

# Harmonious, Hollow or Hostile: Exploring cognitive offloading in multimodal representations involving haptic and visual modalities

Student Name  
Dr. Alissa N. Antle  
IAT 844 Tangible Interfaces  
Date

## 1. PROBLEM

Tangible user interfaces (TUIs) have emerged as an alternative interface paradigm whereby the interface is comprised of one or more physical objects infixed with computation. Two fundamental aspects of TUIs are the coupling of external representation with physical artefacts and the multimodality inherent in tangibles. Price [6] has argued for greater emphasis on the role of representation, particularly with respect to cognition, in the design of tangible environments. Recent research reflects this need; Bakker et al.'s *Weathergods* addresses conceptual representation in tangibles, i.e. symbolic and iconic representations [2 & 3]. Echoing Price's assertions, making use of the multimodality to offload cognition is supported by cognitive learning theories, for example Cognitive Load Theory [7]. Further, at least one study has shown the importance of considering cognitive load in the design of multimodal systems [4]. However, TUIs possess two modalities, visual and tactile (haptic), dealt with by the same cognitive system, namely the visual-spatial sketchpad [1]. This calls into question the effect of multimodal representation involving haptic and visual modalities on distributed cognitive load, which has not yet been empirically explored [1].

## 2. DOMAIN

This problem will be approached from the domain of HCI. It involves answering questions on how to design an interface from a human-centred perspective, in particular how best to address the trade-offs of human cognition. It suggests exploring and comparing different implementations of interfaces with the potential of supporting a theory or aspect/s of a theory, and with these results lending structure to existing frameworks. Further, the results could influence the development of future interaction techniques with regard to cognitive distribution and offloading.

## 3. DESIGN

This problem would be best situated in the Application level of the CAT triangle, with a possible liminal presence between this level and the Concept level. Given that this project will not necessarily suggest new, novel or innovative technology, but rather speaks to interface design decisions, it does not fit in the Technology level. It is a human-centred design problem that takes into consideration human issues: it addresses the matter of cognitive load, which is itself attributable to the limitations of the human cognitive system and the needs that come out of those limitations.

While it may not itself be a paradigm, this problem does speak to current frameworks, such as Price's representational approach to the design of tangible artefacts [6]. Indeed, this project seeks to address cognition with regard to modality in representation. Further, it seeks to determine an unexplored area of Cognitive Load Theory, and aims to support or reject what the theory suggests regarding modalities processed by the same cognitive system bearing no benefit on cognitive load.

## 4. QUESTION

Do visual and tactile modalities of representation as facilitators of interaction in tangibles compete, complement or have no effect on cognitive offloading? This question posits the Cognitive Load Theory's understanding of the visual-spatial sketchpad as articulator of both visual and haptic information.

## 5. PROTOTYPE

The research prototype will be comprised of two tangible artefacts. Both will incorporate external representations. Each representation will employ one of the following sets of modalities: visual or visual and haptic.

That the prototype features discrete sets of interface form lends itself to the domain of HCI. The forms are not novel, in that they are not designed with special sensors, actuators or other technology not yet implemented in tangibles; nor does the prototype require new algorithms or functionality: thus the prototype does not directly address the computing science / engineering domain. While the prototype will carry some aesthetic value, its aesthetics can be variable without affecting the research. Further, instead being assessed through philosophical inquiry, aesthetics or analytical artistic frameworks, the prototype calls for the scientific method to give it purpose in the context of the research question.

Building on this, the prototype can then be seen as driven by the Application level of the CAT triangle. It is the research – the application of the prototype – that drives the design of the interface form and its focus on the human-centred design issue of cognition offloading. The context within which the prototype can be situated is variable, and could include content from learning modules to explorations in narrative to video games.

## 6. VALIDATION APPROACH

The prototype is envisioned to be used in an empirical experiment whose aim will be to clarify the role of cognitive systems-sharing modalities in TUIs. This method is chosen partly because empirical evidence is lacking in this area [1] and also because the research question can be answered by observable data based on two variables, as follows the structure of empirical studies [8].

The development of the prototype will conform to the requirements of the determined validation approach. In particular, it will allow for two variables: the haptic (tactile) modality as the independent variable and the effect on cognitive offloading as the dependent variable. The independent variable will have two states: engaged or unengaged, where engagement refers to whether or not the haptic modality is employed in the representation of the tangible artefact. Internal validity will be assessed, in particular construct validity, which assesses the appropriateness of the operationalization of the concept, and face validity, which is a general impression of whether or not the measure measures what it is supposed to [8].

Casaday and Rainis [5] suggest a number of industry-derived approaches to evaluating the rigor of the prototype during its design. Those that pay particular respect to prototyping include heeding usability during design (as opposed to following the design process), parallel iteration (working through versions of components of prototypes simultaneously) and formative evaluation.

## 7. REFERENCES

- [1] Antle, A. N. and Wise, A.F. Getting down to details: Using learning theory to inform tangibles research and design for children, *Personal and Ubiquitous Computing, Special Issue on Children and Tangibles*, (2010), under review.
- [2] Bakker, S., Vorstenbosch, D., Hoven, E. van den, Hollemans, G. and Bergman, T. (2007). Tangible interaction in tabletop games: studying iconic and symbolic play pieces. In *Proceedings of the International Conference on Advances in Computer Entertainment Technology (ACE '07)*, ACM, Vol. 203, 163–170.
- [3] Bakker, S., Vorstenbosch, D., Hoven, E. van den, Hollemans, G. and Bergman, T. (2007). Weathergods: tangible interaction in a digital tabletop game. In *Proceedings of the First International Conference on Tangible and Embedded Interaction (TEI '07)*, ACM, 151–152.
- [4] Cao, Y., Theune, M. and Nijholt, A. (2008). IncreTable, a mixed reality tabletop game experience. In *Proceedings of the Thirteenth International Conference on Intelligent User Interfaces (IUI '09)*, ACM, 335–344.
- [5] Casaday, G. and Rainis, C. (1996). Requirements, models and prototypes for HCI design. In *Conference companion on Human factors in computing systems: common ground*, ACM, 361–362.
- [6] Price, S. (2008). IncreTable, a mixed reality tabletop game experience. In *Proceedings of the Second International Conference on Tangible and Embedded Interaction (TEI'08)*, ACM, 151–158.
- [7] Oviatt, S. (2006). Human-centered design meets cognitive load theory: designing interfaces that help people think. In *Proceedings of the Fourteenth annual ACM international conference on Multimedia (MULTIMEDIA '06)*, ACM, 871–880.
- [8] Reinard, J. C. *Communication Research Statistics*. Sage, Thousand Oaks, CA, 2006.