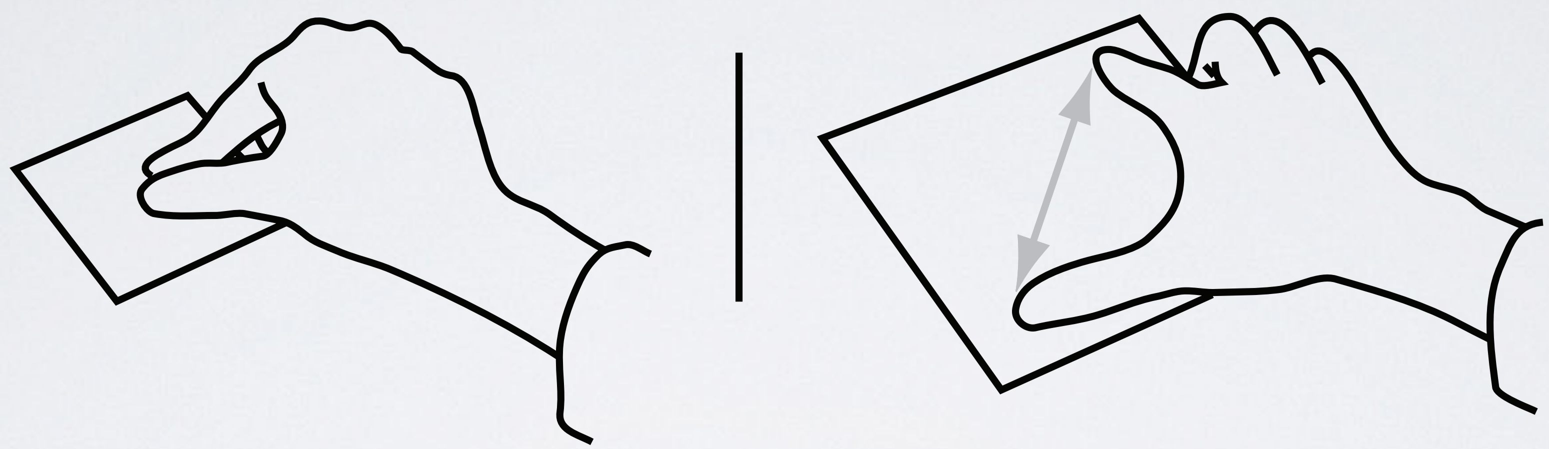


Gestural User Interfaces

Chat Wacharamanotham

A definition in human discourse

"Gesture (…) are **communicative movements** of the hand s and arms which **express** – just as language – speakers' attitudes, ideas, feelings and **intentions**…" (Müller, 1998)

Full taxonomy see (McNeill, 1992). Figure (Kelly et al., 2011)

"It [large piece of canvas] can be used to make tents (metaphoric gesture)..."

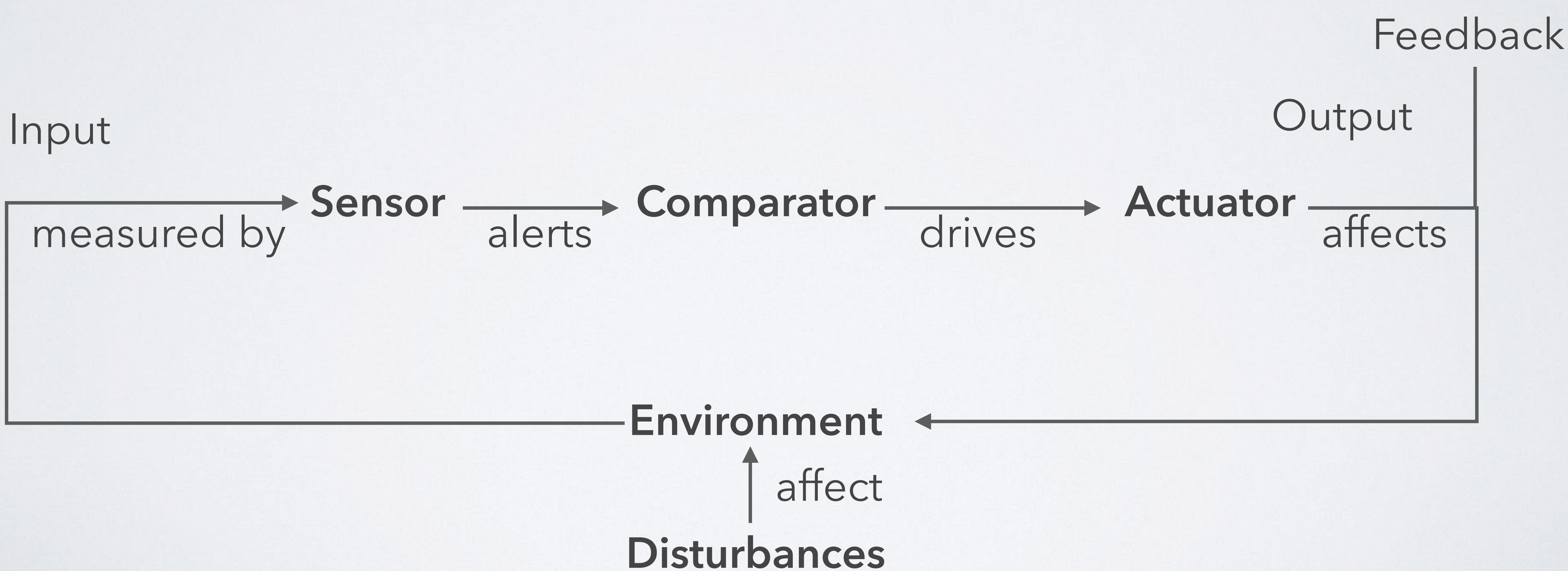
"… or a tent (iconic gesture)."

"The sixth one (deictic gesture) would be a small axe."

"So shelter is very important (beat gesture) in this cold weather."

A definition in HCI

"Gesture (…) is any **physical movement** that a digital system can **sense and respond** to **without** the aid of a traditional **pointing devices** such as a mouse or stylus" (Saffer, 2009)



Basic components of any gestural systems (Saffer, 2009)

Do I need gestural user interface?

Gestural UI are **not** suitable:

- Heavy data input (use keyboards instead)
- Absence of visual feedback (e.g., a system without a screen or targeting users with visual impairments)
- Unmet physical demands (e.g., swipe to receive a phone call in winter)
- Context (e.g., privacy, embarrassment)

(Saffer, 2009)

Do I need gestural user interface?

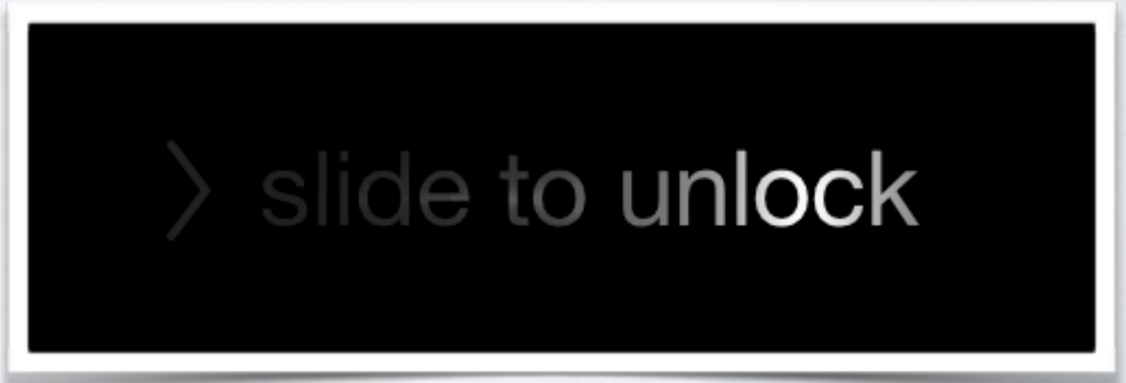
Gestural UI are **good** for:

- Natural interactions: interact directly with objects in physical way
- Less cumbersome or visible hardware
- Flexibility in hardware
- Fun

(Saffer, 2009)

Design principles for gestural systems

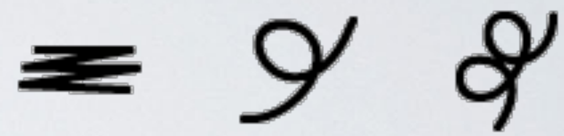
- **Discoverable:** provide affordance and guidance on where & how
- **Responsive:** acknowledge users' action with feedback
- **Clear conceptual models:** clear association between users' action and consequences



See more in (Saffer, 2009) and (Norman, Interactions '10)

Gesture design process

- **Stock:** generic set used by many applications
  - Recognizers provided by the toolkits
  - Potential reuse; no additional learning



Windows Vista Pen Gestures

- **Designed** by experts
  - Easy to tune the recognizers
- **Elicited** from a representative group of users
  - Better match user’s needs and expectation
- **User-defined:** let each end-user create her own gesture set
  - Good for expert users or users with disabilities

(Grijincu et al, ITS ’14; Nacenta et al., CHI ’13)

Gesture elicitation

Method

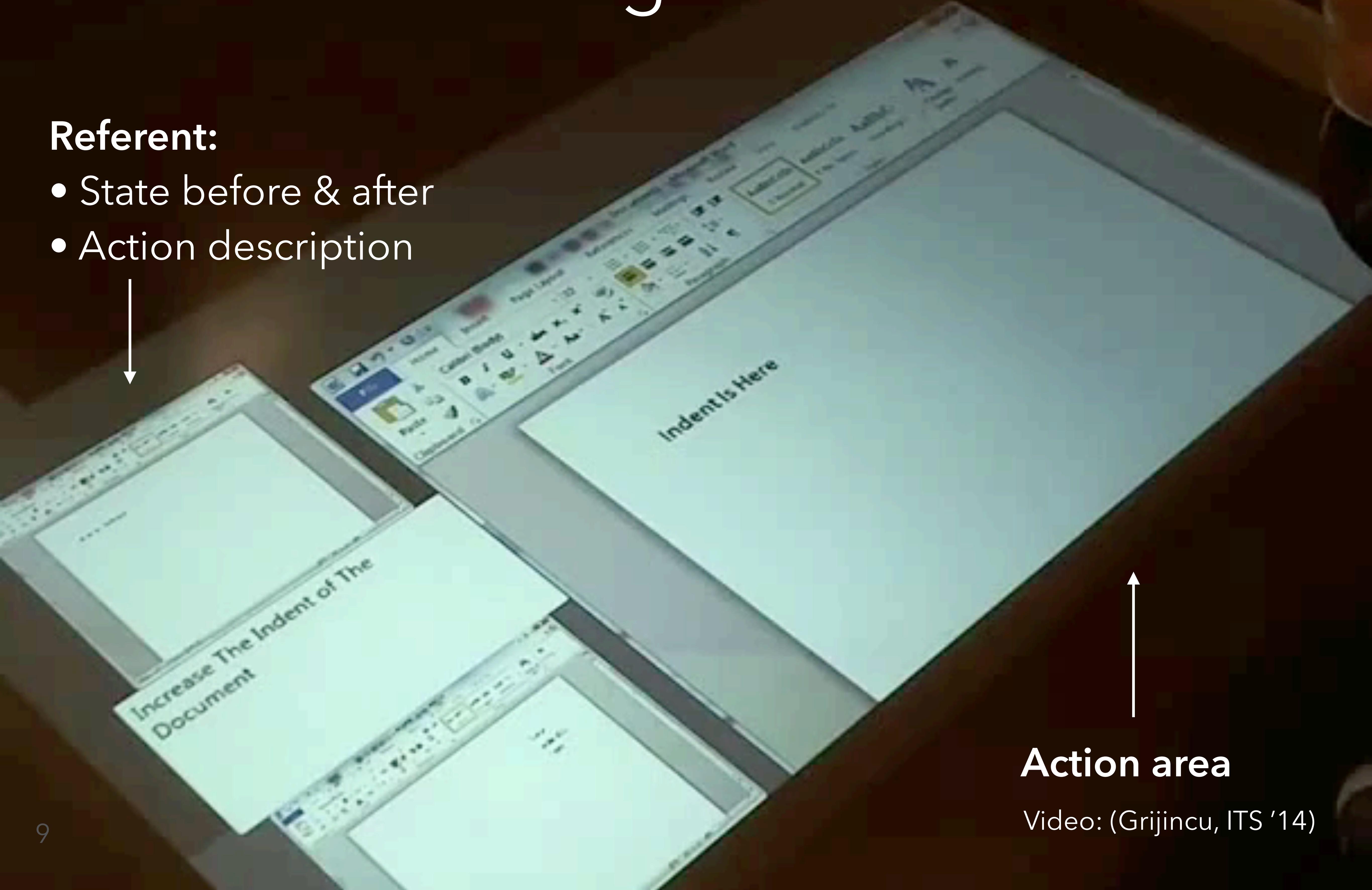
- Recruit participants from representative users
- Show the results of the action (**referent**)
- Ask participants to produce a gesture that come to their mind for that referent
- Calculate **agreement rate**
- Choose the gestures that have high agreement rate

Method proposed in (Wobbrock et al., CHI '05)
Example: surface gesture elicitation in (Wobbrock et al., CHI '09)
Further refined in (Vatavu & Wobbrock, CHI '15)

Elicitation setting

Referent:

- State before & after
- Action description



Action area

Video: (Grijincu, ITS ’14)

Agreement rate

The number of pairs of participants in agreement with each other divided by the total number of pairs of participants that could be in agreement.

$$\mathcal{AR}(r) = \frac{\sum_{P_i \subseteq P} \binom{|P_i|}{2}}{\binom{|P|}{2}} = \frac{\sum_{P_i \subseteq P} \frac{1}{2}|P_i|\left(|P_i| - 1\right)}{\frac{1}{2}|P|\left(|P| - 1\right)}$$

P is set of all proposals for the referent r

$|P|$ is the size of the set P

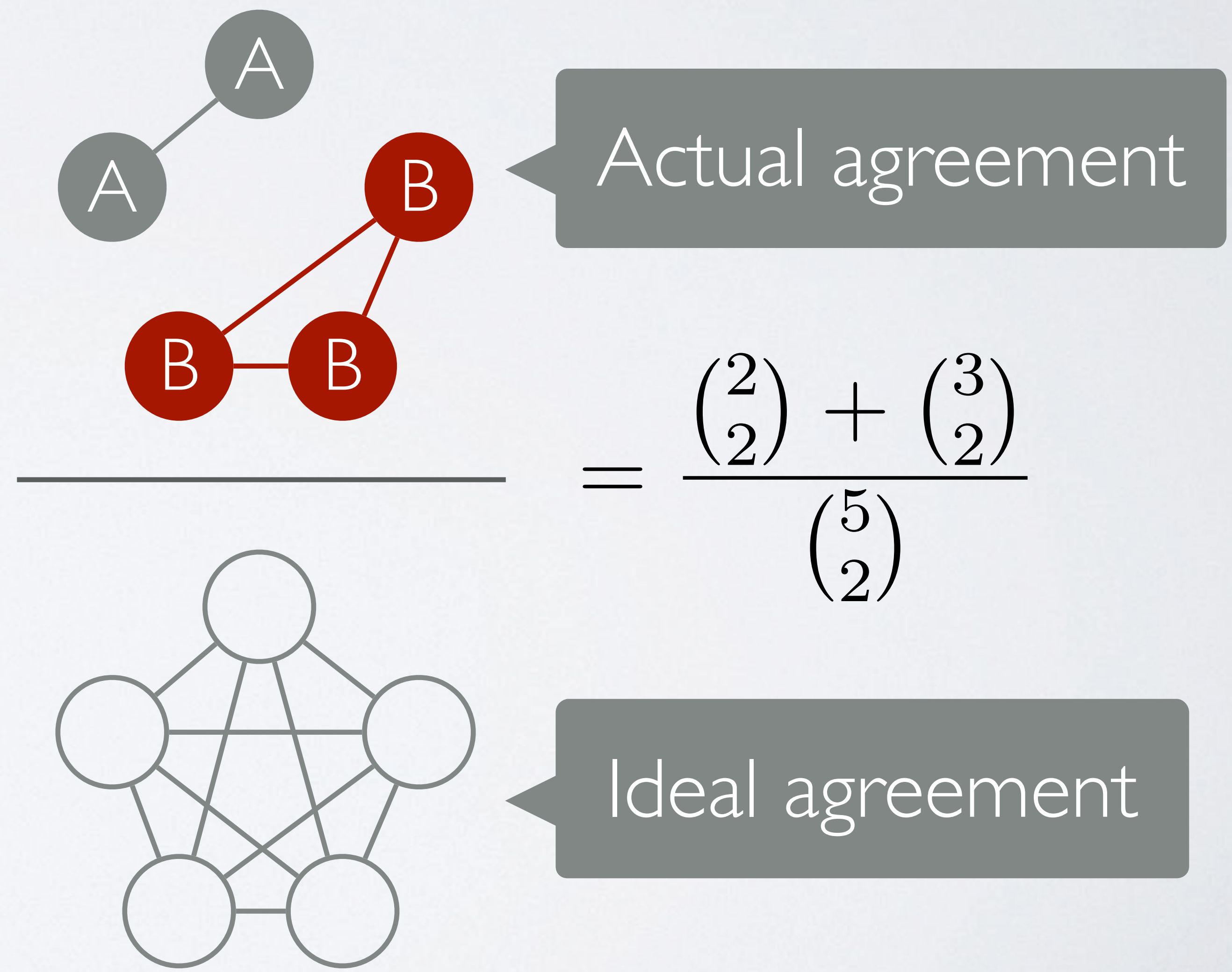
P_i are subsets of identical proposals from P

(Vatavu et al., CHI '15)

Agreement rate

Example: Responding to one referent, five participants produces two gestures: A, B. Connected pairs represents how two participants performed the same gesture.

$$\mathcal{AR}(r) = \frac{\sum_{P_i \subseteq P} \binom{|P_i|}{2}}{\binom{|P|}{2}} =$$



$$= \frac{\binom{2}{2} + \binom{3}{2}}{\binom{5}{2}}$$

The number of combinations "n choose k": $\binom{n}{k} = \frac{1}{2}n(n-1)$

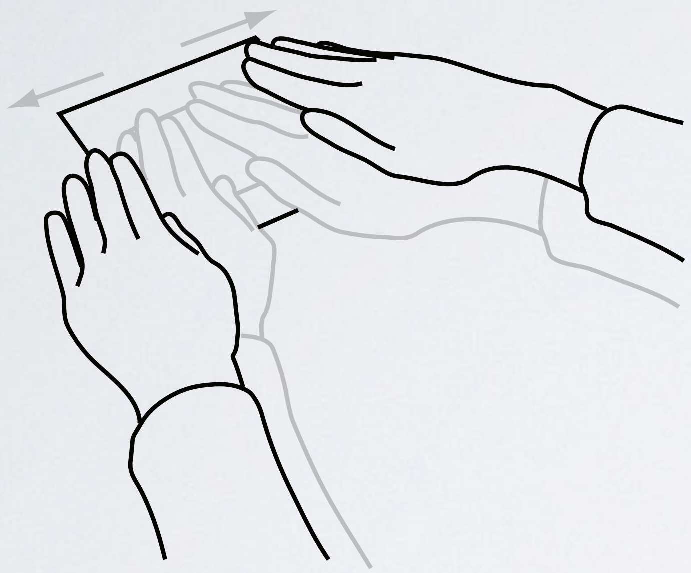
(Vatavu et al., CHI '15)

In-class exercise

$$\mathcal{AR}(r) = \frac{\displaystyle\sum_{P_i \subseteq P} \frac{1}{2}|P_i|\left(|P_i| - 1\right)}{\frac{1}{2}|P|\left(|P| - 1\right)}$$

Calculate agreement rate from the result of a gesture elicitation below

Referent: “Enlarge”   20 participants



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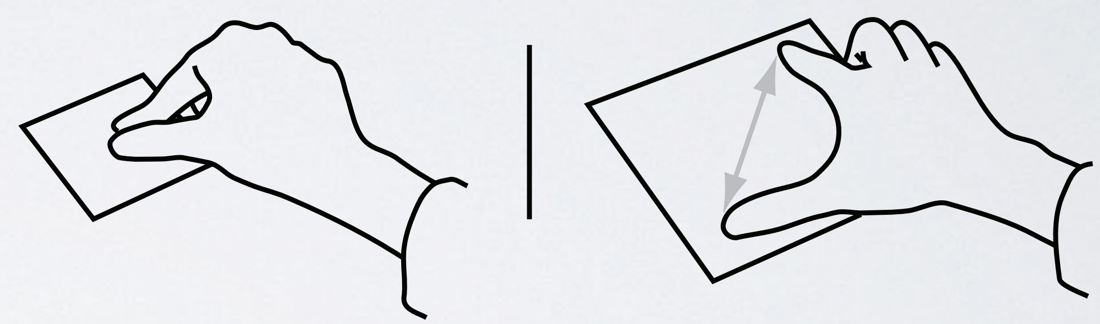

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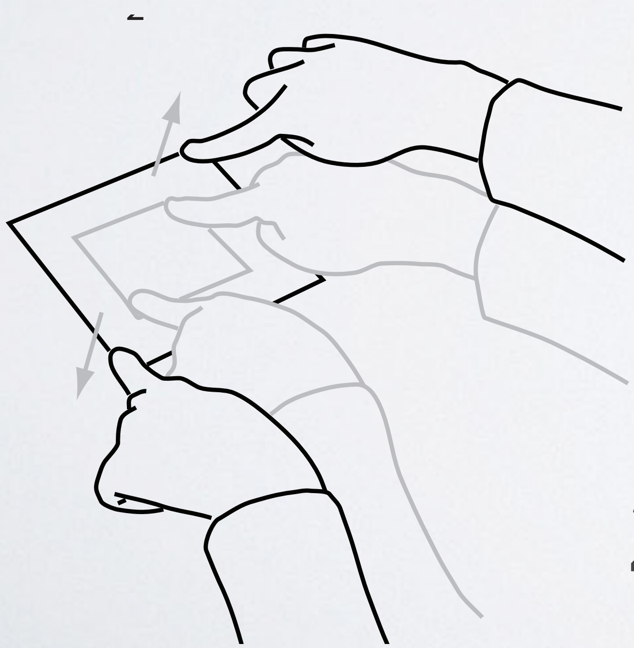

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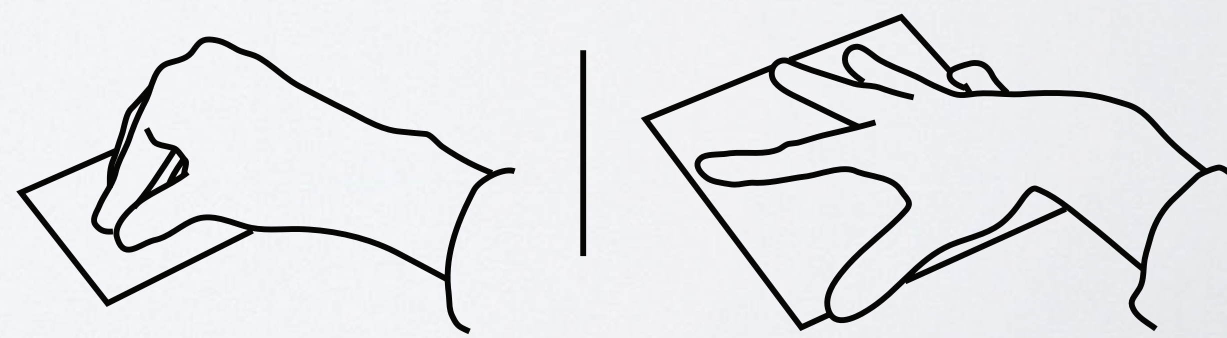

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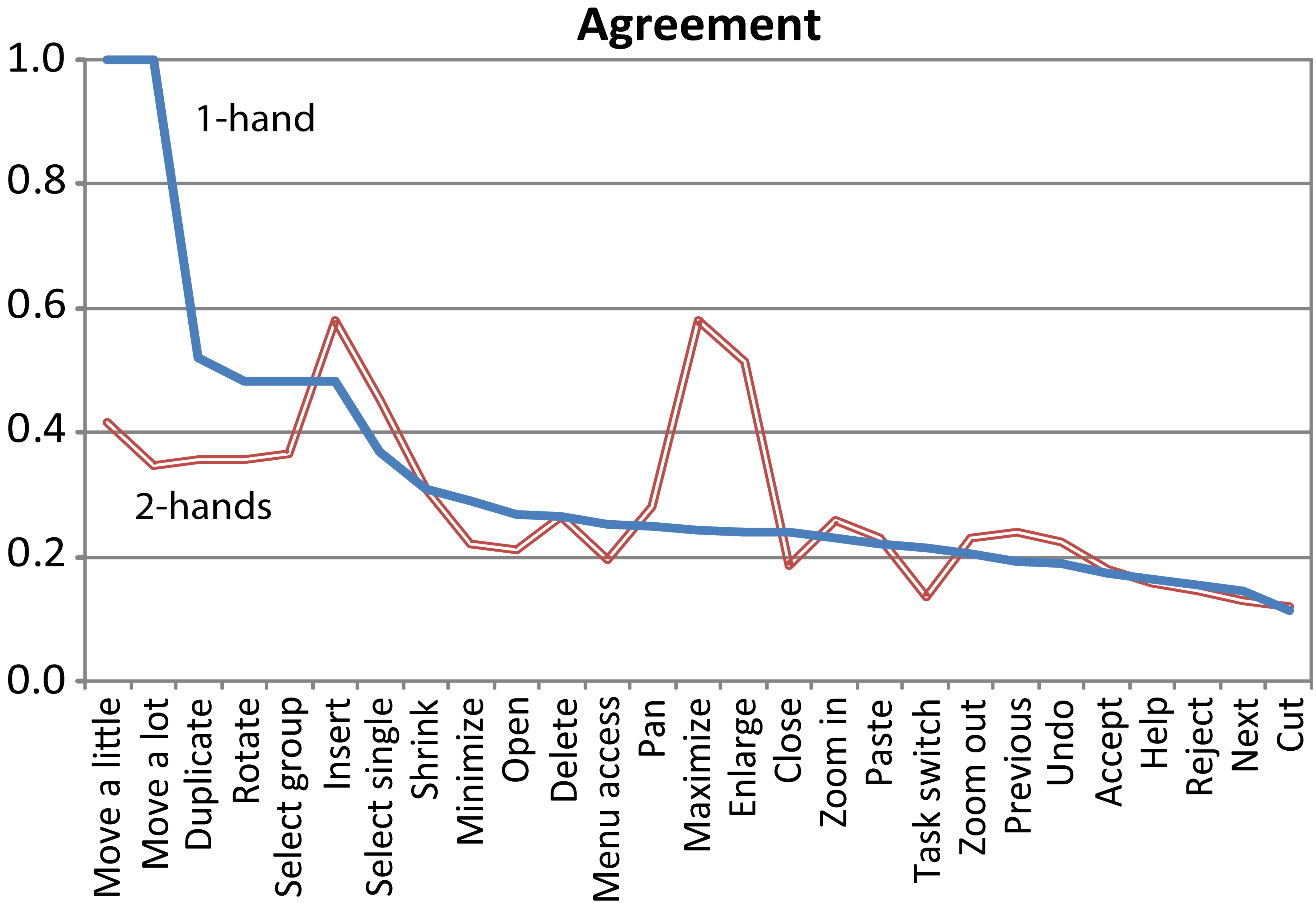


Graph: (Wobbrock et al., CHI '09)

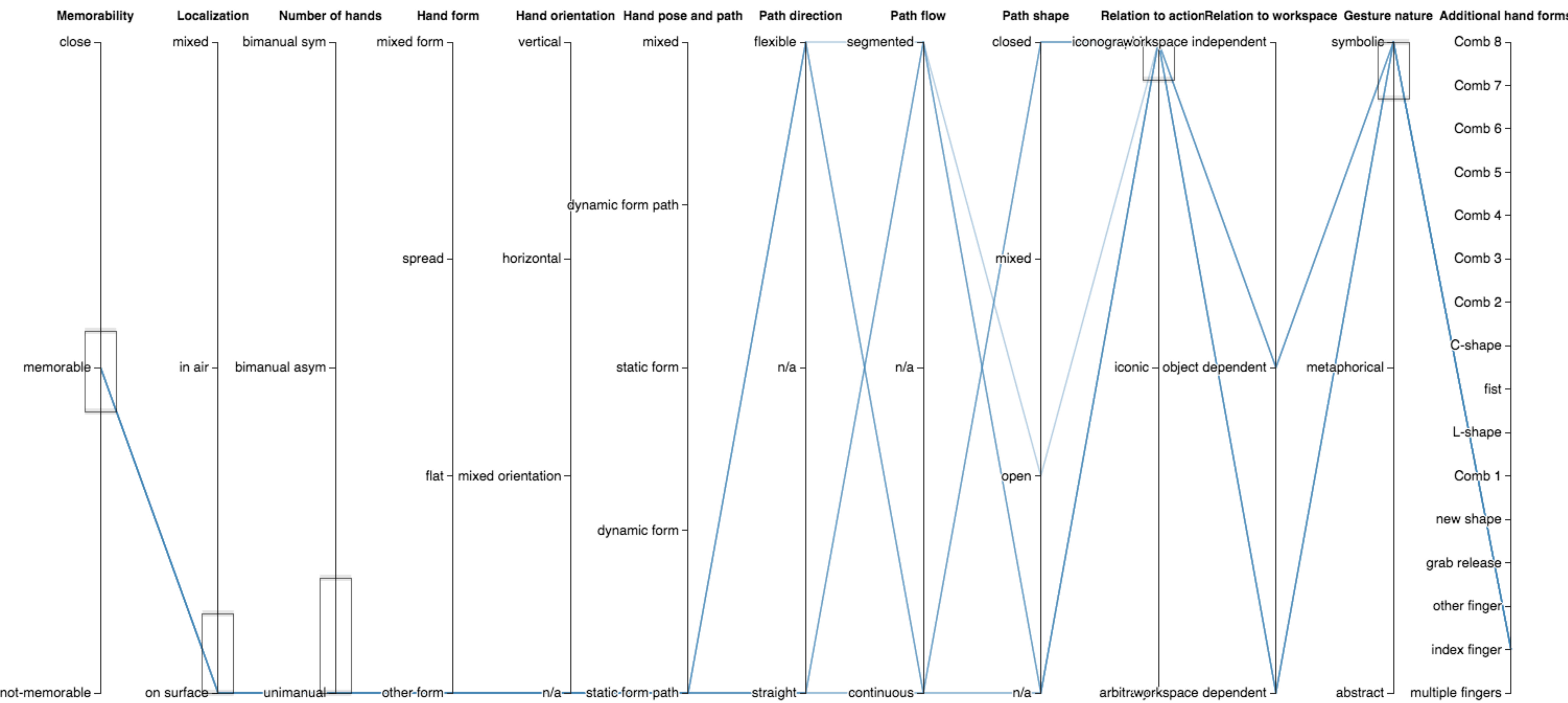
Agreement rating can be used to decide action sets for gestures

Taxonomies of gestures

- Classifications of gestures according to defined **dimensions**
- Allows designers to
  - Compare gestures
  - Explore design alternatives
  - Analyze common properties
  - Describe gestural system capabilities
- Multiple taxonomies exist for different purposes
- Also known as **design space** (see: DIS2)

A taxonomy of hands-to-arm gesture

http://udigesturesdataset.cs.st-andrews.ac.uk/



(Grijincu, ITS '14)

Comparing gestures

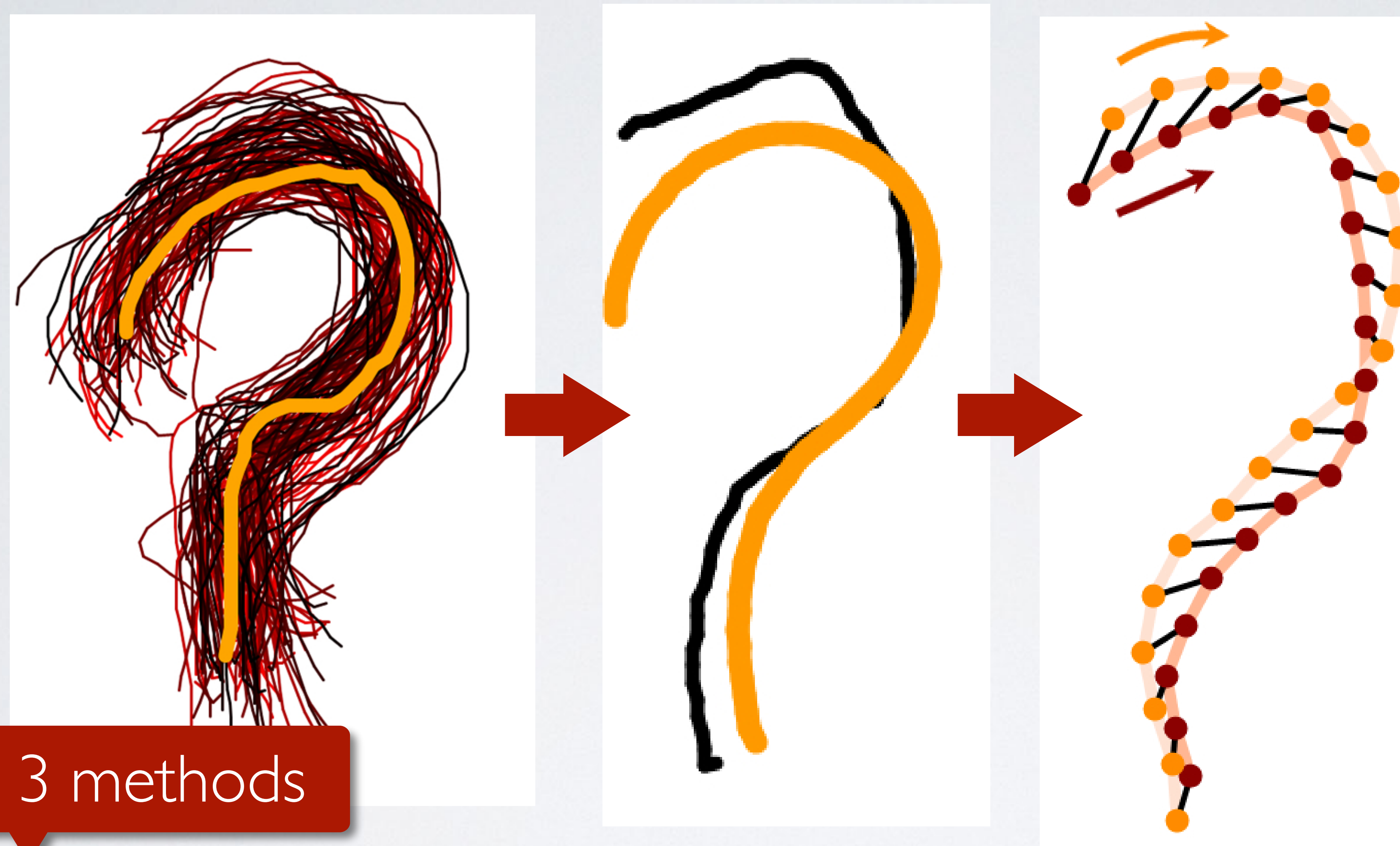
Dependent variable

- Global measures
  - Total path length
  - Articulation time
- Relative accuracy measures: compare gesture articulation with task axis as it unfolds

(Vatavu et al., ICMI '13)

Relative accuracy measures

Reading assignment



3 methods

Compute task axis from dataset

User Input (black)

Align

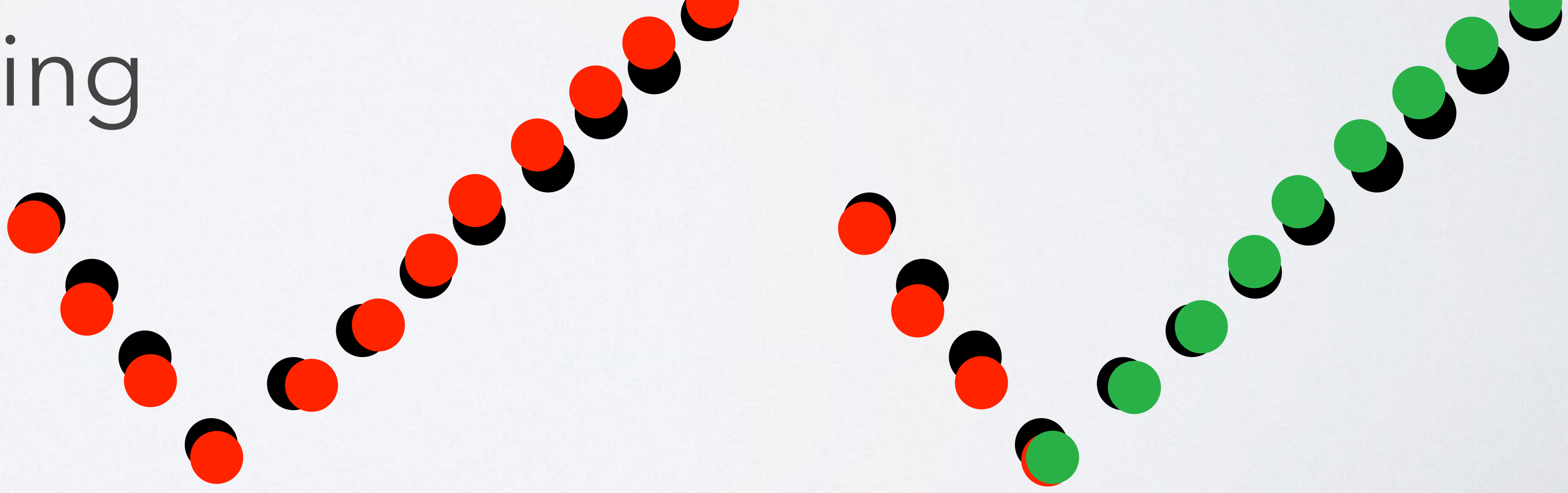
Three types of accuracy measures

Calculate

(Vatavu et al., ICMI '13)

Relative accuracy measures

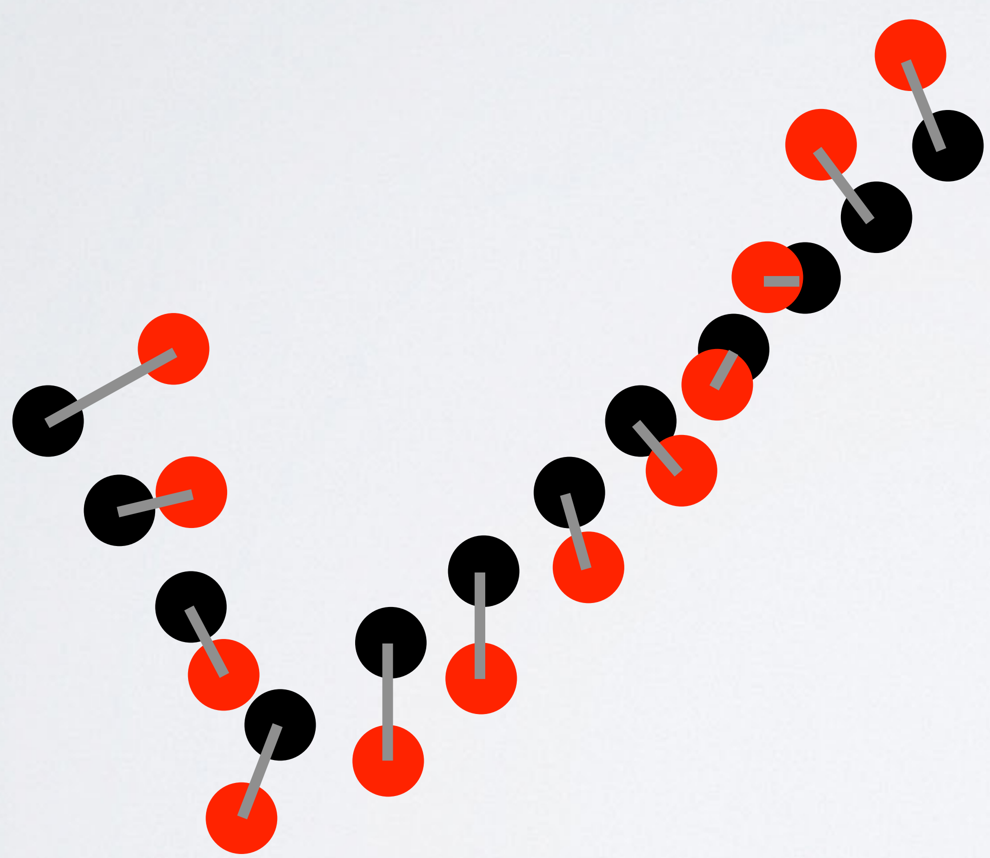
- **Geometric accuracy:** shape, size, and bending
- **Kinematic accuracy:** time (how fluent)
- **Articulation accuracy:** consistency
    - Stroke count
    - Stroke ordering



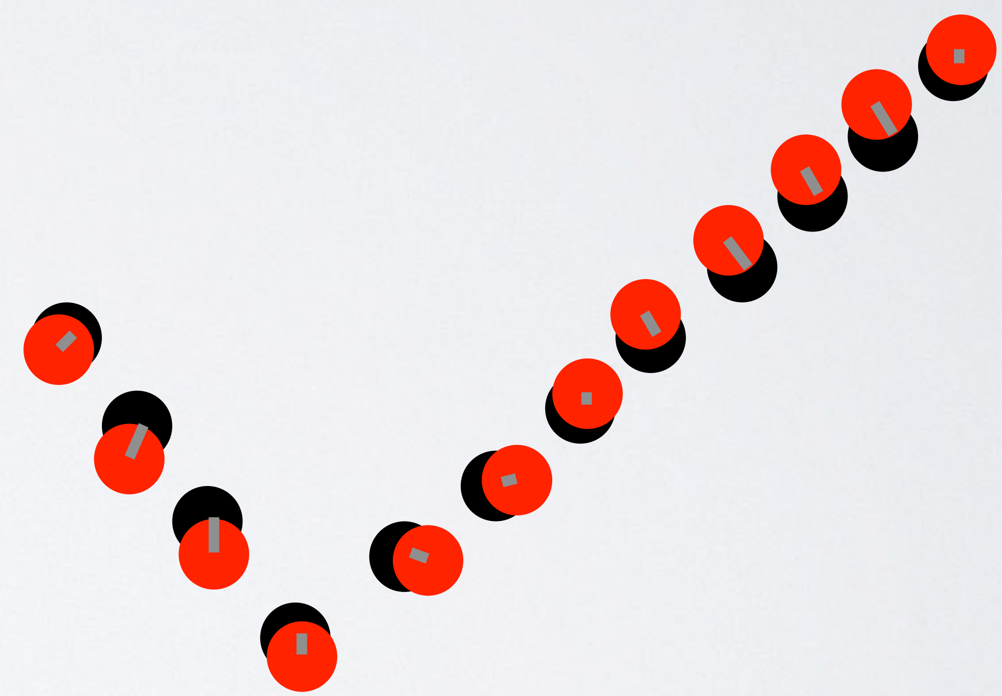
(Vatavu et al., ICMI '13)

Geometric accuracy: shape error

$$\frac{1}{n}\sum_{i=1}^{n}\left\|p_{\sigma(i)} - \overline{p}_i\right\|$$



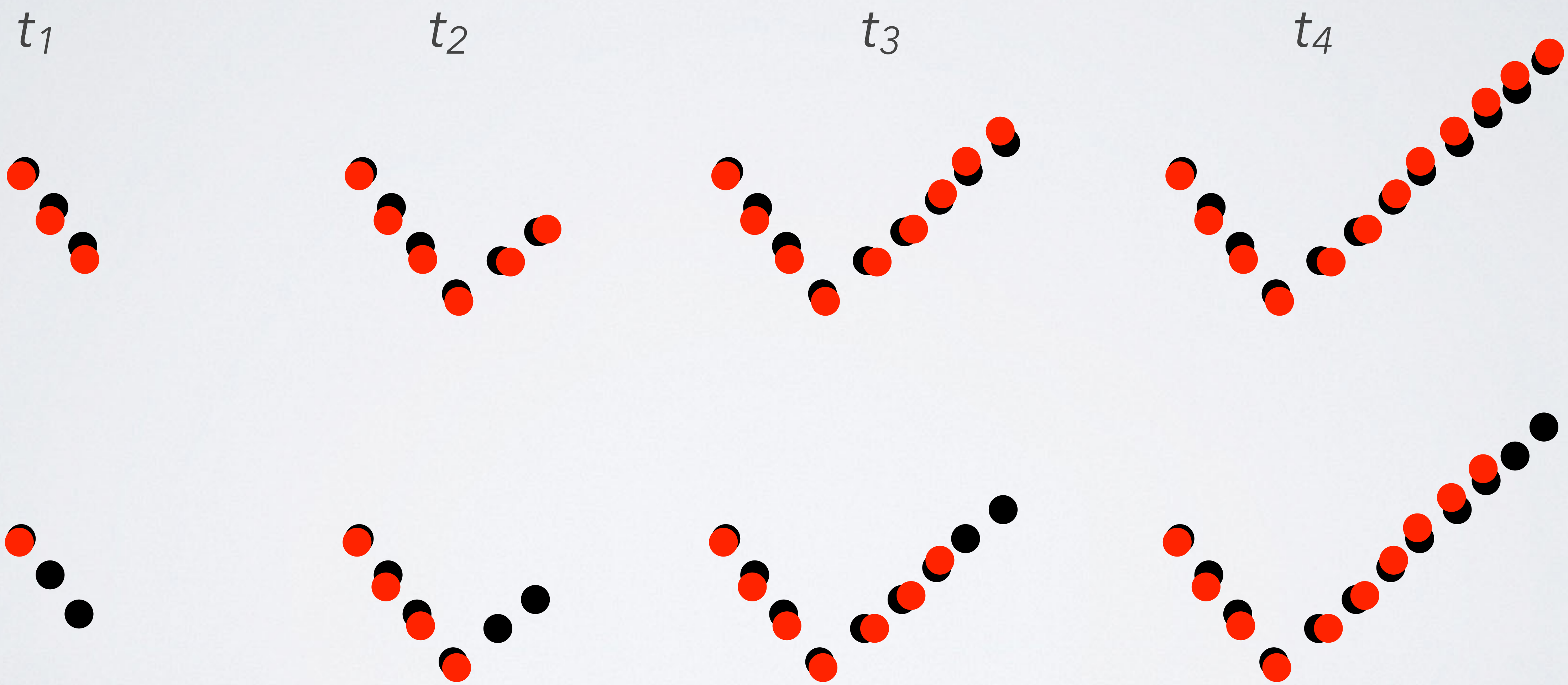
Higher shape error



(Vatavu et al., ICMI ’13)

Kinematic accuracy: time error

$$|\mathcal{T}(p) - \mathcal{T}(\overline{p})|$$



Higher time error

(Vatavu et al., ICMI '13)

Gesture guidance and feedback

- **Feedforward:** provide information before execution or completion
    - Gesture's shape
    - Associating command
- **Feedback:** provide low-level information about the recognition process
- Can be combined

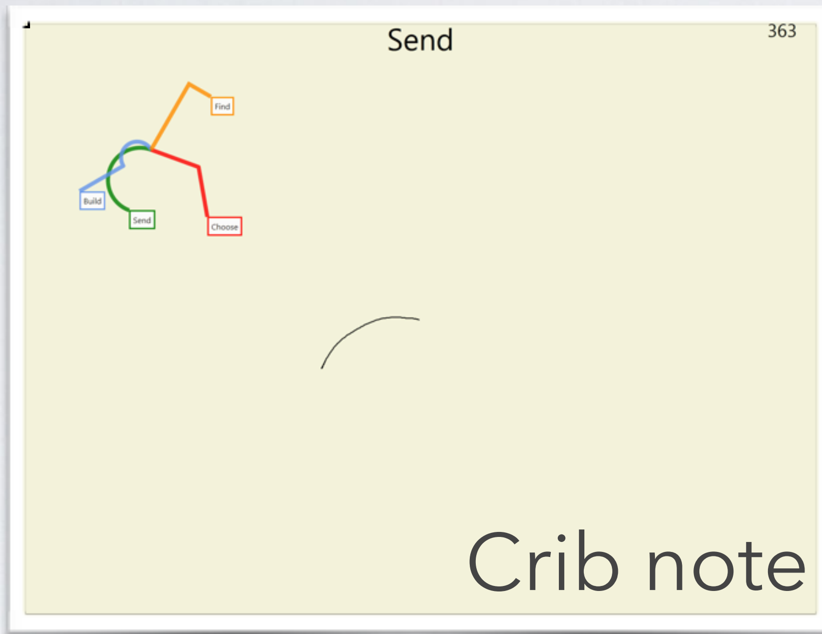
(Bau & Mackay, UIST '08)

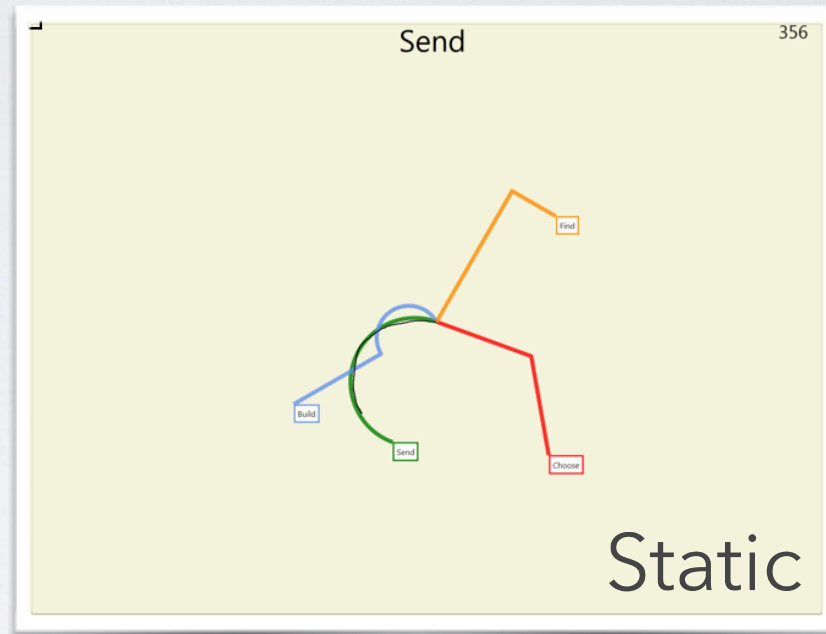
OctoPocus: feedforward and feedback for stroke gestures

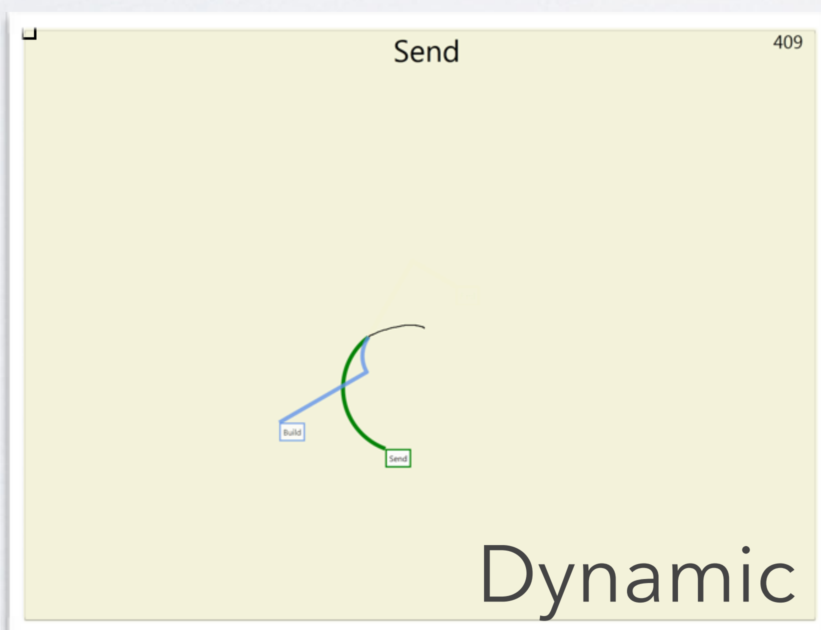
(Bau & Mackay, UIST '08)

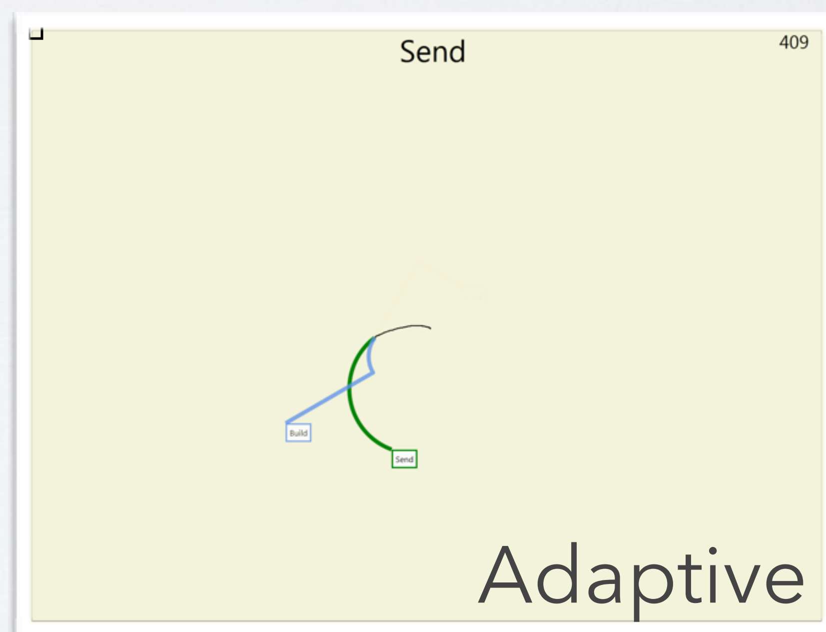
How do gesture guides influence learning and user performance?

Methodology & Interpretation



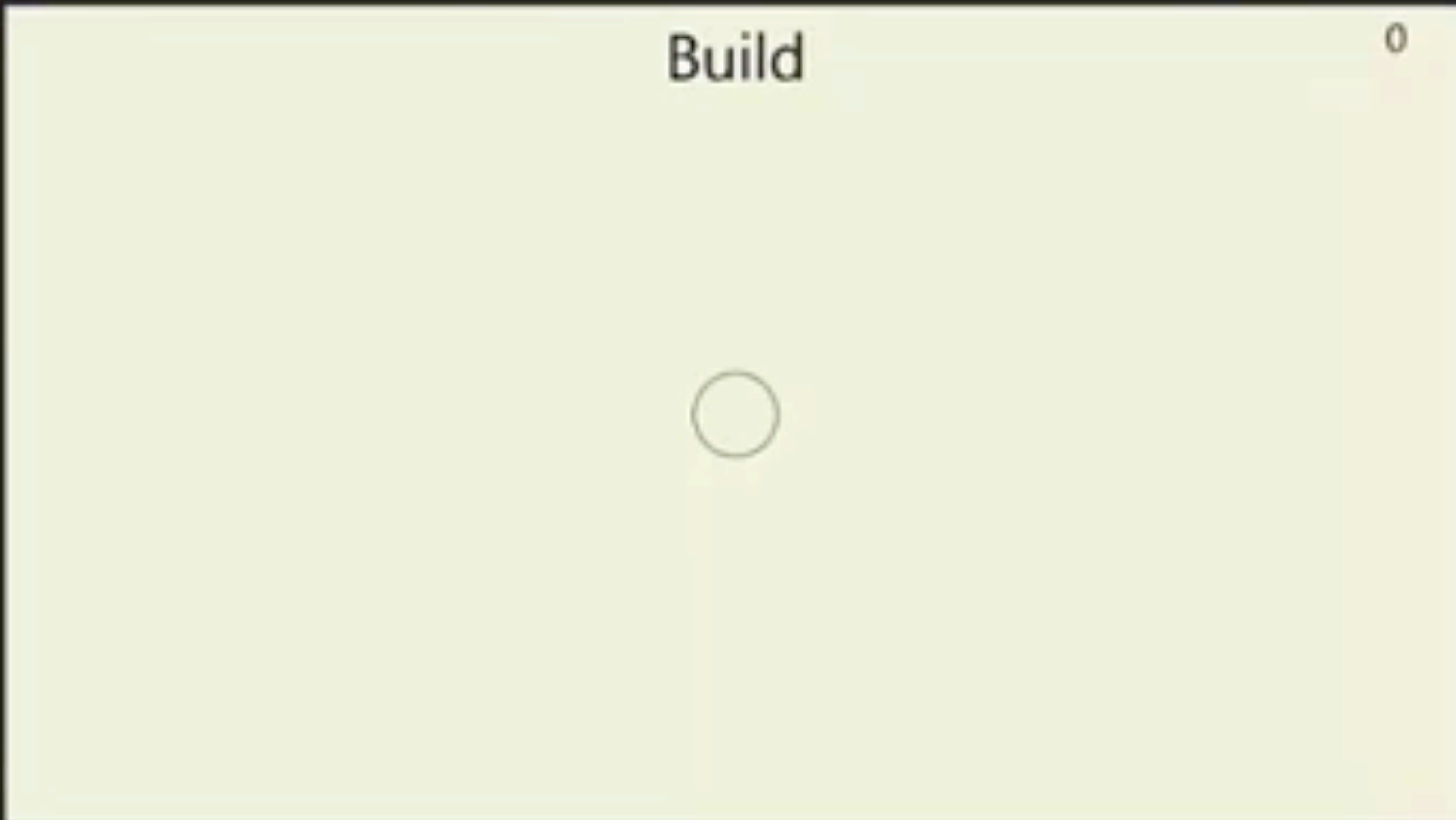






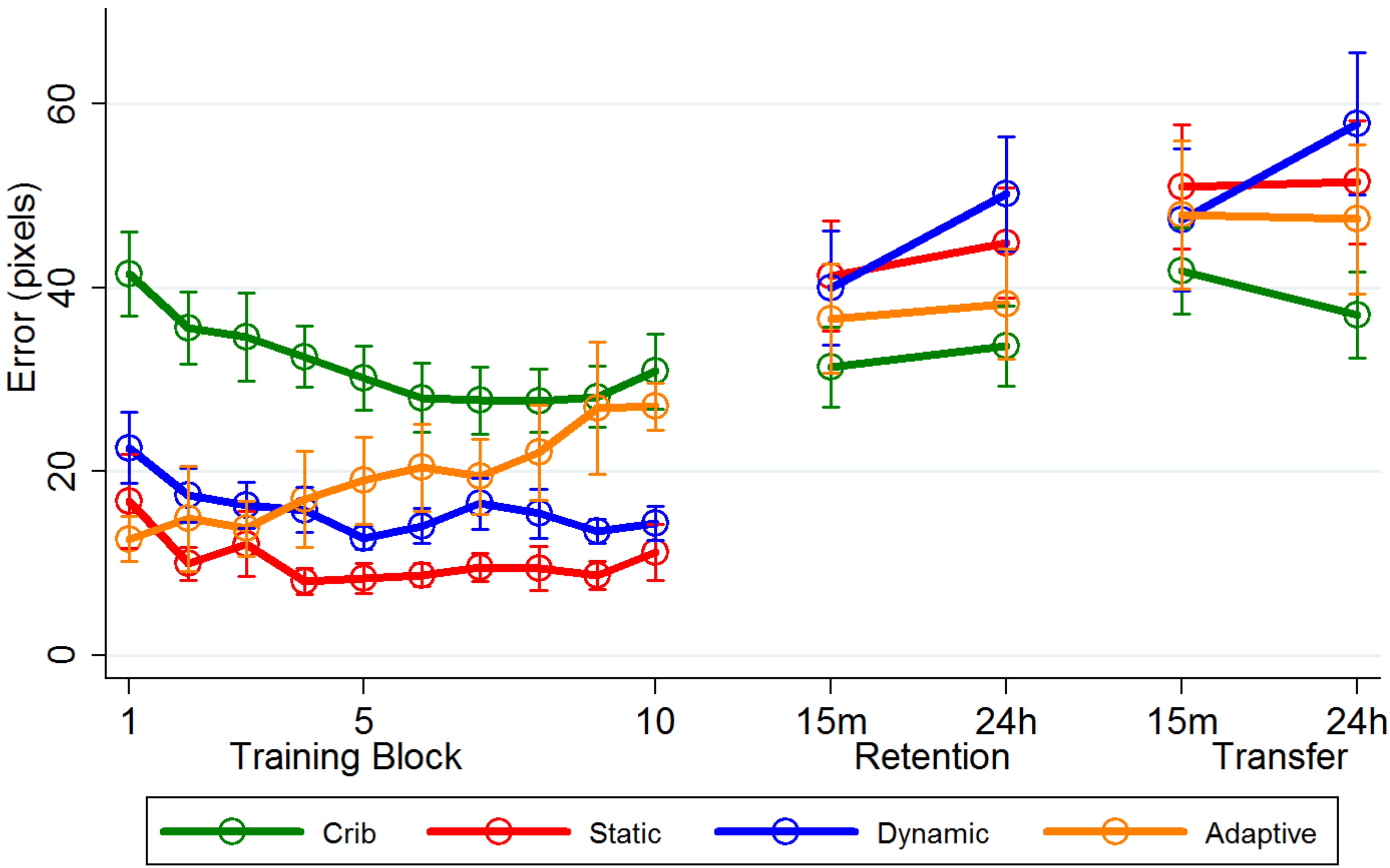
(like OctoPocus) (static guide, removed partway through)

(Anderson & Bischoff, CHI '13)

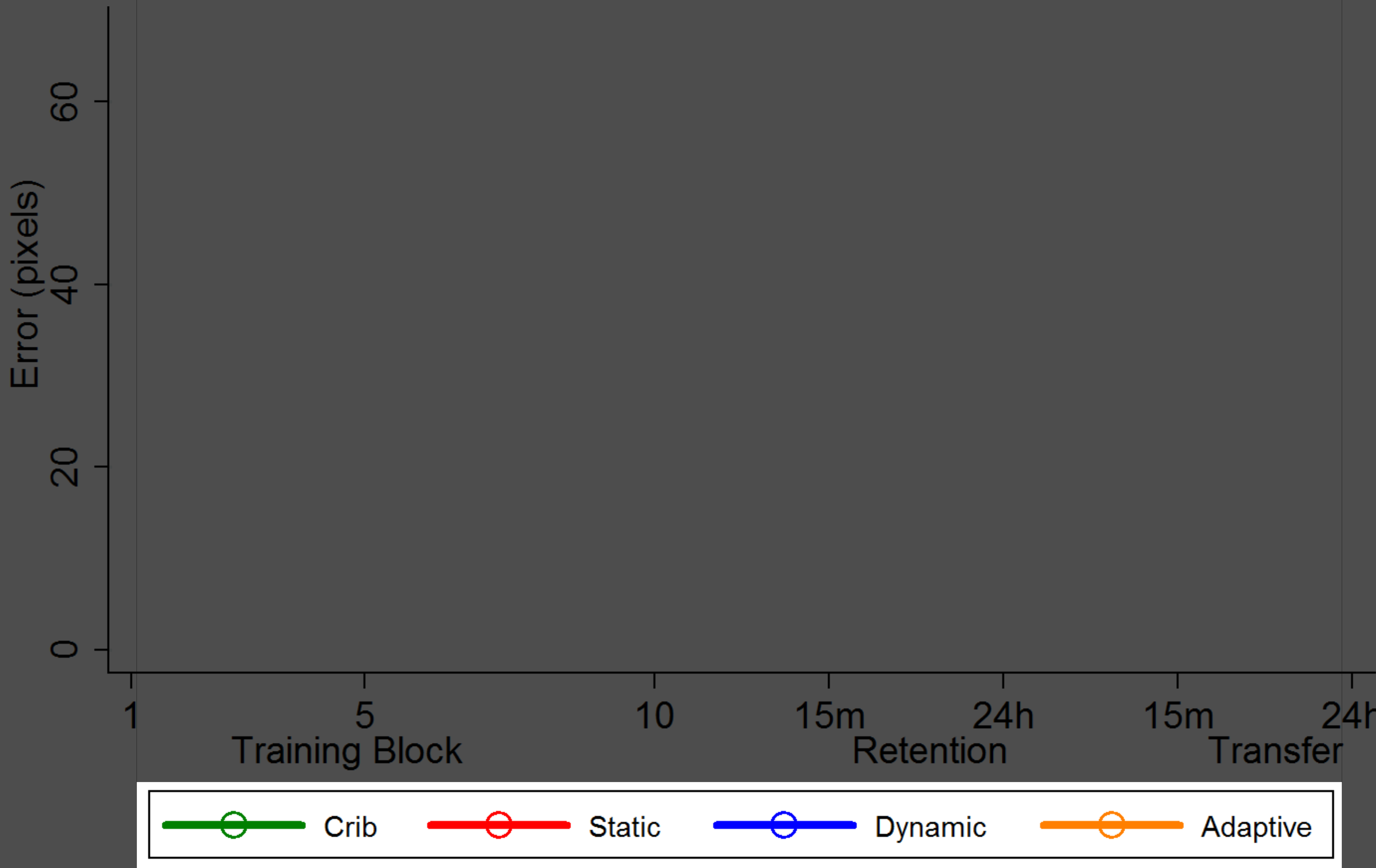


Adaptive feedback: static guide, removed partway through

(Anderson & Bischoff, CHI '13)



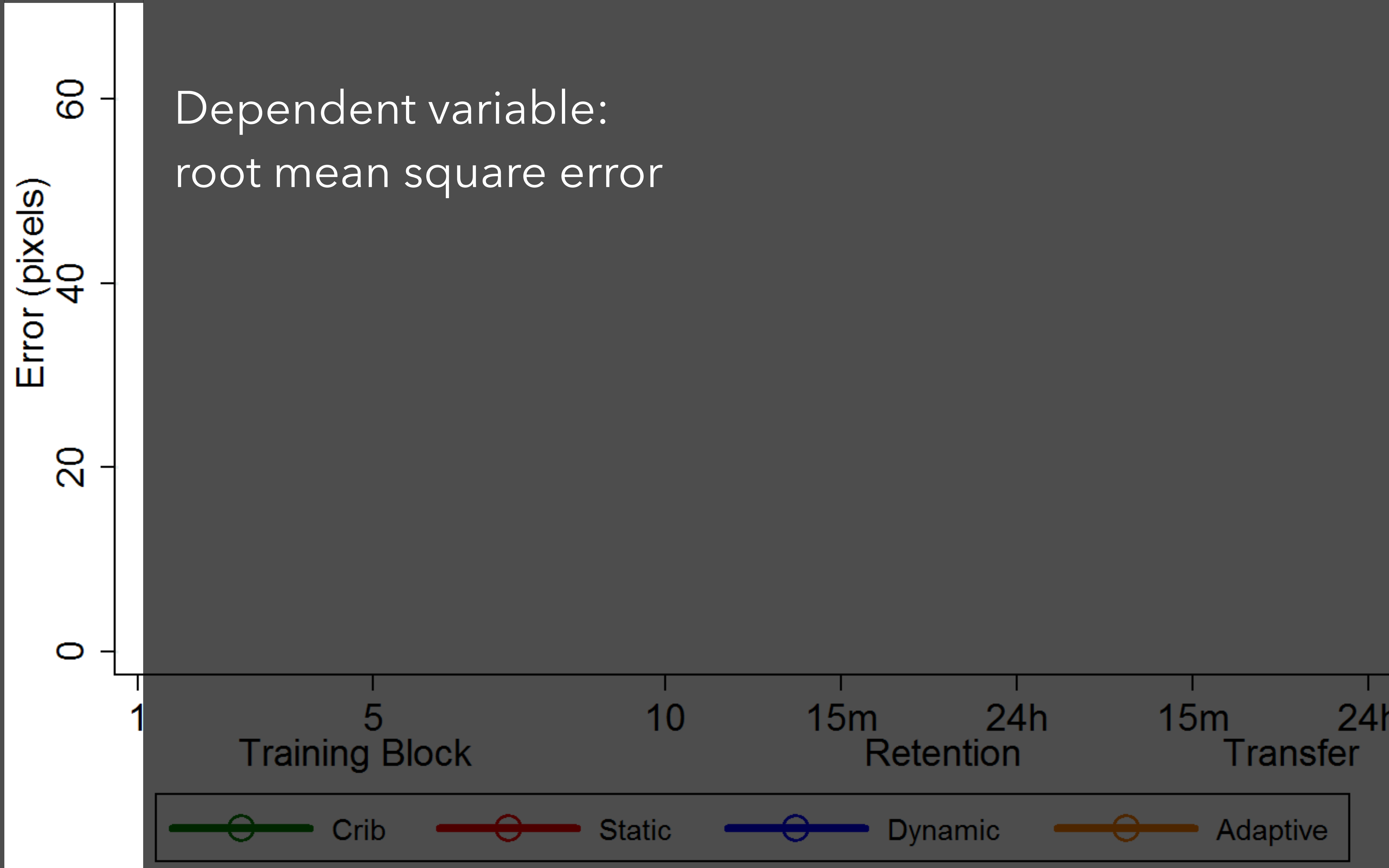
(Anderson & Bischoff, CHI ’13)



Independent variable: feedback type (between-subjects)

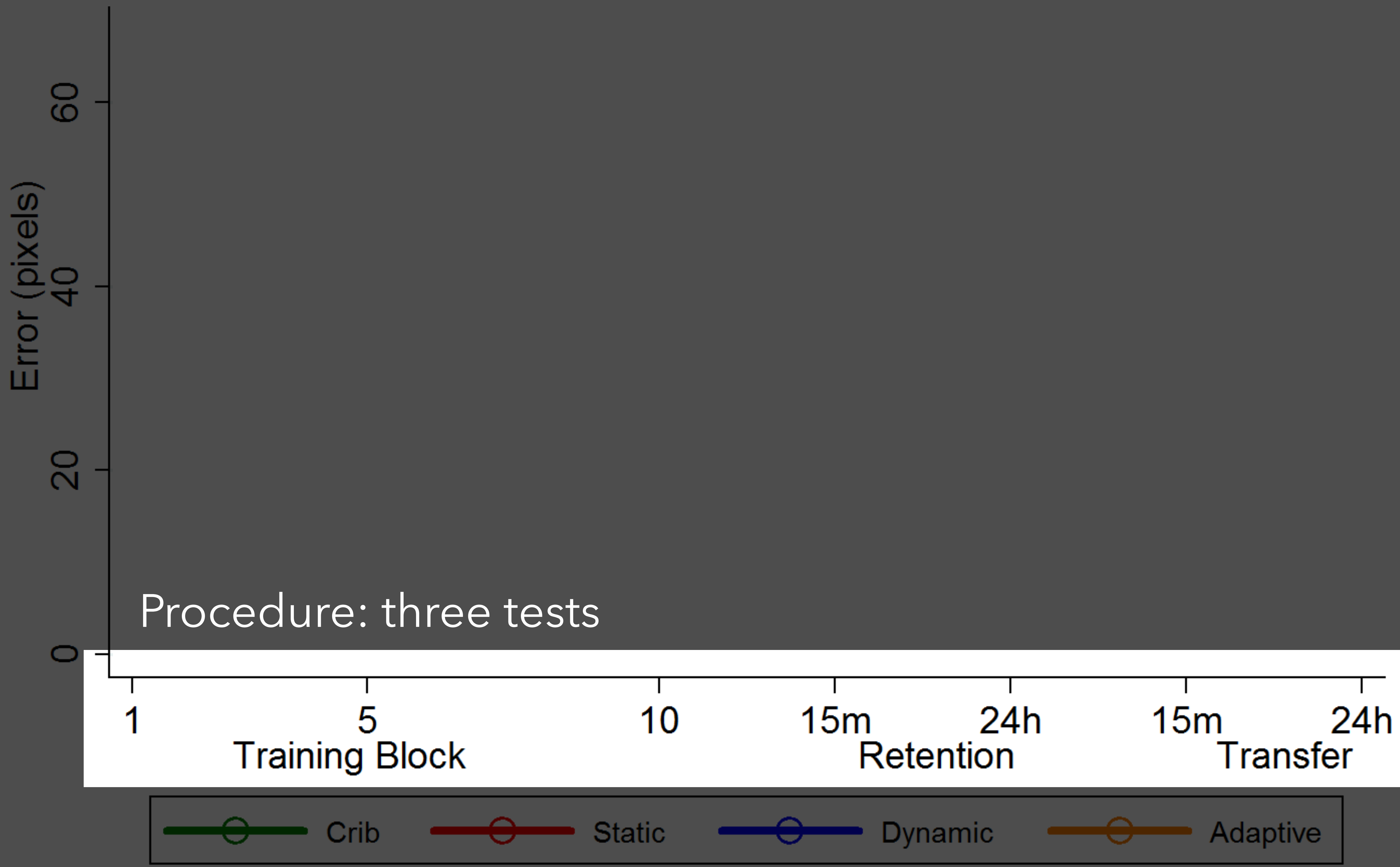
(Anderson & Bischoff, CHI '13)

Dependent variable:
root mean square error

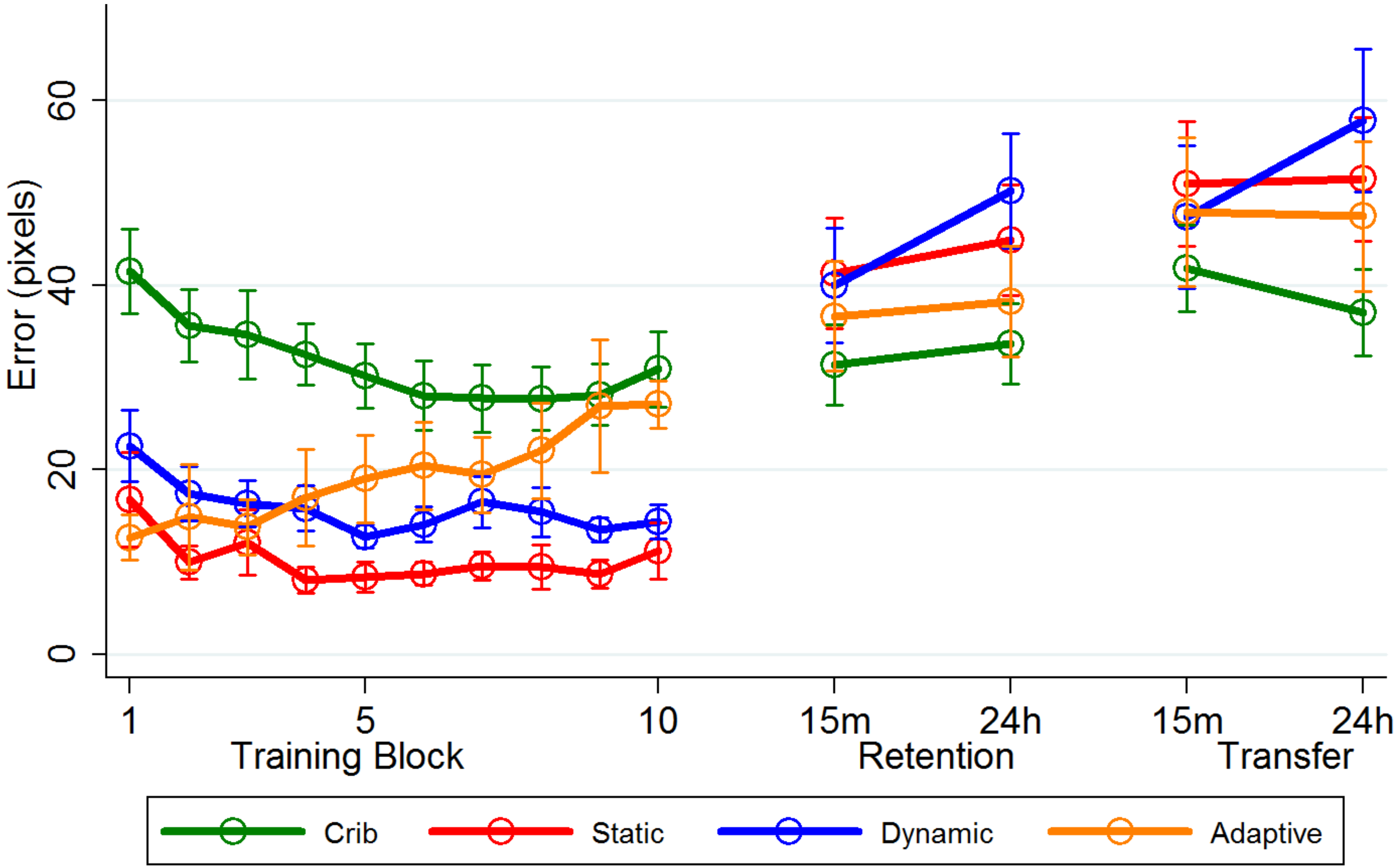


(Anderson & Bischoff, CHI ’13)

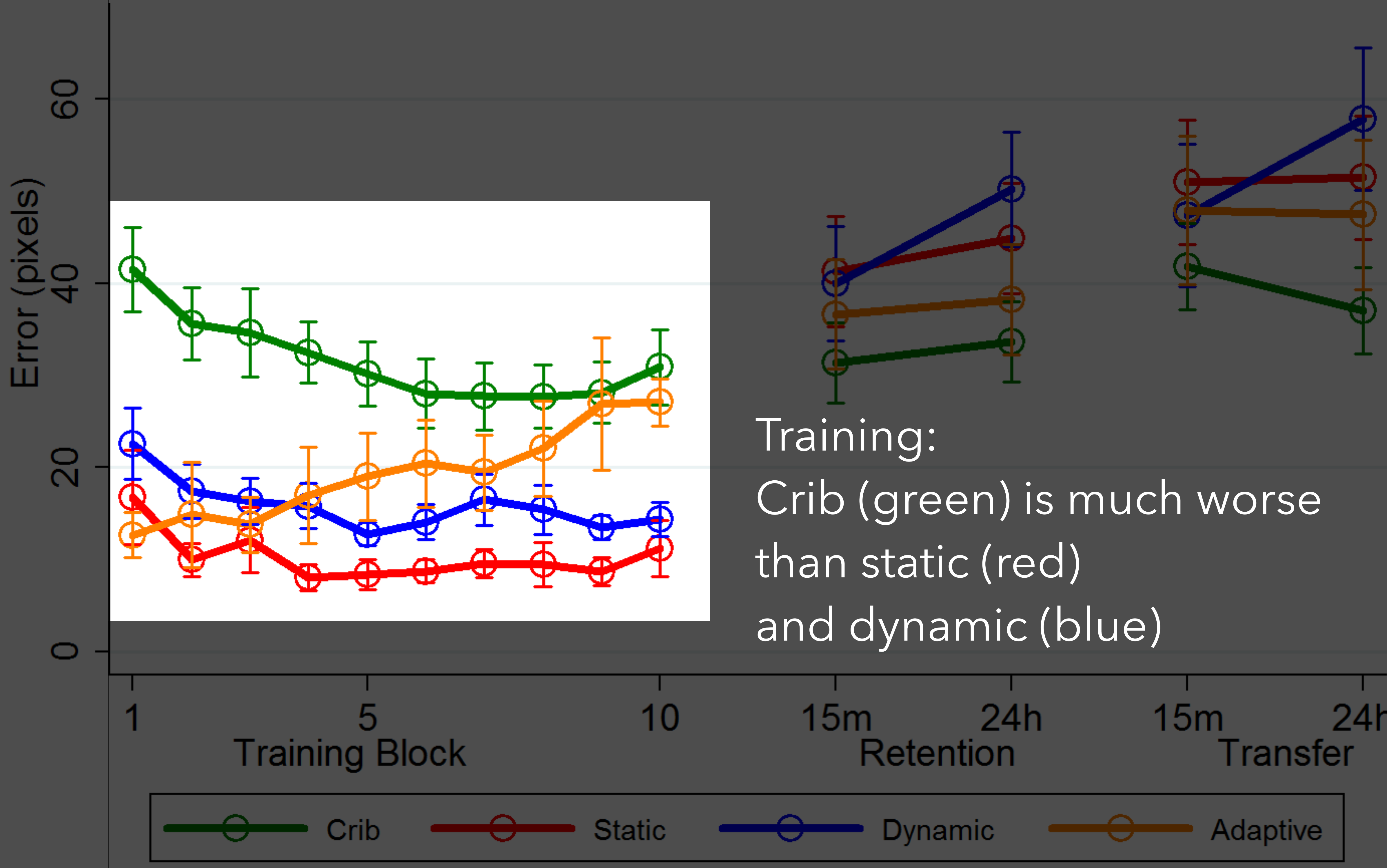
Procedure: three tests



(Anderson & Bischoff, CHI '13)

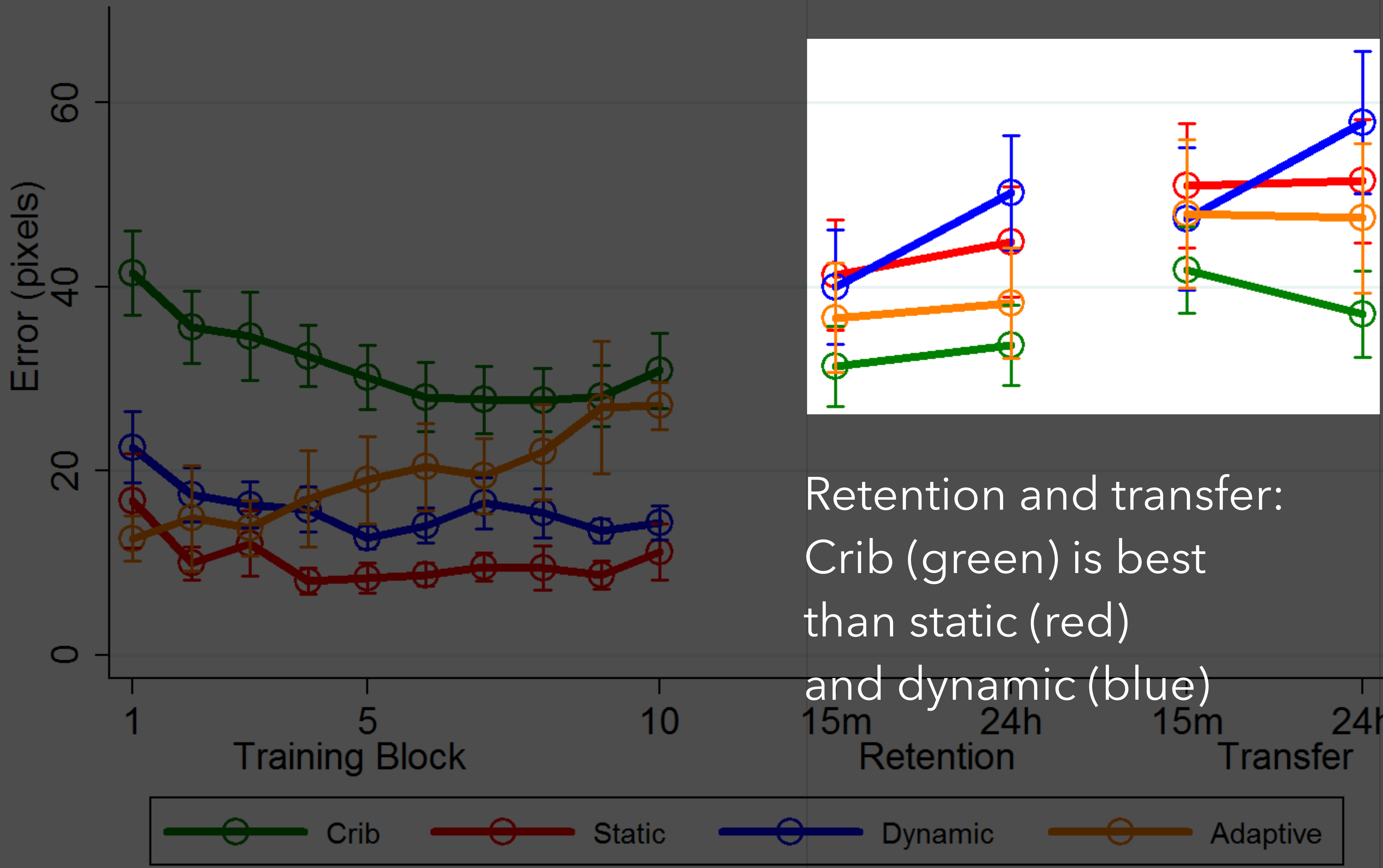


(Anderson & Bischoff, CHI '13)



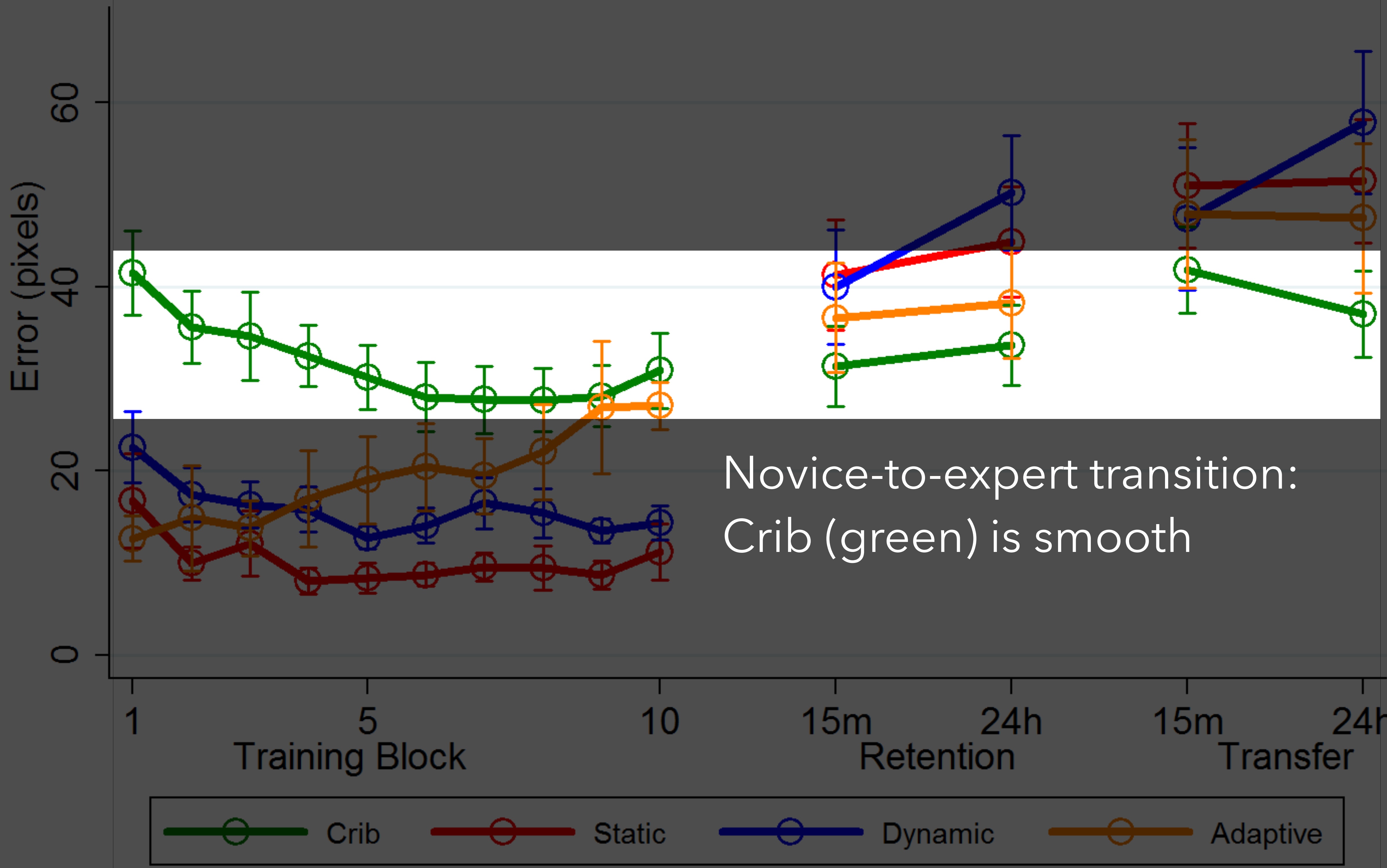
Training:
Crib (green) is much worse than static (red) and dynamic (blue)

(Anderson & Bischoff, CHI '13)



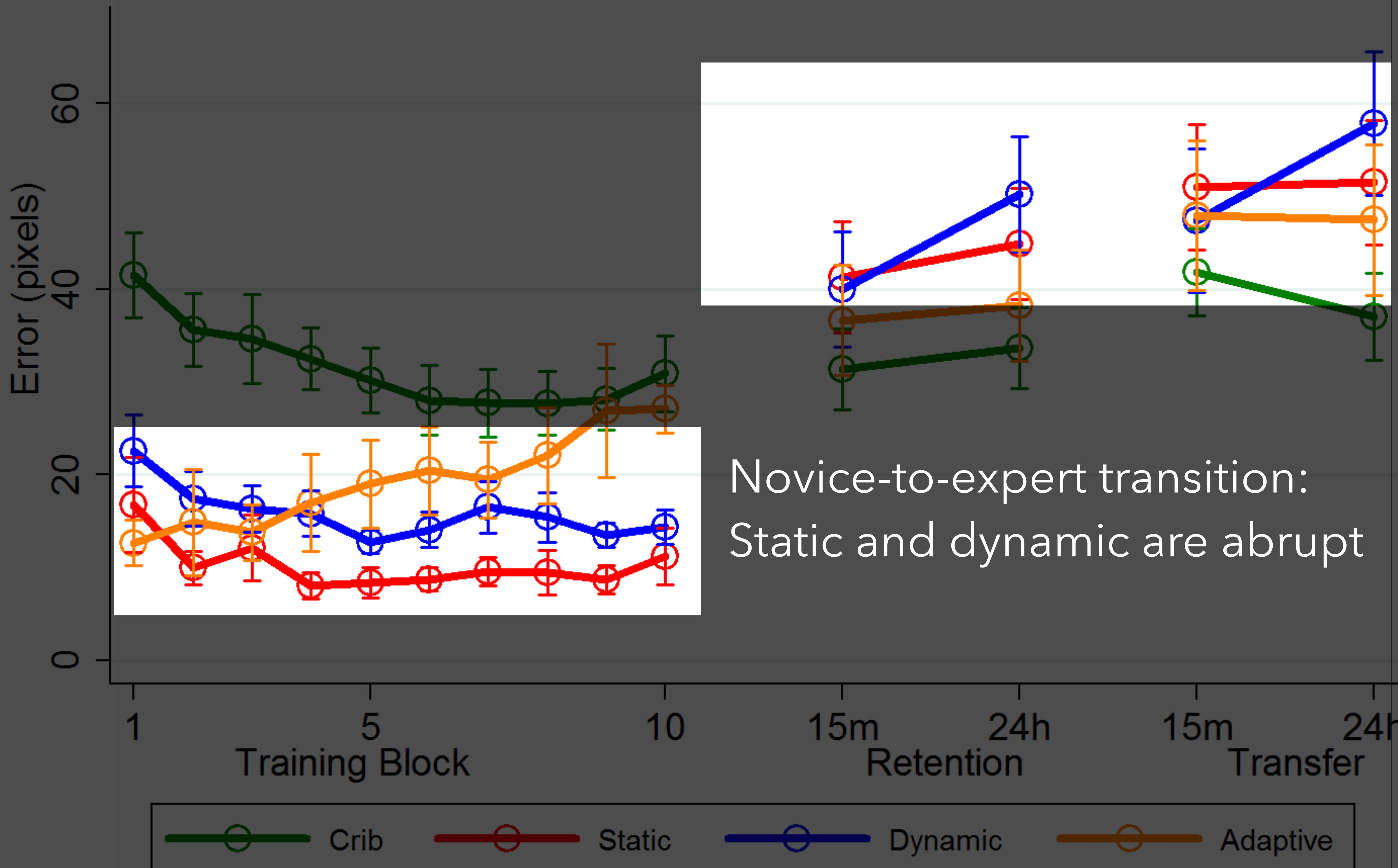
Retention and transfer: Crib (green) is best than static (red) and dynamic (blue)

(Anderson & Bischoff, CHI '13)



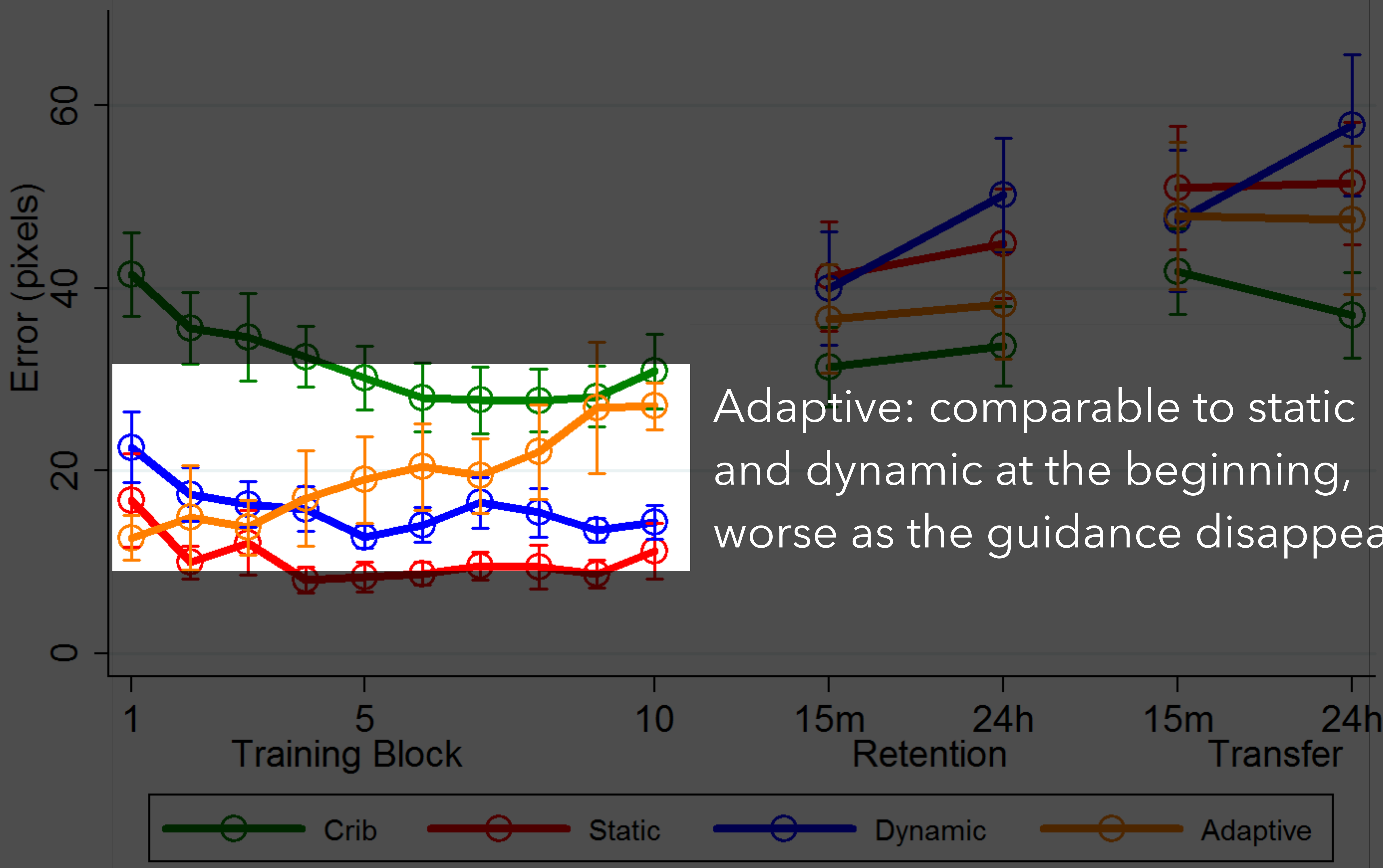
Novice-to-expert transition:
Crib (green) is smooth

(Anderson & Bischoff, CHI '13)



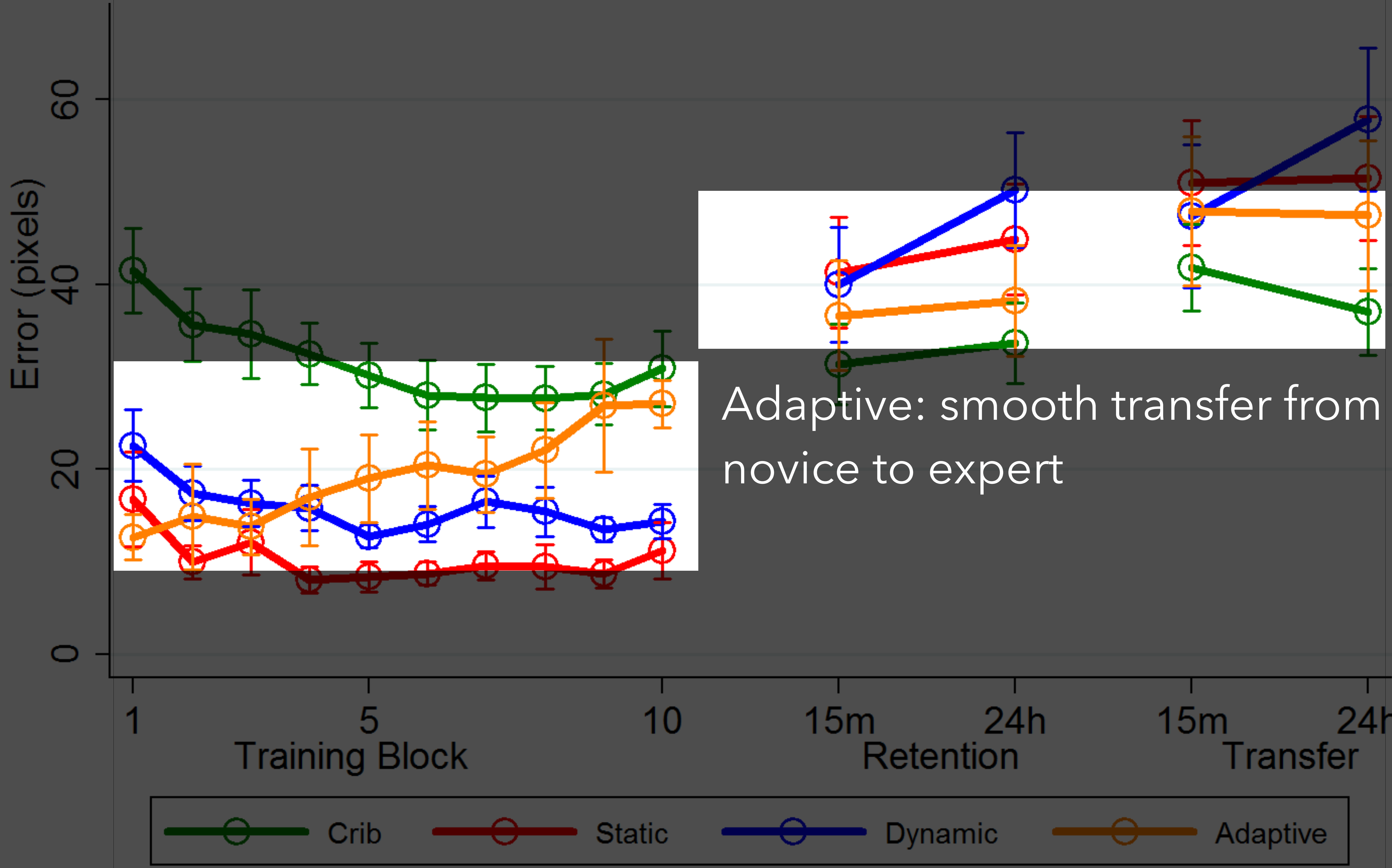
Novice-to-expert transition:
Static and dynamic are abrupt

(Anderson & Bischoff, CHI '13)

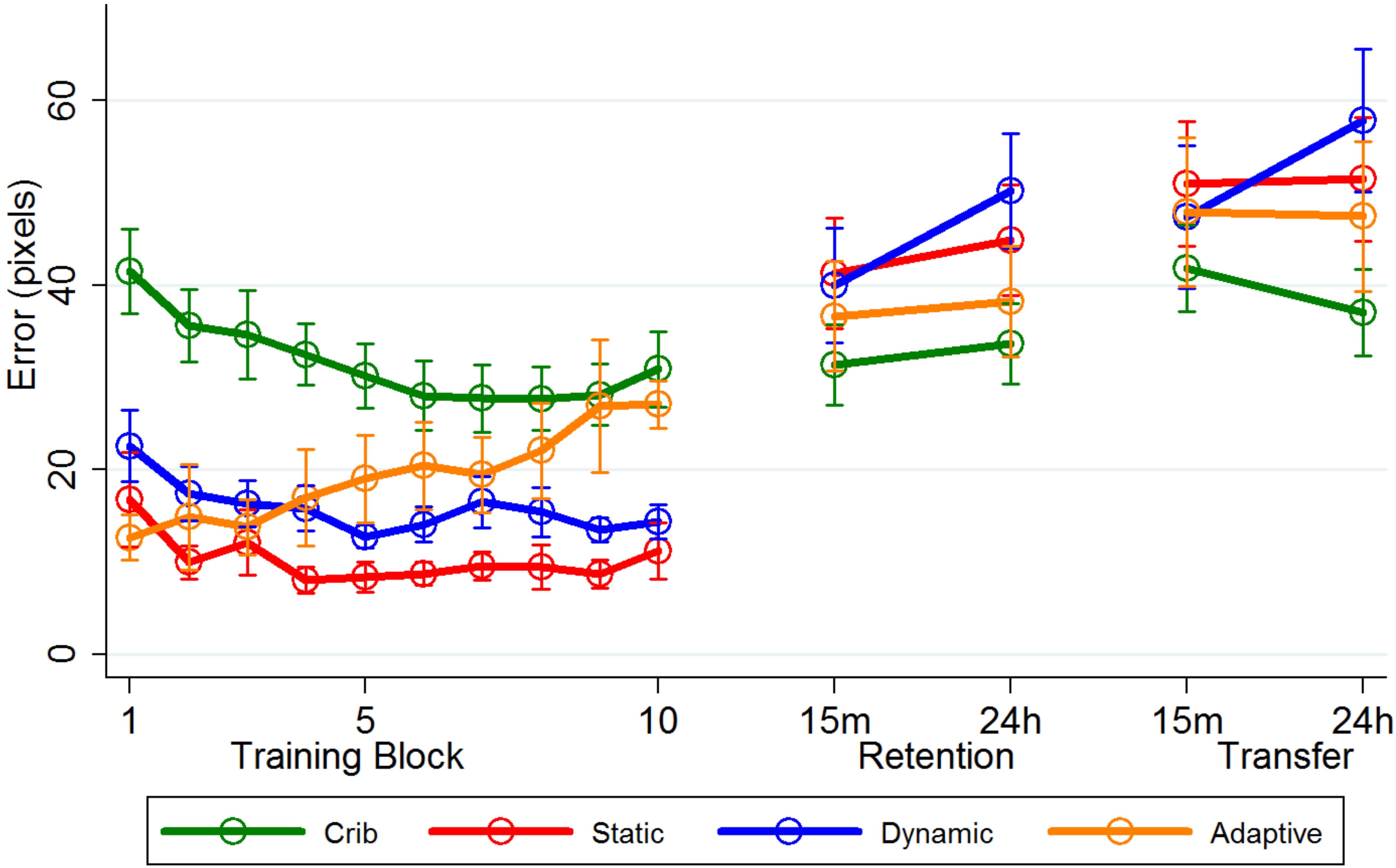


Adaptive: comparable to static and dynamic at the beginning, worse as the guidance disappears

(Anderson & Bischoff, CHI '13)



(Anderson & Bischoff, CHI '13)



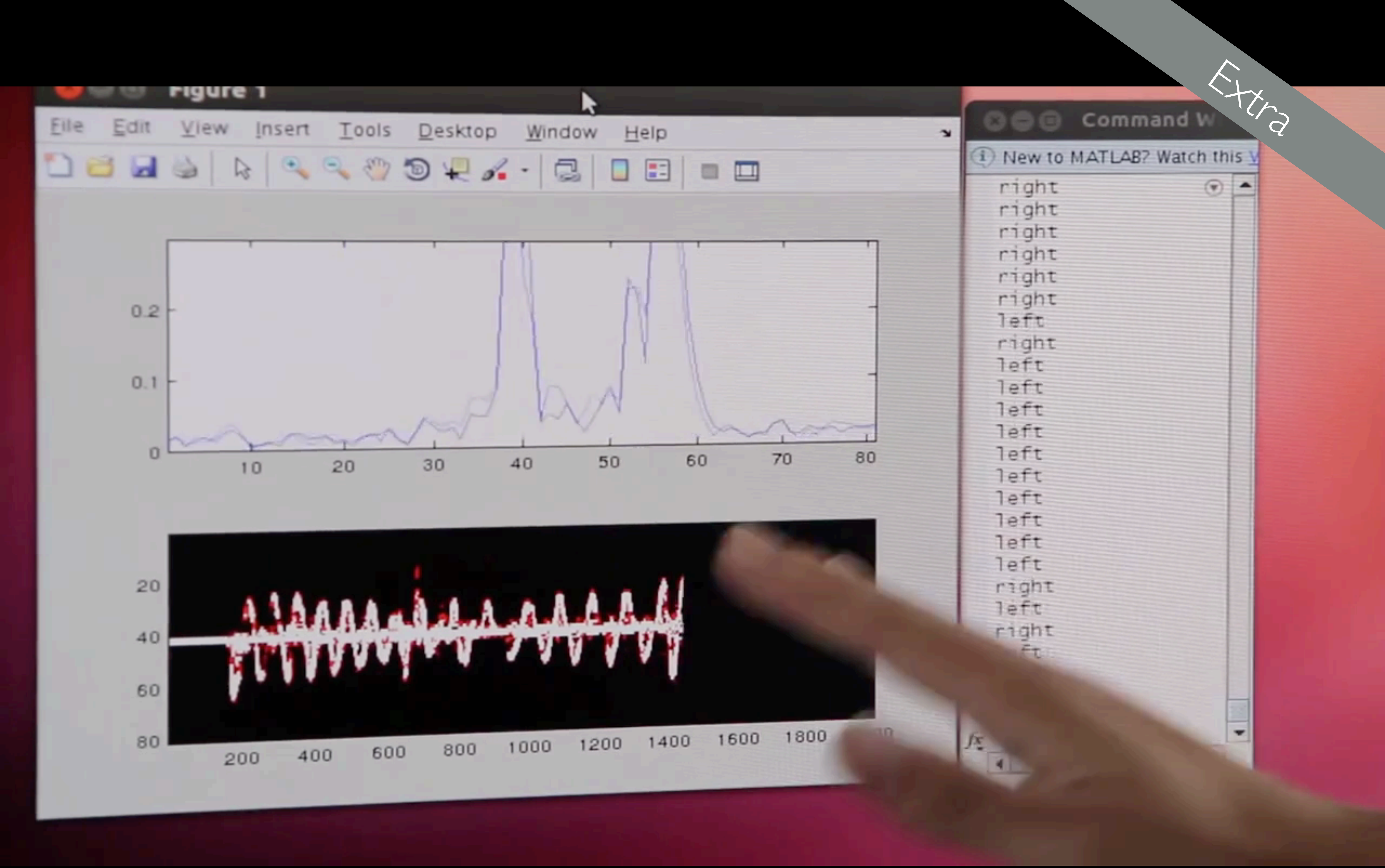
(Anderson & Bischoff, CHI '13)

Sensors

Extra

Not covered in the lecture
= Not in the exam

- Data sources:
  - Accelerometer & gyroscope
  - Vision
  - Muscle
  - Touch screen
- Data types:
  - Time series
  - Point coordinates



Video: http://wisee.cs.washington.edu/

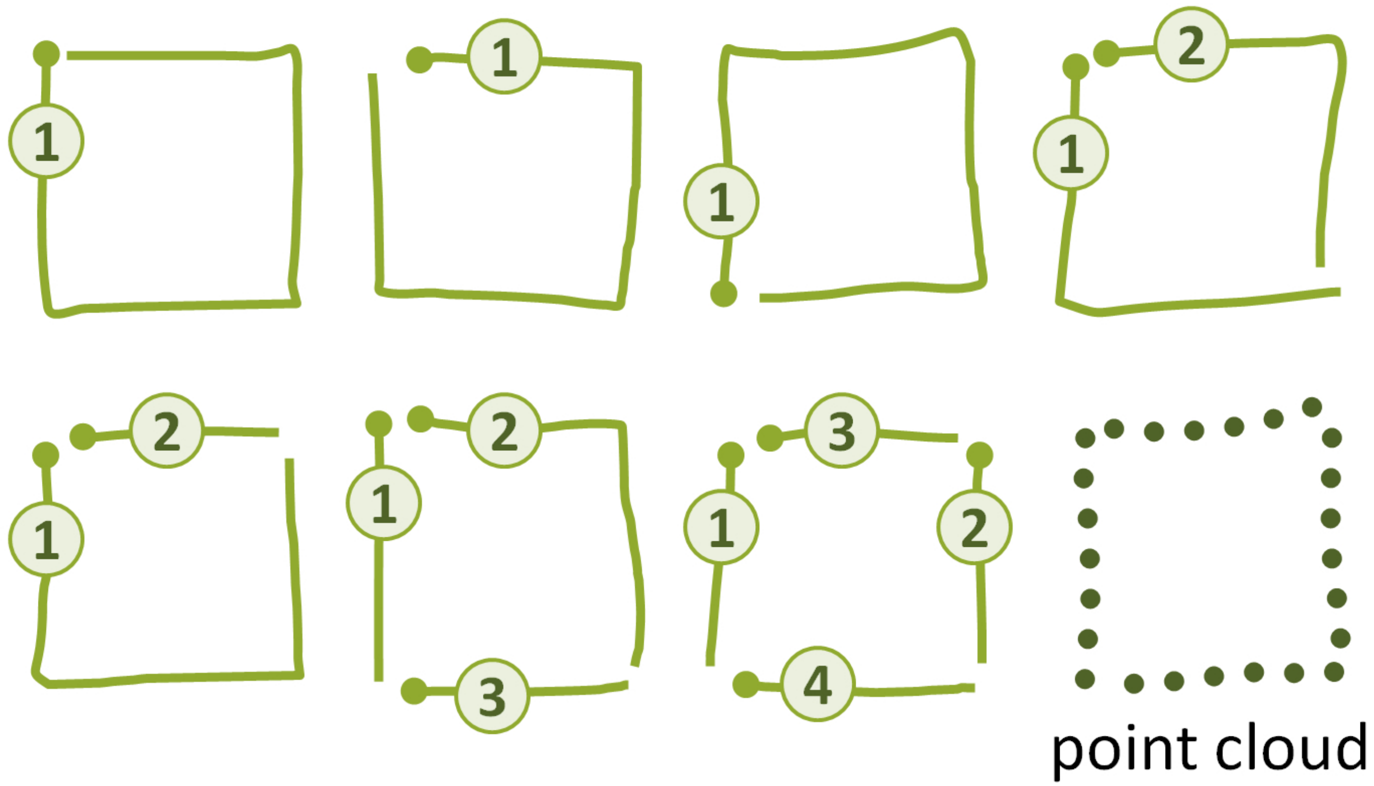
WiSee use wifi signals for gesture recognition

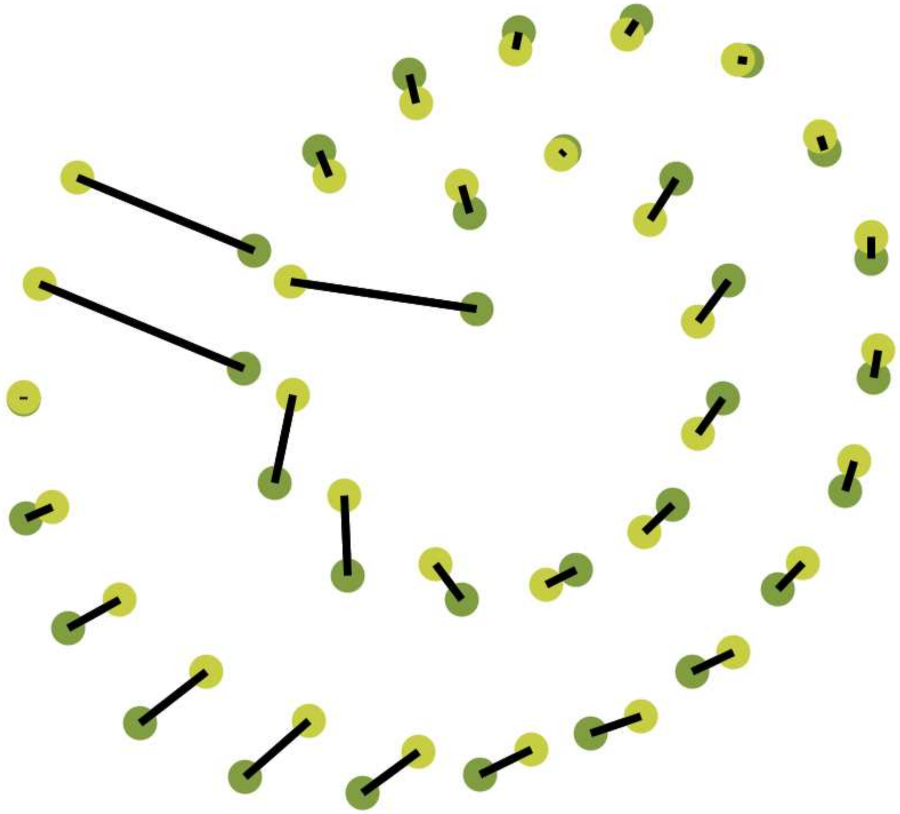
(Pu et al., Mobicom '13)

Recognition: template matching

Extra

$P recognizer



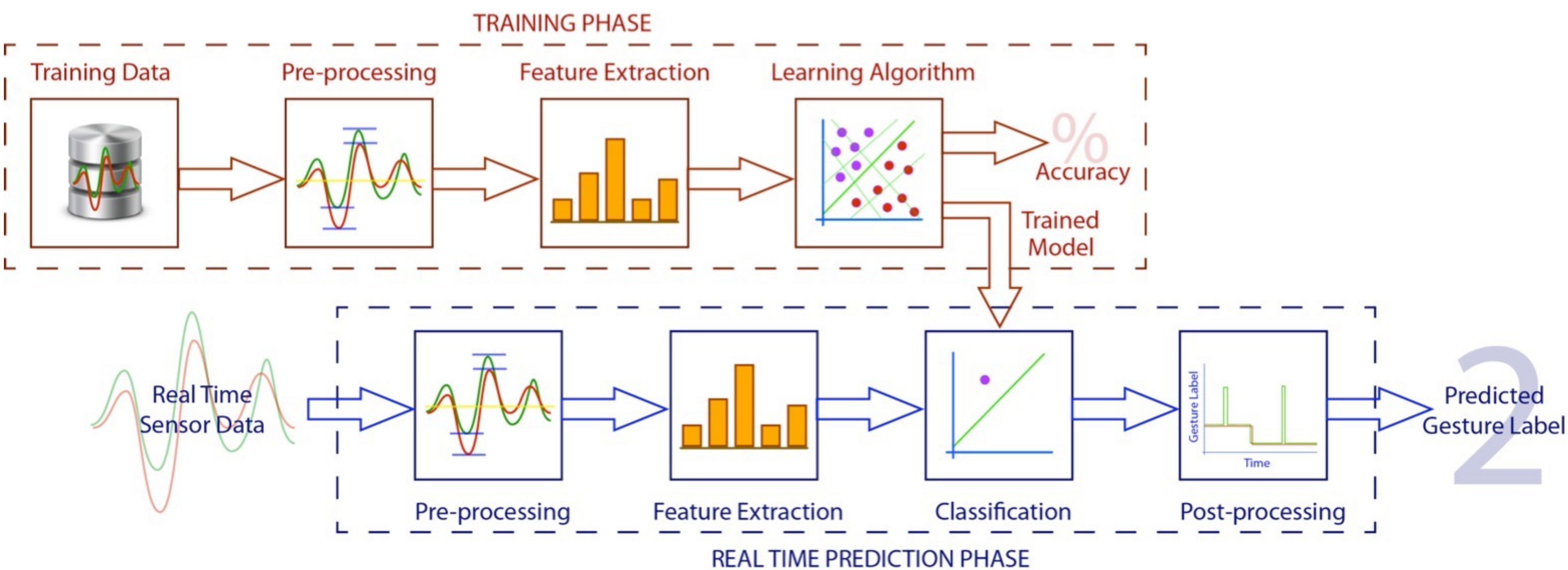


Software & online demo:
https://depts.washington.edu/aimgroup/proj/dollar/

(Vatavu et al., ICMI '12)

Recognition: machine learning

Extra



Ready-to-use Gesture Recognition Toolkit:
http://www.nickgillian.com/software/grt

(Gillian & Paradiso, JNL Machine Learning Research, 2014)

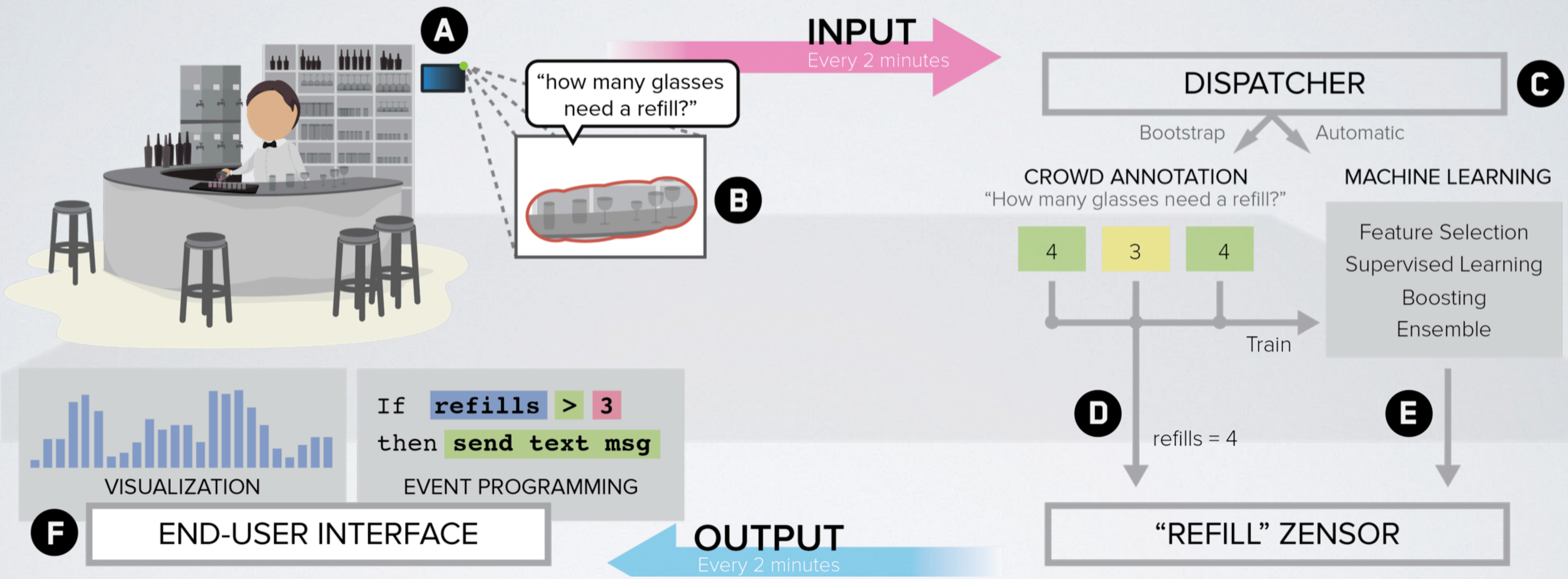
Extra

Zensors: hybrid crowd sourcing and machine learning

(Laput et al., CHI '15)

Zensors architecture

Extra



(Laput et al., CHI '15)

Summary

- Design principles for gestural systems
- Gesture elicitation and taxonomy
- Gesture accuracy measures
- Gesture guidance and learning
- Sensor data and gesture recognizers

Reading assignment: Vatavu et al. "Relative accuracy measures for stroke gestures." ICMI '13.

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