Entity and Space Cues in Animated Graphics

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Abstract. This study explored extraction of macro and micro information from un-cued and cued user-controllable Newton's Cradle animations. Cued versions used visuospatial highlighting of either entities or inter-entity spatial relations. There were no differences in the quality of demonstrations of Newton's Cradle dynamics produced by participants in the cued and un-cued conditions. However, inappropriate cue choice during free interrogation of the animation was associated with less effective extraction of micro information.

Keywords: animation; cues, macro and micro dynamics, information extraction, entities and relationships.

Introduction

When presented with an animation containing complex, hierarchical dynamics, learners tend to differentially extract macro and micro information. If there is a high level of dynamic contrast between macro aspects of an animation and the rest of the display, learners may overlook the less perceptually salient micro information. Unfortunately, these micro aspects are often crucial to a proper understanding of the depicted content and if they are not extracted from the animation, mental model quality can be compromised. Visual cueing is widely used in static graphics to re-direct learner attention to high relevance, low salience information that may otherwise be neglected. However, research in which such cues are applied to animations has produced mixed results (e.g. de Koning, Tabbers, Rikers, & Pass, 2010). This research has typically used these cues with animations that had a high level of visual complexity. Further, the cueing was confined to directing attention towards high relevance entities but did not specifically address relational aspects such as the spacing between those entities. The exploratory study reported here investigated the potential of cueing spatial relations as well as entities as a means of facilitating the extraction of low salience, high relevance micro information. In contrast to previous research on cues that involved visually complex subject matter, the Newton's Cradle animation used for this study has a very simple visual structure (a horizontal row of five identical balls suspended from strings). Because extraction of relational information is fundamental to the building of a high quality mental model, it may be that this aspect of Newton's Cradle micro dynamics needs to be cued explicitly, rather than trusting it will be extracted as a by-product of cueing the entities involved.

In previous work with un-cued Newton's Cradle animations (Lowe & Schnotz, 2007), deficiencies were found in the extraction of information about both the entities involved in the micro dynamics of the system and the spaces between those entities. Although animation presentation speed appeared to have some influence on the profile of information extracted, micro aspects concerned with spatial relations were relatively neglected (c.f. Fischer, Lowe, & Schwan, 2008; Meyer, Rasch, & Schnotz, 2010). This failure was accounted for in terms of the masking of micro dynamics (exhibited by the middle balls of the device) by the far more perceptually salient macro dynamics of the terminal balls. The micro behaviour of the middle balls plays a key role in the transition between the two main types of macro movements exhibited across the time course of the Newton's Cradle operation: (i) the 'alternating bounce' observed when the process begins, and (ii) the 'joint swing' that occurs towards the end of the sequence. Visuospatial cueing of both entities and relations offers a potential alternative to speed manipulation as a way of helping learners to extract micro information from a Newton's Cradle animation.

Method

Research Design and Materials

Different versions of a user-controllable Newton's Cradle animation were used for: (i) an entity-cue condition (Figure 1a), (ii) a space-cue condition (Figure 1b), and (iii) an uncued control condition. To facilitate hierarchical integration across macro and micro levels of information, participants in the experimental conditions could freely switch between two different cue views – terminal or middle cueing. Initial presentation of terminal or middle cueing was counterbalanced across participants. The dependent variable was the level of success in learning the dynamic processes involved in the behaviour of the Newton's Cradle as measured by the quality of participants' demonstrations.

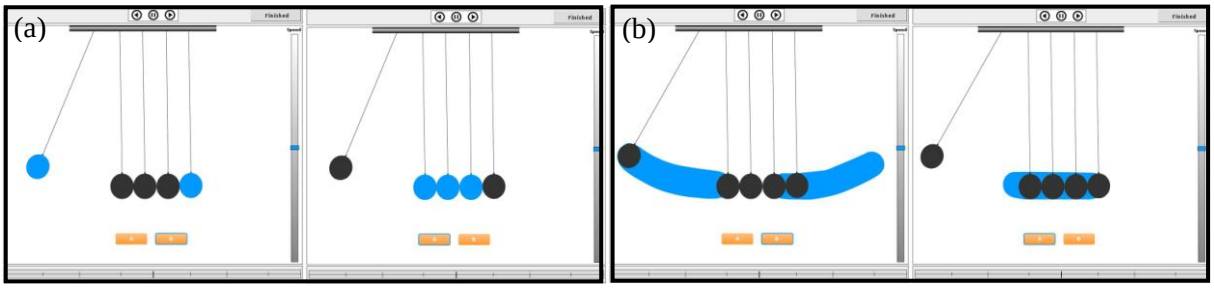

Figure 1. (a) entity-cued display with terminal and middle cueing (b) space-cued display

Participants

Forty eight Education students at Curtin University, Australia, voluntarily participated in the study.

Procedure

Participants were randomly assigned to the control condition or an experimental condition. Following a familiarization practice task, participants were presented with the Newton's Cradle animation. Before commencing the learning task, participants were told that after viewing the animation, they would be asked to demonstrate the behaviour of the Newton's Cradle using five coins (representing the balls). They were encouraged to pick up as much information as they could about the changes taking place in the Newton's Cradle over time. Participants were free to use the controls as they wished until they felt confident in demonstrating what happened in the animation. After viewing the animation, participants gave their coin-based demonstrations (they could use both hands to manipulate the coins). Videoed demonstrations were scored as to the amount of macro and micro detail exhibited.

Results

An analysis across the three viewing conditions revealed no significant differences in macro or micro detail demonstrated. Overall, macro scores (M = 4.50, SD =1.64) were significantly higher than micro scores (M = 2.35, SD = 1.50), F (1, 47) = 34.39, p < .001. The more time participants spent with the terminal cues during the animation, the worse their micro scores were (r = -.453, p = .012). To explore this relationship more closely, participants were divided into three groups according to the proportion of time spent viewing terminal or middle cued depictions; (i) Strong Middle preference (>

2/3 time viewing middle cues, $N = 10$), (ii) Strong Terminal preference (> 2/3 time viewing terminal cues, $N = 9$), (iii) No strong preference (remaining cue group participants, $N = 11$). The uncued participant group was also included for comparison ($N = 18$). There was no difference in macro scores between the four groups, $p > .25$. However, effects were found for micro scores ($M_{Middle} = 3.0$, SD = 1.49; $M_{Terminal} = 1.44$, SD = 1.42; $M_{Nopref.} = 1.73$, SD = 1.56; $M_{Uncued} = 2.83$, SD = 1.20), F (3, 47) = 3.47, $p = .024$, $\eta^2 = .65$. Post hoc analyses revealed that participants in the Uncued and Middle groups performed significantly better than those in the No Preference and Terminal groups

Discussion

Despite the visual simplicity of the Newton's Cradle animation, neither entity-based nor spaced-based visuospatial cueing improved the extraction of target information. Further, even those who used the middle cues did no better than the control group. The provision of additional user-control with respect to cue selection appeared to have negative consequences. In particular, participants who chose to spend more time with terminal cues tended to produce poorer demonstrations of micro information. The likely effect of these macro-oriented cues was to reinforce the already powerful intrinsic attention-attracting effect of these terminal aspects of the display. Because the terminal balls are visually identical to the middle balls, we can attribute this effect to spatiotemporal properties that produce a high level of dynamic contrast with the rest of the display. This study reinforces the notion that mere provision of adjuncts designed to help learners process animations more effectively does not guarantee that the opportunities they offer will be well used. The findings provide yet another indication of how the effectiveness of cueing techniques can be influenced by the context in which those techniques are applied. In order for cues to direct learner attention effectively, they must not only out-compete other potential attention-directing attributes of a display but also be used appropriately by learners. It appears that conventional cues (as long used for static depictions) may not always have the desired effects within an animated context. This suggests that animations require a more sophisticated approach to cueing that takes greater account of both the dynamics of these depictions (c.f. Boucheix & Lowe, 2010) and the capacity of learners to use the cues provided in a sufficiently strategic manner.

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