Long Cane Design and Biomechanics: Factors That Affect Drop-off and Obstacle Detection

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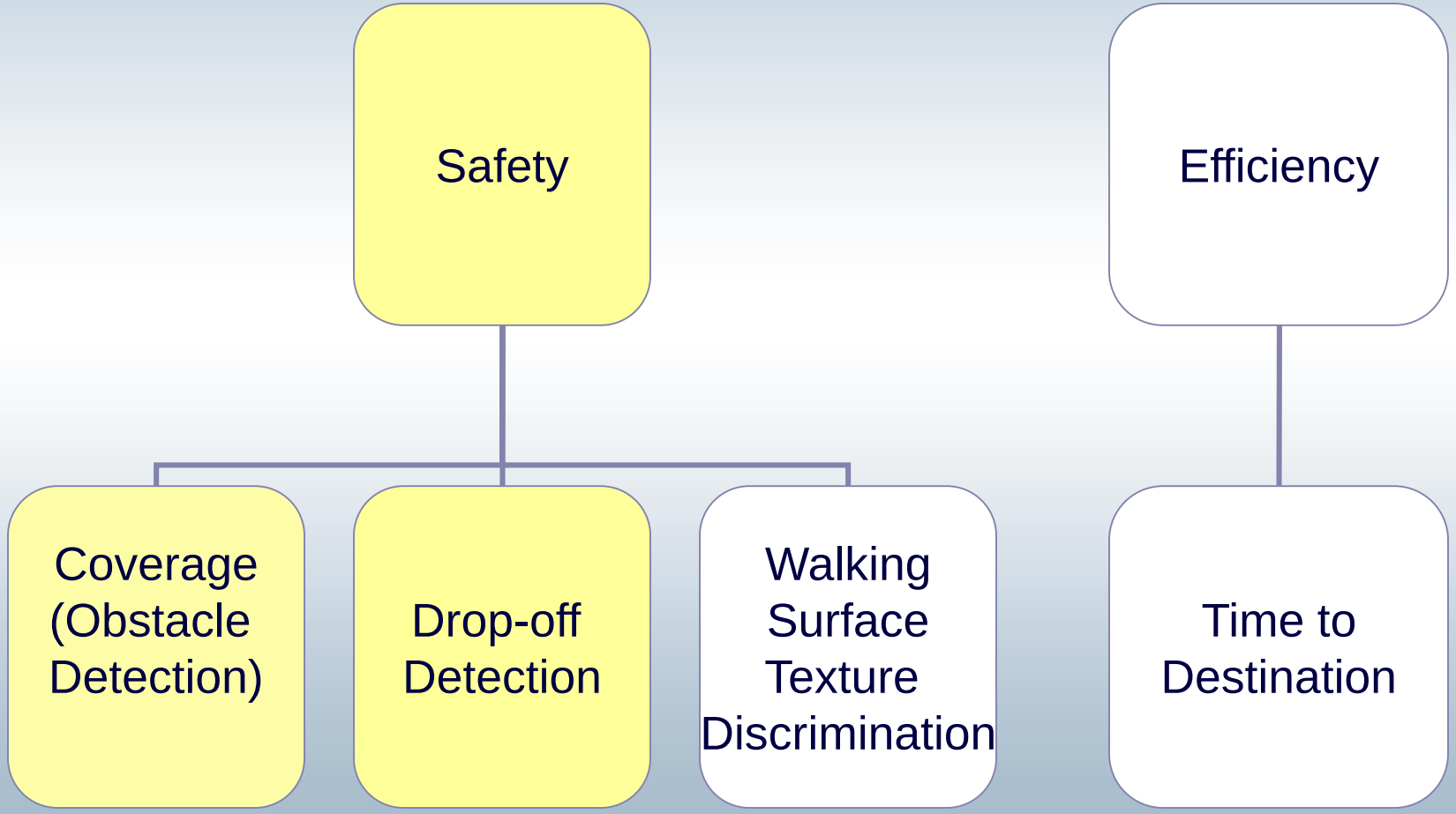
Cane Techniques

- Two-point touch technique
- Constant contact technique

Cane Travel Performance



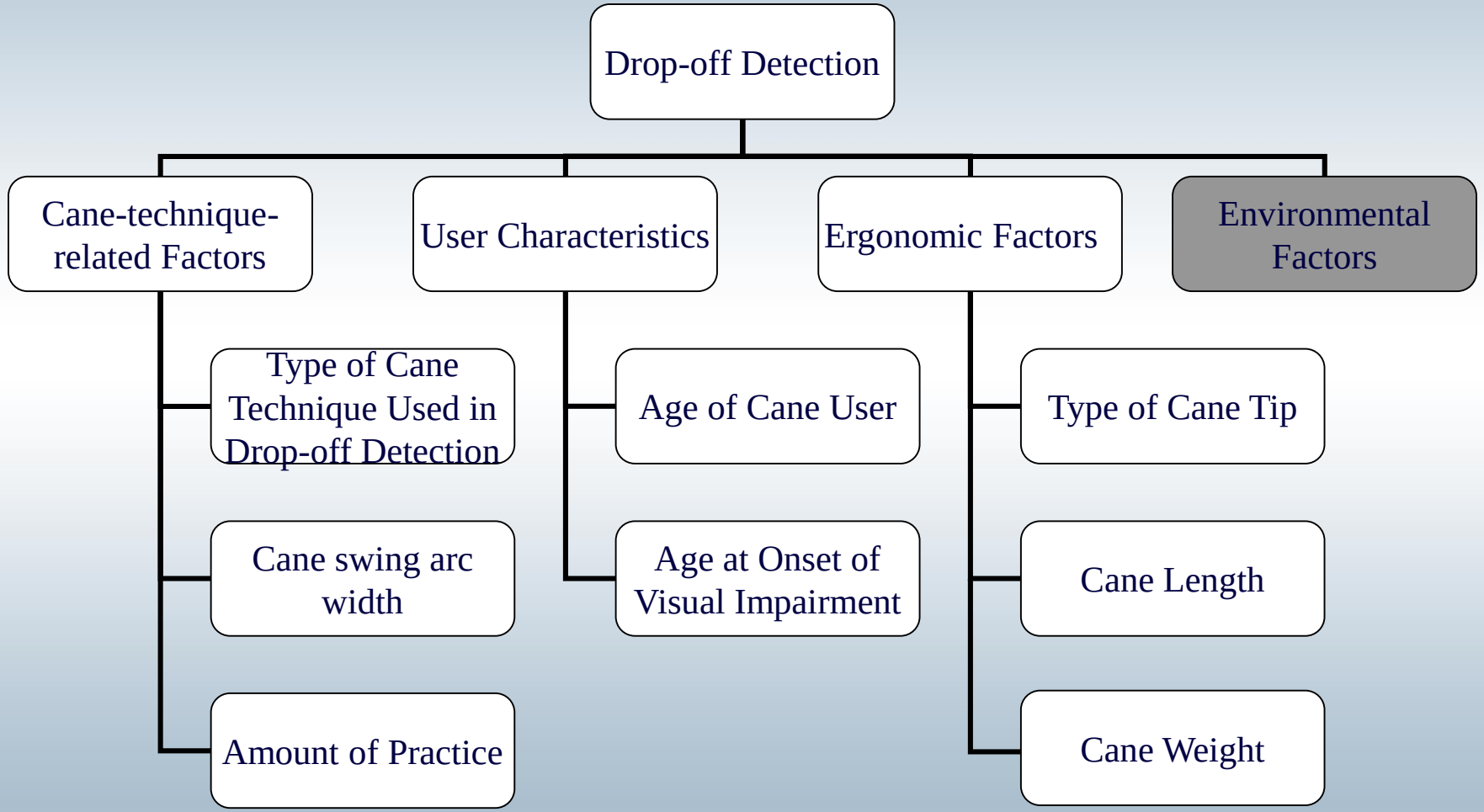
Drop-off Detection

- Critical for blind travelers to detect drop-offs reliably
  - Curb
  - Uneven surfaces
    - Pothole, sunken slab

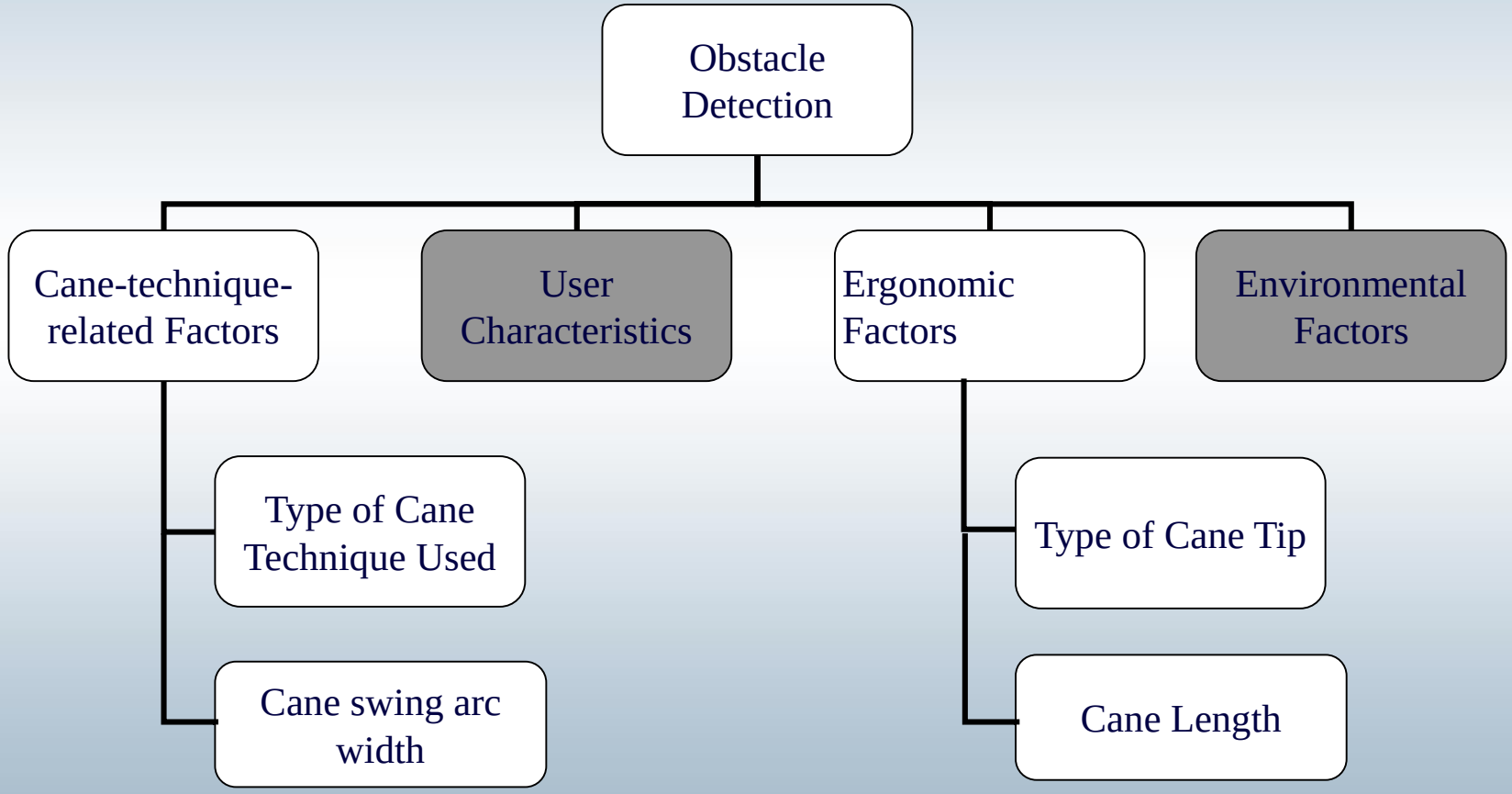
Obstacle Detection

- Critical for blind travelers to detect obstacles reliably
  - Trip over obstacles (construction cones, bricks, etc.)
  - Collision with obstacles (sign posts, etc.)

Factors Related to Drop-off Detection



Factors Related to Obstacle Detection



Methods
(Drop-off Detection Studies)

Recruitment Criteria

- Legal blindness with no other disabilities
- Familiarity with both techniques
- At least one month of cane training
- 13-16 cane users participated in individual studies

Drop-off Detection Experiment

- Test site
  - 8-foot-wide concrete hallway in CHHS building basement
- Sleep-shades and headphone set

Apparatus

Participant Approaching the Drop-off on the 32-foot-long Walkway Used in the Study

Experiment Procedure

- Starting point randomization
- 64-96 trials per participant
- Block randomization to prevent order effect
- Block randomization to randomly select drop-off depth for each trial

Key Findings
(Drop-off Detection)

Previous Findings

- Drop-off detection performance (Significant factors)
  - Constant contact (CC) better than two-point touch (TT)
  - CC's advantage is larger for less experienced
  - CC with marshmallow roller (disadvantageous tip) was still better than TT with marshmallow (advantageous)
  - Younger cane users were better
  - Individuals with earlier-onset VI were better
  - Heavier cane was better
  - Standard length was better than extended length (16" longer)

Previous Findings

- Drop-off detection performance (Factors that were NOT significant)
  - Preferred cane technique
  - Cane shaft rigidity
  - Cane tip (marshamllow tip vs. marshmallow roller tip)

Methods
(Obstacle Detection Studies)

Recruitment Criteria

The same as drop-off detection studies

Obstacle Detection Experiment

- Test site
  - WMU's CHHS building 4F hallway
- Sleep-shades and headphone set

Apparatus

Circular objects of different sizes (diameters of 2”, 6”, 10”, and 14”) and heights (1”, 3”, 5”, and 7”) were created with Styrofoam and linoleum.

Apparatus

Objects presented either at the midline of the walking path or slightly off to the side following a randomized schedule. A 20-foot-long rail (3 feet high), built with PVC pipes, was placed beside the walking path for participants to trail with the free hand.

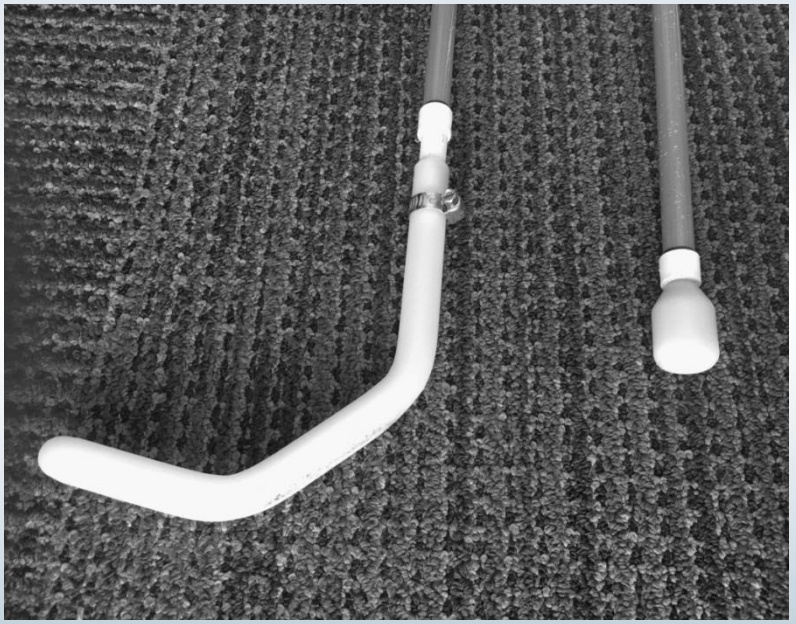
Experiment Procedure

- Starting point randomization
- 128-192 trials per participant
- Block randomization to randomly select obstacle size and height for each trial

Key Findings
(Obstacle Detection)

Key Findings

- Obstacle detection performance
  - CC better than TT for short obstacles
  - Bundu basher tip was better than marshmallow tip
  - Cane length and cane swing arc width didn’t have a significant effect



DISCUSSION

Discussion

- One of the most significant and prevailing finding
  - Presence of CC's advantage over TT in drop-off detection
- Particularly noteworthy is large effect size
  - 50% threshold: half as large
  - Large drop-offs
    - TT: missed 1 in 15
    - CC: missed less than 1 in 100

Discussion

- Surprising finding
  - Failure to detect even tall obstacles at least 1 in 3 times
  - Consistent with Uslan (1978)'s finding (68.9% path coverage rate)
  - Bundu basher tip somewhat improves the obstacle detection rate (from 35% to 25% misses)
  - Raises a question of whether we should modify the current cane techniques

Future Study Plans

- Biomechanical and ergonomic factors affecting drop-off and obstacle detection
- Surface texture discrimination
- Ecological validity

Future Drop-off Detection Studies

- Factors to be examined:
  1) Cane-holding hand position (centered vs. off to the side)
  2) Gait-swing coordination (rhythm & step)
  3) Cane grip (rubber, cork/foam, wood)
  4) Modification of conventional cane techniques

Future Obstacle Detection Studies

- Factors to be examined:
  1) Cane-holding hand position (centered vs. off to the side)
  2) Modification of conventional cane techniques

Future Texture Discrimination Studies

- Factors to be examined:
  1) Type of cane tip (shape, size, and presence of bearings)
  2) Type of cane grip (rubber, cork/foam, wood)
  3) Cane shaft material (flexible vs. rigid)

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