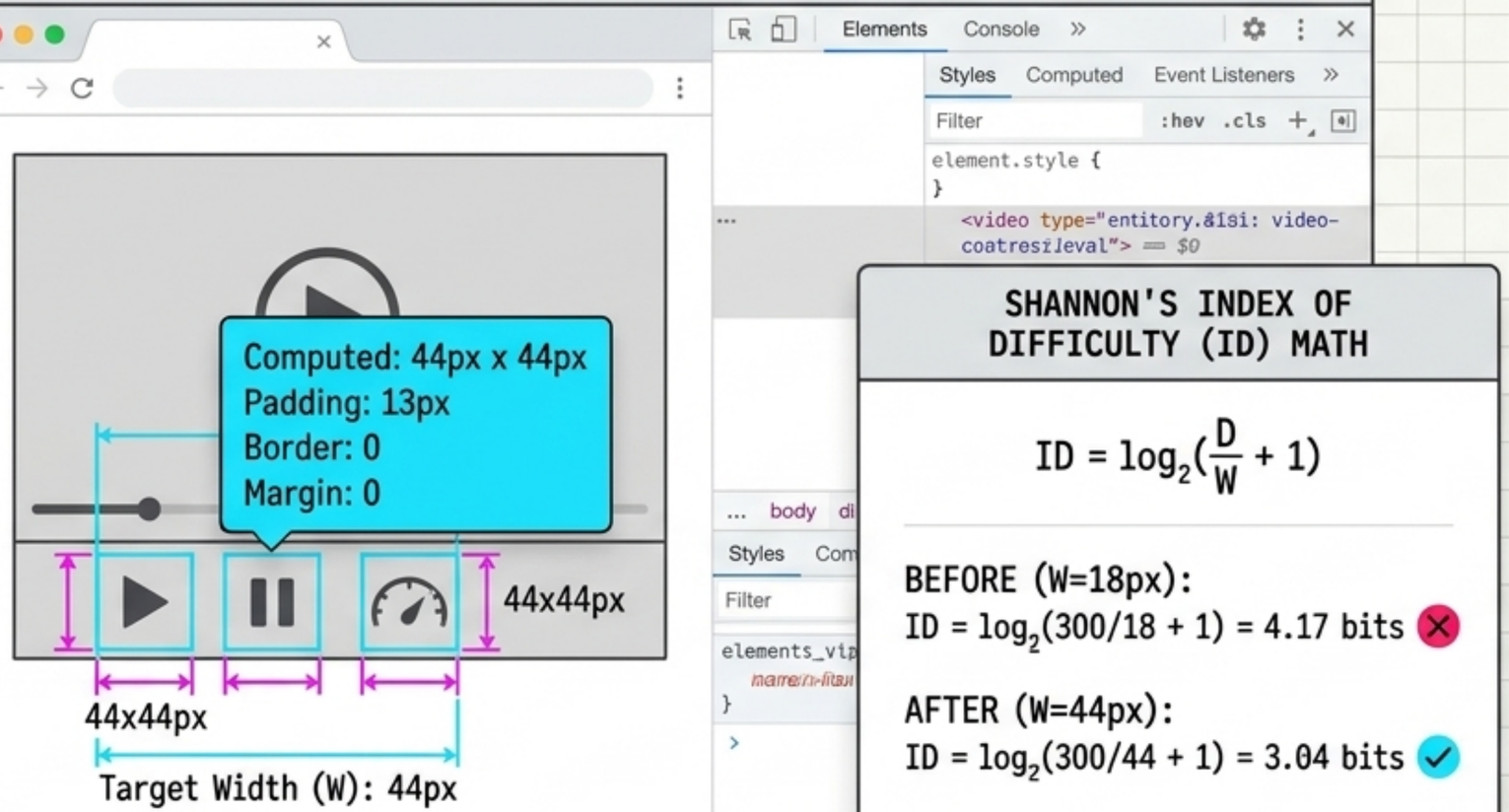
- **1. Pointer:** Speed menu rebuilt as an explicit click-toggled popover.
- **2. Mobile Thumb:** Hit-boxes scaled to 44px, spaced adequately to prevent adjacent destructive slips.
- **3. Safety:** Note deletion bound to pointerup (allowing slide-off abort) + a 10s toast-based Undo replaces the popup.
- **4. Keyboard/Zoom:** Playlist sorter adds explicit Up/Downrrow buttons (tabindex='0'); the interface reflows flawlessly at 400% zoom (320 CSS px).

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SECTION 7 // Hands-On

DevTools Hit-Box & ID Audit

DEVTOOLS INSPECTOR: COMPUTED BOX-MODEL & SHANNON'S ID CALCULATION



SHANNON'S INDEX OF DIFFICULTY (ID) MATH

$$ID = \log_2\left(\frac{D}{W} + 1\right)$$

BEFORE (W=18px):
$ID = \log_2(300/18 + 1) = 4.17$ bits

AFTER (W=44px):
$ID = \log_2(300/44 + 1) = 3.04$ bits

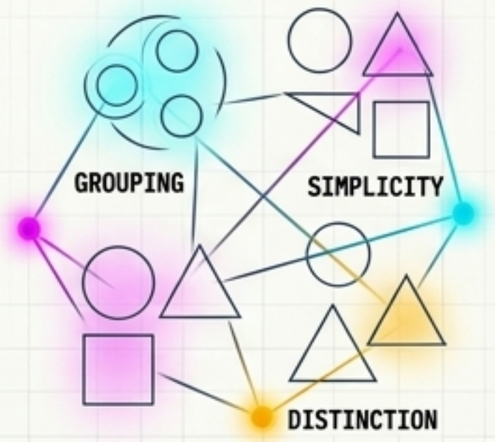
METHODOLOGY STEPS // AUDIT PROTOCOL

1. Use the DevTools inspector to visualize computed box-models versus visual iconography. Check for invisible padding.
2. Calculate the Shannon Index of Difficulty (ID) before and after increasing Target Width (W).
3. Validate pointerup abort capabilities via Event Listener Breakpoints.
4. Ensure sequential keyboard navigation (Tab) matches the visual layout order perfectly.

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THE 5-POINT MOTOR CONTROL SHIPPING CHECKLIST

1. Base target sizes meet **24px** (AA) or **44px** (AAA) minimums.
2. No hover-dependent nested steering tunnels; use **click-toggles** or safe cones.
3. Destructive event listeners bound to **pointerup** (allowing slide-off aborts).
4. **Drag/Pinch** interactions feature single-tap button fallbacks.
5. **‘Undo’** preferred over confirmation popups for reversible actions.



NEXT UP (S11E03): “How People Perceive: Grouping, Simplicity and Distinction” — Moving from motor execution to visual processing.

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