6 Interaction Momentum – Industrial Application Design and Consistency Across Platforms

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With the proliferation of devices in industrial settings to improve productivity and task performance, specific interactions and content-to-form mappings will need to be consistent to support interaction momentum and operator attunement to the task and not the technology. This position paper presents a framework informed by ecological psychology, and previous research in human-computer interaction and procedural operations in process control that can provide a foundation for developing design principles for cross-platform consistency for industrial applications. Four principles are presented as a starting point for consideration.

INTRODUCTION

The high pressures for productivity and efficiency in industrial settings have increased the demand for tools, technology, and applications that can help workers handle a wide scope tasks with fewer and fewer resources. This has resulted in a proliferation of technologies to support plant operations. In some cases, these technologies augment existing platforms and are used in particular situations. For example, paper procedures have be augmented with computer based versions to facilitate procedure automation and mobile coordination of tasks. Effective design and consistency are critical to support interaction momentum as end users switch from different platforms while executing tasks. This position paper discusses a framework for mapping content to function to form across multiple platforms while taking into account platform capabilities and limitations. It is postulated that certain aspects/forms of user interaction (i.e., forms that map to key behavior shaping constraints) should remain consistent or invariant; other aspects are less important in terms of consistency and are free to change based on the limitations of the platform. Two main cases are discussed for illustration. First, research results from form variability studies in process control monitoring are presented. Second, different aspects of procedural operations are used as examples with three main platforms: paper, PC-console, and mobile devices. The final section concludes with some initial design principles for consistency across platforms.

THEORY AND FRAMEWORK

The theory behind this paper stems from research in ecological psychology and the concept of the use of coordinative structures [1] (or higher-level control). Coordinative structures are the linkages of component resources into higher-level functional collectives; they define component configuration opportunities to support higher-level functions based on moment-to-moment context. Engaging in higher-level control activates the processes of utilizing these coordinative structures to support higher-level functions in a changing context, including cross-platform operations.

Key to ecological psychology is the notion of coupling between a human and the environment. At the juncture between the human and environment lies the connector or interface that can help facilitate cognition, perception, and action. This interface can directly or indirectly specify the environment. By becoming attuned to the interface or picking up cues to reason analytically, people can be coupled to the environment, making adaptation and coordinated action possible. The types of information that are consistent or invariant impact how well an operator is able to adapt to different types of changes.

A model of the coupling between the human and the environment is shown in Figure 1. There are three parts to the model: the environment (distal structure), ambient array (proximal structure – invariant forms), and human.

The environment consists of substances, surfaces, objects, media, and events [2]; these characteristics define the distal structure of the environment. From a Gibsonian perspective, these aspects of the environment offer the human a large number of action possibilities or affordances [2]. They are described relative to the human, independent of the person's intentions or goals. These affordances do not need to be perceived by people to exist. However, they offer people opportunities to act

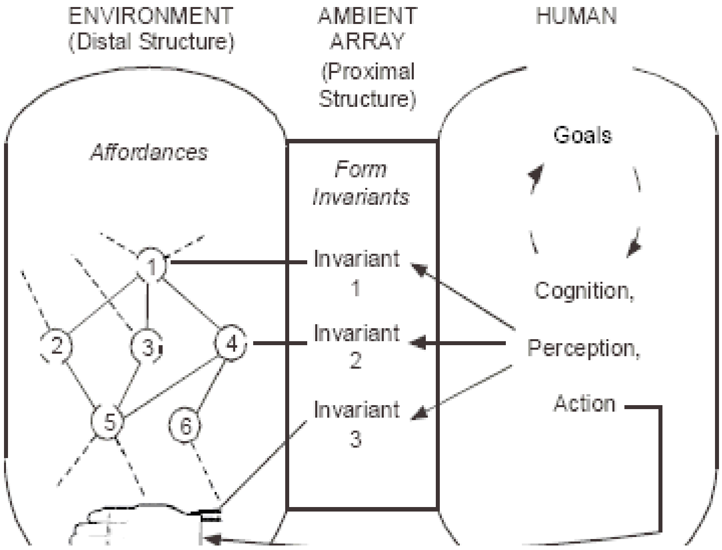

Figure 1: An ecological model of human-environment interactions [3].

The ambient array is the connection or interface between the environment and the human that can facilitate active perception and coordinated, adaptive action. Proximal structure is formed within the ambient array emanating from various aspects of the environment through a medium (e.g., illumination). From a Gibsonian perspective [2], the ambient array can have proximal structure forming invariants that can map to various aspects of the environment. Information is a result of a one-to-one correspondence between the proximal form invariants and distal affordances.

The human is composed of highly integrated and multi-layered physiological systems. From an ecological point of view, adaptation and coordination occur at the levels of cognition, perception, and action, and are guided by goals and intentions. At these levels, the human can actively pick up form invariants from the ambient array that map onto affordances in the environment. In this process of picking up form invariants (i.e., attunement to the proximal structure), the human acts within the environment (e.g., manipulates objects or moves within the environment). Once this occurs, perception and adaptive, coordinated action are possible.

Consistency across platforms is analogous to form invariants in the above discussion. Critical cues that remain invariant across platforms facilitate greater attunement of the human to the environment and interaction momentum, enabling successful adaptation and task completion.

PREVIOUS RESEARCH

Two main research areas are presented that further support the framework and provide insights into cross-platform consistency requirements.

DISPLAY FORM IMPACTS IN PROCESS CONTROL

Research in human-computer interaction provides some insight in the principles and requirements of form consistency or invariance that can be generalized to cross-platform consistency considerations [4].

Previous research examined the role of information and display form invariance on operator adaptation in a process-control microworld environment [3,5]. The purpose was to assess the impact of form perturbations on a participant's level of control and ability to successfully adapt to change. This is analogous to cross-platform and interaction inconsistencies.

Figure 2 outlines the interface and form perturbations that were examined.

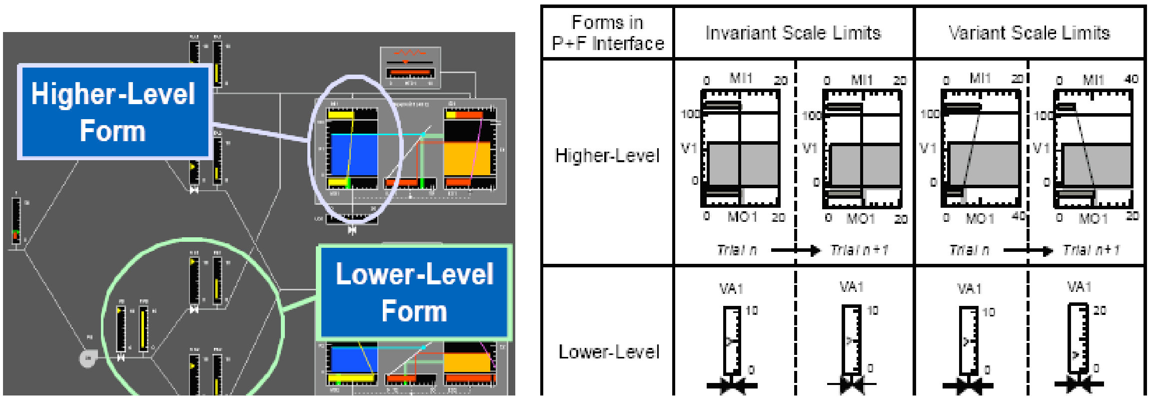

Figure 2: Perturbations in forms across trials from a process control microworld [3].

After the learning period, two groups of participants were exposed to either higher-level or lower-level form perturbations. Higher-level forms directly map to higher-level functional process variables (e.g., mass-energy relations); lower-level forms directly map to lower-level functional process variables (e.g., equipment functions).

Consistent or invariant forms that map onto the higher-level functions of a domain were determined to be critical for attunement to form and component perturbations. Display changes to lower-level forms had a minimal impact on the ability for an operator to adapt to change. This suggests that information that operators need to be critically attuned to (i.e., higher-level functions) should remain invariant across situations and platforms.

CROSS-PLATFORM CONSISTENCY IN PROCEDURAL OPERATIONS

An example of an industrial application where these issues are being investigated is procedural operations in process control. Procedural operations involve the use of a set of explicit guidelines and instructions that, when followed by the operations personnel, will minimize deviations from design or operating intent and will avoid hazardous conditions and other undesirable outcomes [6].

Current practices involve the use of paper of static on-line procedures. New technologies and platforms, such as mobile devices, automation, and interactive procedures, are being introduced to improve procedural efficiency, compliance, coordination and performance [6]. It is envisioned that operators may use different platforms to execute procedural tasks in different situations and at different timeframes. For example, an operator may review and annotate a paper version of a complex procedure in his office. Then, the operator may supervise the automated executions of the first few steps at the control room console, while coordinating with field operators who have mobile devices. Later in the procedure, the operator my go to the field to complete a couple of tasks manually using a mobile device. Finally, the operator may go back to the control room and sign-off on the procedure.

Critical to procedural operations is the task list. In some cases, the formatting and structure of the tasks are coded in a particular way (bold letters) for salience and scanability. Over time, users do not need to read every work to encode the logic of the task; its form effectively conveys cues for action. Other elements of procedures are less critical to the task, but provide supporting information. This information is less utilized and referenced. Thus, when designing formats across platforms, formats should be consistent for critical content (i.e., tasks) that work well in alternative platforms. For less critical information, operators either preferred formats that are compatible with platform constraints considering ease of use, or can access this information from another platform or location.

INITIAL PRINCIPLES FOR CROSS-PLATFORM DESIGN

To tackle the issue of consistency across platforms in industrial applications, one should first consider the key functions and content that are critical and that operators need to attune to independent of platform. These will constitute the key content and interactions that need to be supported to accomplish the tasks. At the same time, platform capabilities, constraints, and effective modes of interaction need to be examined.

Based on the above, the following principles are proposed for inclusion in effective cross-platform design. Based on previous research, the aspects that should be consistent will highly dependent on the application, domain, and context of use.

- Principle 1: Content that is critical to task completion, performance, and behavior-shaping constraints that users attune to for action needs to be consistent in form across platforms.
- Principle 2: Secondary and supporting information that are not critical to shaping critical behaviors do not need to be consistent (but certainly can be if appropriate). This information should be organized and accessed considering the constraints of the platform.
- Principle 3: Navigation metaphors should be compatible across platforms to support interaction momentum.
- Principle 4: Other aspects of application design should conform to effective user centered design practices for the platform considered.

CONCLUDING REMARKS

As devices become increasingly ubiquitous and connected, and used to support tasks in different contexts, cross-platform consistency will be come an increasing focus and challenge. Each platform has its own constraints and limitations. Good interaction modes in one platform may be clumsy in others. This position paper describes aspects of applications that need to consistent to build interaction momentum between the user and the task. Understanding what users need to attune to when performing tasks is critical in defining consistency requirements. Other aspects of the design do not need to be consistent, but should be compatible to the capabilities of the platform.

REFERENCES

[1] Kelso, J. A. S. (1995). Dynamic patterns: The self-organization of brain and behavior. Cambridge, MA: MIT Press.

[2] Gibson, J. J. (1979). The ecological approach to visual perception. Boston: Houghton Mifflin.

[3] Hajdukiewicz, J. R. (2001). Adapting to change in dynamic worlds. Toronto, ON: University of Toronto.

[4] Burns, C. M., & Hajdukiewicz, J.R. (2004). Ecological Interface Design. London: Taylor & Francis/CRC Press.

[5] Hajdukiewicz, J. R. & Vicente, K. J. (2002). Designing for adaptation to change and novelty: Functional information, emergent feature graphics, and higher-level control. Human Factors, 44, 592-610.

[6] Bullemer, P., & Hajdukiewicz, J. R. (2004). Effective procedural practices and tools for process operations. Human Factors and Ergonomics Society 47th Annual Meeting (pp. 2401-2405). Santa Monica: HFES.