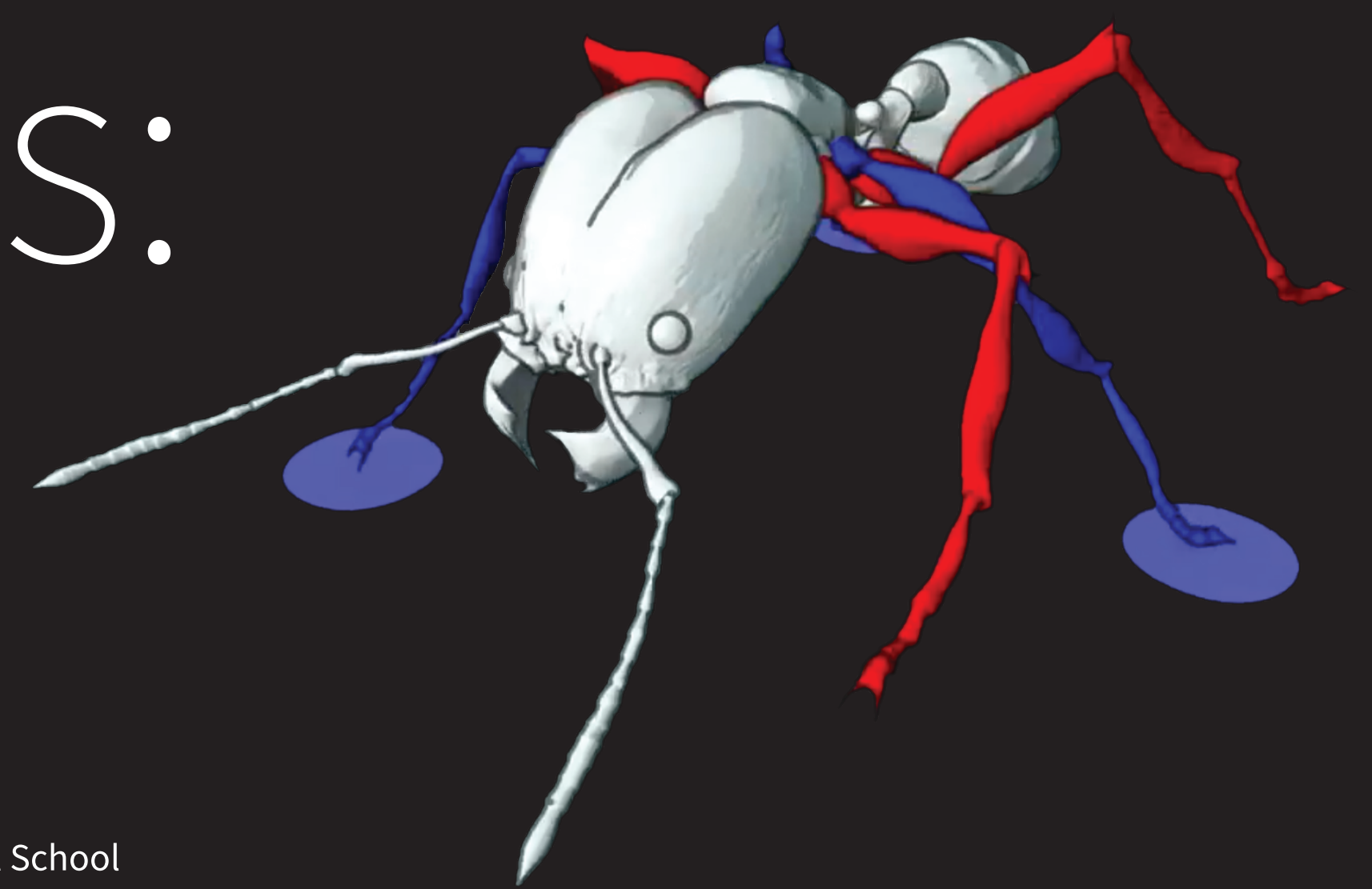# Improving mental models from visualizations:
A relation set approach to design for dynamic content

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Animation Processing Model (APM)

The APM details processing activities that viewers need to carry out in order to comprehend a complex animation (i.e., to build a high quality mental model of the referent subject matter).

Key features:

- The APM characterises animation processing in terms of five interrelated phases that are iterative and cumulative (although not necessarily strictly sequential)

- The processing activities involved are shaped by the perceptual and cognitive constraints / proclivities of the human information processing system

- These activities involve bottom-up and top-down processes that interact as the viewer is composing a mental model

- Perceptual processing (especially re dynamics) has a powerful influence on what information is extracted and made available as raw material for subsequent composition activity

- The ultimate quality of the resulting mental model depends on how successfully the viewer decomposes the animation's dynamic flux into relevant event units (phase 1 processing).

Applying the APM: Ant Locomotion

Ants are very familiar but most people don't understand their locomotion, which involves complex dynamics making it a very suitable application for the APM

Key aspects of ant locomotion are:

- Body is moved forward by leg pulls (flexion) and pushes (extension): 'drive' aspect

- Efficient continuous locomotion requires alternating leg tripods: 'prepare' aspect

- High quality mental model must properly integrate both these aspects

- Pilot: Comprehensive, uncued ant locomotion animation (figure 2.a) – ineffective
  - Rich hierarchical dynamic structure means inter-representational competition for attention
  - Salience-relevance mismatches mean key information is missed (wrong attention direction)

Exploratory Study: Cueing Ant Locomotion

- Participants: Teacher Education Students (Elementary School trainees)

- Output measure: Manipulable physical ant model (figure 2.c - performance video recorded)

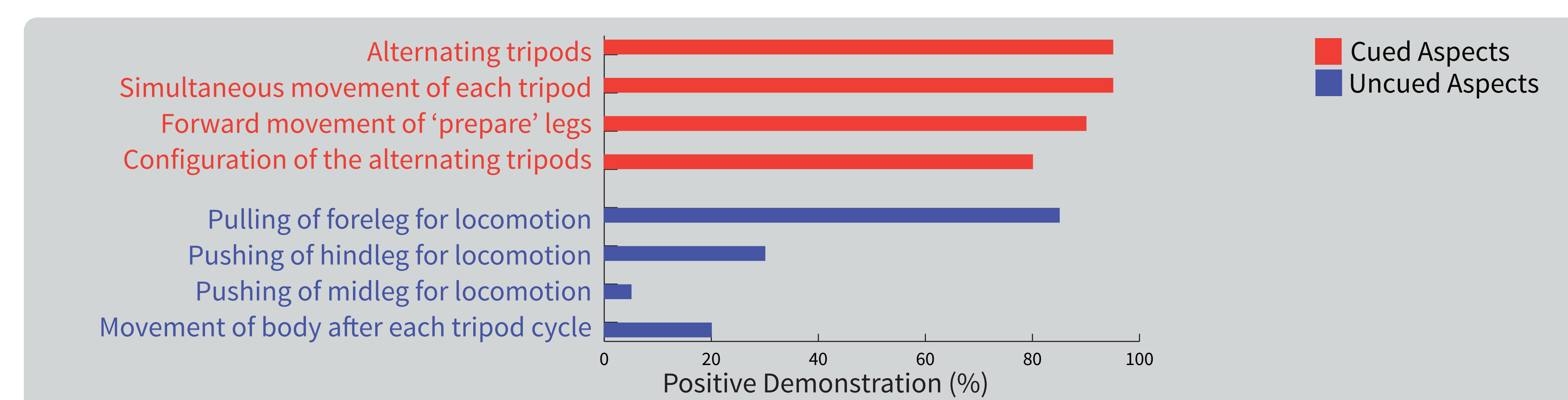- Study Design: 20 participants manipulate model before & after viewing cued animation (figure 2.b)

Figure 3. Results from exploratory study.

Next Steps: Relation Set Approach

- Rather than just treating symptoms, instead address fundamental cause

- If domain novices can't decompose comprehensive animations, don't require them to!

- Alternative – circumvent APM phase 1 processing by providing pre-decomposed material

- Supply appropriate 'kit of parts' (relation sets) then help viewers compose in optimal way

- Relation sets are strongly related groups of event units that can be readily interconnected

- Viewer composition facilitated by assembling well designed and sequenced relation sets

- Progressive, cumulative assembly of relation sets to give higher quality mental models

APM

BOTTOM UP INFLUENCE ↑↑↑↑

Phase 1: Localized perceptual exploration
Parsing the continuous flux of dynamic information (decomposition)
Individual event units

Phase 2: Regional structure formation
Relational processing of local segments into broader structures (composition begins)
Dynamic micro-chunks

Phase 3: Global characterization
Connecting to bridge across 'islands of activity'
Domain-general causal chains

Phase 4: Functional differentiation
Characterization of relational structure in domain-specific terms
Functional episodes

Phase 5: Mental model consolidation
Elaborating system function across varied operational requirements
Flexible high quality mental model

TOP DOWN INFLUENCE ↓↓↓↓

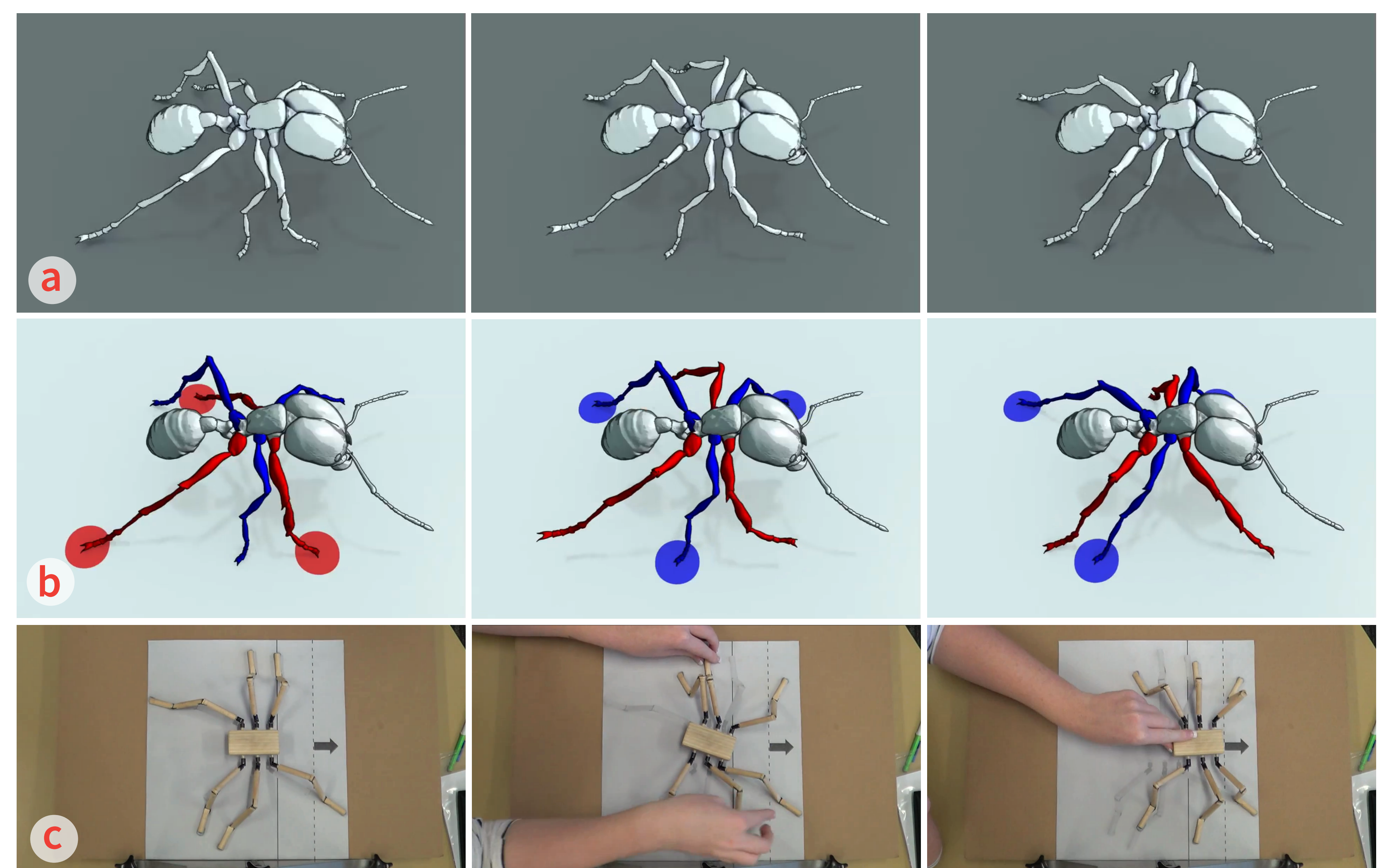Figure 1. Animation Processing Model (Lowe & Boucheix, 2012)

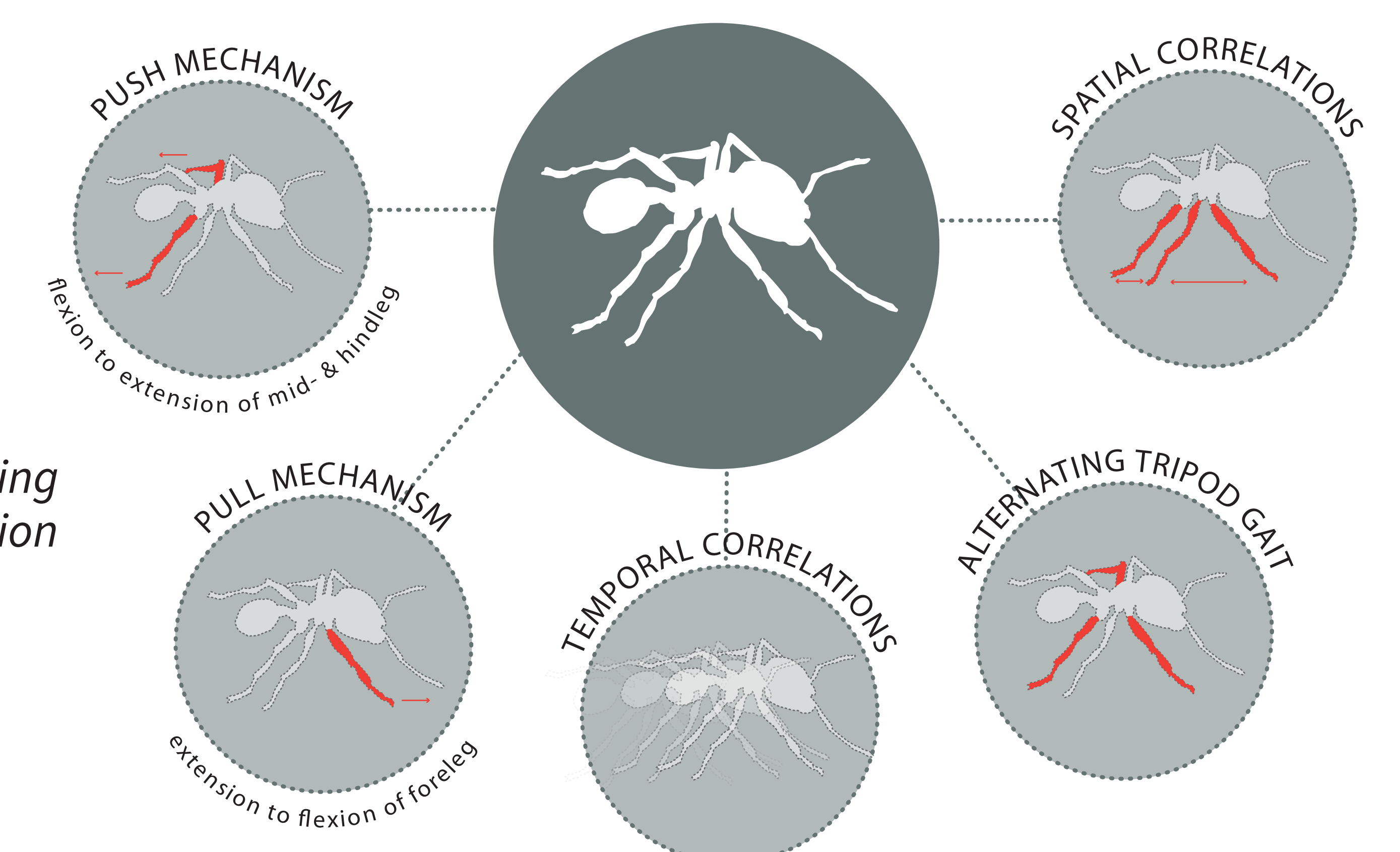Figure 2. a) 'Uncued' ant locomotion; b) 'Cued' ant locomotion; c) Manipulable physical ant model.

Figure 4. Possible relation sets that may contribute to composing a mental model of ant locomotion

References: Lowe, R.K. and Boucheix, J.M. (2012). Dynamic Diagrams: A composition alternative. in P. Cox, B. Plimmer, P. Rodgers (ed), *Diagrammatic Representation and Inference*, pp. 233-239. Heidelberg: Springer-Verlag.