TOWARDS AN IDEAL IN INFORMATIVE ART

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Informative Art is an emerging form of Ambient Information System in which the traditional role of information visualization is supplanted into everyday environments in the form of traditional art objects, such as paintings and posters. It is in short, "a dynamically updated information display with the decorative role of visual art." (2) As different research groups and art practitioners explore the notion of Informative Art, common themes and design strategies are beginning to emerge. These themes suggest the potential for a common vocabulary to emerge within this field and for more robust design strategies and evaluative methods to be realized, which previously the field has suffered from a lack of. Most importantly, as a relatively new sub-genre of ambient information systems, there has been little effort to identify or evaluate the perceptual effects which may be relevant to the design of Informative Art, or an exploration of the types of data and styles of art which may be fruitful to explore. It will become increasingly critical to build knowledge of these aspects if Informative Art is to fulfill its highest expressive potential and informational capacity.

INTRODUCTION

The Design Space

Informative Art (IA) is a term coined by Redstrom in 2000, in his paper Informative Art: Using Amplified Artworks as Information Displays. Since that time, there has been an attempt to define the design space of Informative Art and to characterize its affordances and defining characteristics. In general, IA applications are of two kinds: display/screen-based, or embedded in physical objects. Examples of physical IA applications include Dangling String (36), Water Lamps and Pinwheels (37), and Information Percolator (35), while the more numerous display-based applications include Aesthetic Information Collage (6), InfoCanvas (7), Hubscape (9), MoneyTree (10), as well as the various applications of the Future Applications Lab's Informative Art (1-5).

In order to form a meaningful discussion of the visualization aspects and affordances of Informative Art, it is important to elucidate its design space as well as aspects from related

fields. Placing IA in the context of related fields may generate opportunities to cross-pollinate ideas and reveal design strategies which may be relevant. Informative Art is closely related to ubiquitous computing, and is itself a form of ambient media or peripheral awareness display. In this sense, informative art is a “lightweight method” of seeking awareness information, similar to ambient media and peripheral displays (8). Redstrom et al. have also sought to highlight the capacity of Informative Art to promote ‘moments of concentration and reflection” (1) and enhance “time presence” (3), relating it closely to Weiser’s notion of Calm Computing and giving rise to their own concept of Slow Technology.

It is clear that Informative Art stands in contrast to using concepts and techniques from art to improve application usability or to allow for denser information visualization, as is seen in techniques such as layering and brushstrokes. Its design space is characterized by an emphasis on aesthetic considerations and its intended role in residing in the periphery of awareness. Redstrom uses the concept of *amplifying reality* to characterize the embedding of technology, in this case information, in order to enhance or amplify the expressions of real-world objects, such as art hangings (1). In a sense, IA is generally preoccupied with the pursuit of an aesthetic end using information visualization simply to enhance the expression. In many cases, strict adherence to an aesthetic goal or fidelity to the artistic template is prioritized above the demands of sound information visualization and this if often described as being within the design space of Informative Art (1, 4).

There has also been some effort made to suggest that Informative Art does not seek to reduce the cognitive load of users (1, 3, 4) despite acting as a peripheral awareness device, and does not seek to be instantly comprehensible as in Slow Technology (3). In addition, the possible data sets that can be represented in Informative Art typically range from local information about the physical environment, to digital communications (RSS, email), to global data (weather, earthquake activity). It has also been generalized that IA is not intended for conveying quantitative data (2). Redstrom goes so far as to suggest that even without explicit comprehension of visual mappings, users will “gradually feel a clear presence of information” (1) from the applications and although this knowledge will be abstract, this is a main property of the design space of Informative Art.

Other examples of Informative Art use a similar approach and build visual collages based on existing artistic styles which can convey real-time information about news feeds, or other digital information, often using a combination of verbal and visual imagery (7-11). These applications typically use indexed image databases and generate literal depictions of semantic content of the information feed, which can often be problematic (11). Despite the different details of application implementation, Informative Art applications are generally consistent in their wish to "create displays which are first aesthetically interesting and then as an added bonus, able to convey information" (6) as well as their intended role in residing in the periphery of awareness.

A Taxonomy

Recently, Pousman and Stasko have noted that "accumulating theoretical and craft knowledge has been stymied by the lack of a unified vocabulary to describe" (14) ambient information systems. They have defined a taxonomy across 4 design dimensions: Information Capacity, Notification Level, Representational Fidelity, and Aesthetic Emphasis. Their work has done much to consolidate some of the disparate vocabulary being used within the domain of ambient information systems, contributing to "a framework for understanding their design attributes." Pousman and Stasko are especially successful in defining their design dimensions in ways which have the potential to point out "design trade-offs between aesthetic emphasis and flexibility, and between a system's information display style and display capacity". It will be useful to make use of their taxonomy in order to unambiguously relate knowledge about perceptual effects and visualization techniques relevant to Informative Art back to research within this field.

Are We There Yet?

Some pointed criticisms from the domain of HCI point to the fact that many of the concepts from Ubiquitous Computing, which "was originally conceived for the work place" (32), are problematic when imported wholesale into the domain of the household (31, 32). Bell et al. suggest that by *defamiliarizing* the domain of the home, it is possible to open the design space. Indeed, Bell's criticism of much of the information technology intended for the home seems also to apply to Informative Art: "the design space currently seems unnecessarily constrained." Indeed on one hand, there is the claim that "adequacy of information 'presentation' should be a mere consequence of the fact that fundamental aesthetic problems are solved in a satisfactory manner."(1) On the other hand, we often see a strict adherence to abstract art templates,

artistic styles of past painters, and other seemingly arbitrary aesthetic constraints. It may be the case that currently, Informative Art does not adequately qualify as either art or information visualization, but rather merely approximates both. Either this is the result of design, a matter of definition, or both; in any case, it may be assumed that an ideal in informative art does exist, and its discovery is possible.

Although IA is arbitrarily constrained in some respects, it seems that the lack of evaluated bases for design strategies in this domain has led to unconstrained and designer-centric approaches. In this sense, the domain is not constrained enough, due to the lack of knowledge about perceptual effects and visualization science relevant to the design of these applications. It seems that inherently, the domain of Informative Art is one that is characterized by the necessity for tradeoffs between informational conveyance and aesthetic flexibility and so the pursuit of an *ideal in Informative Art* lies in the appropriate harvesting of balances.

THE SCIENCE OF INFORMATIVE ART

The Basics

Assuming that there is a desire to bring the concept of Informative Art within the domain of true visualization science as well as artistic expression, it is critical to examine the perceptual bases that currently exist in information visualization and pursue design strategies that “reflect what we already know about what works” (18) as Stephen Few puts it. It is constructive to get a sense of

how Informative Art applications should ideally behave, in order to implement visualization science to offer solutions.

The literature on Informative Art and more generally ambient information systems, suggests some key properties that are important to design for. Firstly, it is universally expected that Informative Art applications effectively operate in the *periphery of awareness*, minimize distraction, and not be disturbing. In fact, it is potentially more accurate to describe ideal functioning as capable of fluidly moving from the periphery of attention to the focus and back. Skog et al. also suggested that the information source should "have a relevant scope and a suitable rate of change" (4) in order to be perceived as dynamic but not distracting, while Pousman and Stasko emphasize the ability to convey information that is "important to a user's sense of well-being and general awareness" (14). This points to the importance of identifying appropriate *data types* for Informative Art, as well as exposing possible synergies with various artistic styles.

Further, IA should be able to convey information at-a-glance, providing users with the option of taking "opportunistic glances" (14) to access information. Although there is some debate regarding the necessity for ease of comprehension (3) in IA, we adopt the view that in keeping with IA's intended ambient role, where possible, it is generally desirable for IA applications to enhance ease of comprehension. Two points are important here: Redstrom has initiated the notion that IA need not be easily comprehensible, since this may promote reflection and time presence, as in Slow Technology (3). We take the view that since the intent of Slow Technology is to actively promote "moments of reflection" (1, 3) and not incomprehensibility per se, if we can achieve this goal in some other way while preserving comprehension, this represents an ideal to strive for. Indeed, Holmquist et al. concede that in order to begin to use a system, one must first satisfy all 3 levels of their evaluation criteria for comprehension (21). In other words, use is predicated on comprehension and for this reason, it should be optimized. The comprehensibility of an Informative Art application is closely linked with its *data mapping* structure.

Contingent on the underlying data mapping, *aesthetics* is central to the notion of Informative Art and constitutes a "criterion in and of itself" (6). This involves ensuring that the visualizations created are 'environmentally appropriate" (14) and "blend in with surroundings and are appealing to look at" (4) but may also be extended to include notions from *pragmatist aesthetics*

(33)*, Artistic Computing* (27) and the *Aesthetic Interaction Perspective* in HCI (32, 33). Despite an emphasis on aesthetic considerations, there has been little exploration of aesthetic styles or artistic design strategies that may have synergies with information visualization. In order for IA to reach its expressive potential as art, there is a need for more exploration in this regard.

Lastly, there is some precedent in the literature for user customization of both visual mappings and data sets as is the case in InfoCanvas (7). When built into an IA application, these properties help to 'leverage off of the user's previous experience" (8) and may enhance comprehension (19). Ultimately when ambient systems are effectively deployed, it becomes possible to go beyond information visualization to the creation of user experiences, such as the feeling of "social presence" and the feeling of immersion (13). Although "an ambient information visualization is usually not interactive" (4), there is no inherent reason to preclude Informative Art applications from benefitting from *interactivity*, and indeed several relevant interaction models have been suggested which can promote the expressive scope of these applications, without increasing distraction (15, 16). The future of Informative Art may lie precisely in interactivity.

The Periphery

The domain of peripheral awareness is arguably the area pertaining to Informative Art that has been most studied. By mining the related fields of ambient display systems, peripheral displays, and dual-task displays, it is possible to identify strategies that are relevant to keeping an Informative Art application peripheral to attention. First it is important to note that the "usual parameters and characteristics for a work of art have to be heavily modified to be successful in an ambient environment" since art does "not normally strive to be innocuous or inconspicuous" (25). This suggests that peripheral awareness, especially as it relates to Informative Art, is actually comprised of two challenges: how to keep distraction to a minimum, but also how to gracefully draw attention in order to convey some data event or condition. Maglio and Campbell described this as a tradeoff between *distraction* and *feedback* (20). Distraction is something which draws attention constantly, while feedback "can help cue glances" at the display. In this way, inherent in Informative Art is the expressive potential to create art that is both capable of being inconspicuous as well as attention-seeking, depending on context. Given the overarching fact that "attention is central to all perception" (40, p. 359),

the success of an IA application is predicated on the effective mediation of attention and distraction from the periphery.

In general, the key to keeping things in the periphery of attention is to not draw attention; in other words, peripheral awareness is something we don't do rather than something that is done. For this reason, it is important to identify the factors that have the power to draw attention, disturb, or distract, both so that we can avoid them and so that we can identify those techniques that work subtly to selectively draw attention when necessary. Depending on the context of the application and the intentions of the designers, they may decide to exploit these strategies to lesser or greater extents, while keeping in mind that many of these conclusions result from peripheral awareness studies that are often task or performance oriented.

Considering that there is a need for informative art displays to be seen as dynamic and not static, animation and motion are typically used and there is evidence to suggest that they can be used in ways that are beneficial and not distracting. Bartram indicates that the "human visual system is pre-attentively sensitive to motion across the entire visual field" (24) and so using motion can be an effective technique for tracking without increasing cognitive load, especially in the periphery. Since motion is also transient, in the domain of IA which is already constrained in terms of its informational capacity, this has the benefit of increasing "the dimensionality [of data] without overloading density" which is also important since Somervell et al. identified visual density as a factor which "may result in additional distraction" (23) in their peripheral monitoring tasks. Motion, unlike blinking which is often seen as annoying and contains little coding capacity, has the capacity to augment *annunciation,* acting "as what Woods calls a cognitive tool [28] for selectively drawing attention" (24).

Smooth motion specifically has the potential to gracefully draw attention without disruption. Maglio and Campbell found that continuously scrolling animation, irrespective of direction, is more distracting and provides less feedback than start-and-stop animation, although comprehension and recall are equal in both (20). This shows that start and stop animations "balance motion and feedback in displaying peripheral information." They also found that animations that are the result of movement that are too gradual such as slow fading, are too subtle "to provide update feedback" or distraction. This is predicted by perceptual science in the concepts of *change blindness* and *inattentional blindness.* Within peripheral awareness, users

will fail to attend to large changes in a display or to patterns that they are not paying attention to. This has been attributed to the fact that we can hold very little information in our visual memory, and 400 msec is the buffer for visual memory (40, p. 357). Other attributes of motion that can be harnessed to draw attention include *phasic data, large pattern changes,* as well as *push and pull cues*. The phasic attribute of motion has the capacity to not only draw attention selectively (when moving from synchronized to out of phase) but also to convey "not only that an association exists between data but also something of the dynamic semantics of that association". (24) Mack and Rock found that push and pull cues could also cause shifts in attention as well, and there is evidence that large pattern changes are noticeable as well (40, p. 359).

There are some important points to consider in attempting to relate this science of peripheral awareness to the domain of Informative Art. The degree to which an Informative Art designer wishes their system to remain passive or to provide subtle cues for attention will determine the degree to which they will implement these different strategies. Also, since the "rate of change in the information source is something that can not be changed" (4), it may become necessary as Skog et al. suggest, to instead affect the "update rate of the display [which] is under the control of the developer". In other words, by controlling the specifics of animation, it becomes possible to find appropriate representations for information sources of varying rates of change without creating undesirable distraction in the IA display.

It is also important to note that some design strategies employed in various Informative Art applications, such as the Mondrian inspired applications of Skog et al. (1-4), have the perceptual effect of minimizing distraction to the point of never drawing attention, not even selectively. While this may be a deliberate design decision for Skog et al., in general other designers may want to build in subtle cues which can act as notifiers, selectively drawing attention to data events or changes in information. For example, Skog et al. frequently map many of the changes in data, such as changes in weather conditions or local bus scheduling, to color changes (1,4). Since peripheral vision is color blind, this "rules out color signals" (40, p. 361) in annunciation. In these cases, Bartram showed that motion, more than shape or color, is far more effective at attracting a user's attention (40, p. 360). Moreover, while we have a "a low ability to detect small targets in the periphery of the visual field", having "whole groups of objects that move is especially useful in helping us to attend selectively' (40, p. 360). It has also been

found that one second is too short an interval for an event to effectively draw attention from the periphery (23, 30). An eight second interval offers more reliable detection and is more effective at drawing attention (23). Perceptual science predicts this since *saccadic suppression* causes events in the periphery to be missed if they occur during eye movement. These three factors combined suggest that a single, abrupt change in the display is "unlikely to be an effective signal" (40, p. 361) for subtly drawing attention or helping users to cue glances in order to acquire information. Motion, or perhaps the "appearance of a new object in the visual field" (40, p. 361-362) is much more effective at selectively drawing attention.

A final note is in order regarding the nature of information that is peripheral in *display* as opposed to *content*. While it is clear that there are discrete attributes that make visual *content* more or less likely to draw attention or be distracting, there are also factors concerning the placement of visualization objects or displays that effect peripheral awareness. One way in which this is achieved is by "placing the display objects at locations where they do not interfere with too many other sources of information" (1). Also, with increasing digitization, there is a tendency for information and domestic material to "no longer have a physical form" (32) as displays replace artifacts. This stands in direct contrast to most home environments where "persistent visibility is an important matter" and in which people need to surround themselves with objects 'which have history and biographies". By exploring modes of Informative Art that are not necessarily display or screen-based, there is a possibility to promote modes of information presentation which is peripheral in *display* as well as *content.* An interesting example is Rodenstein's Employing the Periphery: The Window as Interface (29). By exploring a display scenario that does not focus on a traditional display object, Rodenstein is able to expose a mode of information presentation which not only operates naturally in the periphery, but also exposes natural synergies between context and data, in that the "window is a natural place to display weather forecasts." Herein we find one of the many trade-offs in Informative Art - the chance to convey information which is peripheral in content and in display.

The Data Types

Currently, there is little consensus or information regarding what types of data are best represented in Informative Art or how to employ those data types based on perceptual science. One view is that the physical environment in which the display is located itself represents a data set, whose attributes can be revealed ambiently. This view presumably has its origins in the

fields of ubiquitous computing where the information exchange in the work environment is revealed through embedded technology. This type of *localized awareness data* often involves mining the physical environment and digital networks for events and information, often through the use of sensors or network parsing. Indeed there are usability benefits from designing IA "so that the scope of the information is clearly linked to the placement and possible users of the display" (4) since the application becomes more compelling when it is relevant to the specific place. The Disappearing Computer Initiative of the European Union seeks to "imbue ambient systems with contextual knowledge about the environment" in order to design "smart architectural spaces that support information conveyance." (14) There is also an expressed preference for actionable data sets that help "in carrying out a certain activity" (4).

Alternatively, some ambient information systems seek to represent more *global awareness data*, often in real-time (1-7, 9, 10). This tendency is most prevalent in more conventional, PC-based peripheral awareness systems such as InfoCanvas(7) and BlueGoo(11), which seek to connect users to a variety of information, much like web-based information dashboards. Time of day, weather, stock, news, airfare, emails, and sports scores are cited as "examples of information people typically seek to maintain awareness of" (19).

Still other IA applications explore the representation of *metadata* as in the example of the Redstrom's Chatterbox (1) in which strings of text from office emails are arbitrarily combined together to form a textual ambient display of recombinant email activity. Pousman and Stasko predict that designers of ambient information systems will begin to explore multiple information sources interacting to affect a single part of the representation, or metadata in other words (14). Indeed, given the constraints that aesthetics can impose on the informational capacity of IA, it may be desirable to directly represent relationships in data through metadata sets, rather than to display raw data.

Despite these differences in types of data represented, in general, ambient information systems "have pointed aesthetic goals and present a very small number of information elements" (14). Indeed, Pousman and Stasko project that they "do not expect the information capacity for ambient systems to increase dramatically" (14) in that they will never turn into information visualization displays showing thousands of data points. Nonetheless, visualization science can

be applied to these data sets to reveal some insight regarding how these data can be visually mapped effectively within the domain of Informative Art.

The Data Mapping

Visualization science can be instructive not only in determining what types of data to represent in Informative Art, but specifically in how to map them effectively. In their evaluation of InfoCanvas, Plaue et al. found that "participants noted and recalled significantly more information when presented" with the non-abstract graphical InfoCanvas than with text-based displays despite having a greater cognitive load due to "having to learn the additional graphical representations employed" (19). Visual art is inherently powerful in conveying information and "people are able to process images rapidly by leveraging the sophisticated, parallel, and high bandwidth nature of the perceptual system." The ability for IA to provide information in the periphery and at-a-glance is also promoted by the fact that "graphics are conducive to recall". Simple graphics, or iconic graphics, may also trigger related concepts in semantic networks of long term memory and "should make excellent memory aids" (40, p. 230). This is especially important in the context of IA where ease of comprehension and at-a-glance conveyance is desirable. *Priming* can further augment the role of visual memory in allowing visual changes to be recognized more readily without directly attending to them.

It is also true that although words have the advantage of being ubiquitous, images are better for "spatial structures, location, and detail" (40, p. 303) as well as for showing structural relationships, such as those seen in bus schedules as Bartram showed (40, p. 304). When it comes to conveying spatial, and especially localized, data in the context of Informative Art, the notion of *frame of reference* can be an important design consideration. Plaue et al. report that "ecological layouts with objects in natural positions have been shown to facilitate faster browsing" in peripheral awareness tasks (19). In Holmquist and Skog's bus scheduling IA application (4) they found that the direction of the buses were not conveyed intuitively, and in their user study they discovered that users needed a connection to the physical world. Some "asked on what wall the display would be situated, using the physical surroundings as a point of reference" (4). In their analysis they concluded that "arbitrary spatial mappings ... tended to be harder to remember" and using body orientation and "actual geographical landmarks...rendered the best results". As a result, in their next iteration the designers made use of *categorical* or *declarative* spatial mapping by depicting the town river abstractly in their display. Visualization

science predicts these effects in that humans use body and head orientation to form an *egocentric frame of reference.* Obtaining at-a-glance information often requires mental synthesis from visual memory and in order "for objects acquired in one fixation to be re-identified in the next requires some kind of buffer that holds locations in egocentric coordinates as opposed to retina-centric coordinates" (40, p. 357). As a result, acquiring a "synthesis of information obtained from successive fixations" is augmented by exploiting an egocentric frame of reference in the data representation.

In the same study, the authors found that users also expressed a desire for actionable data to be highlighted in relevant ways. Indeed, there is a trend within Informative art for all elements of the represented data to be treated almost indistinguishably. When it comes to instructional or actionable information, text is a superior representation than imagery (40, p. 304). However, animation "brings graphics closer to words in expressive capacity" (40, p. 305) and it has been shown "that images and words in combination are often more effective than either in isolation" (40, p. 306). Since there are many artistic styles that make use of typography and textual elements within imagery, IA would benefit from mapping actionable information directly in these ways to enhance conveyance. In general it can be said that "multimodal communication results in fewer misunderstandings" (40, p. 309) and this is especially important in the context of IA, where there is an absence of explicit cues for understanding and the necessity for ease of comprehension.

Since it is "important to make the most crucial information available at a glance" (1), another way in which IA can visually map data in order to reduce misunderstanding and promote comprehension is by maximizing redundancy of coding in representing data dimensions. This is especially important since often "users expressed a dissonance between their own associations to color and [the] mapping" of data (4). Unlike traditional information visualization, IA does not have the benefit of legends, explicit cues, or any other means of ensuring representational fidelity, which is why redundancy is one effective way at preserving comprehension within these systems. Depending on the artistic style of a particular IA application, coding redundantly has different implications since "visual processing of objects is very different from the massive processing low-level features".

In the case of abstract art which is not image based, but instead relies on color, shapes, and lines, comprehension will come from processing of low-level pre-attentive features. Although Skog et al. suggest that IA is not intended to convey quantitative data (39), it is still worthwhile to represent qualitative data less ambiguously, which will ultimately aide comprehension and preserve ambience. Nowell suggests that "color-coding should only be used for the information that is most directly relevant" (4) while integer and real-number data are best represented by size or other scalable visual attributes. Considering the previous discussion regarding the inability of color to effectively mediate attention in the periphery, it becomes important to combine visualization strategies in order to preserve both representational fidelity without compromising the peripheral nature of the display.

Especially in the case of abstract art styles, it is also important for the visual features used have a direct or at least metaphorical mapping to the data represented. Redstrom describes an IA application which uses a generative, abstract aesthetic and employs the Lindenmeyer system of artificial life through a series of highly complex, iterative mathematical expressions to map "information about the frequency of communication over e-mail as well as website traffic" (1). While his intent may have been to convey "abstract knowledge" in this case, in principle and in general, comprehension of IA applications will benefit if users are able to relate low-level perceptual features of the abstract visual to some aspect of the data mapping in intuitive ways, "thus providing a mnemonic" (4). IA is intended to exist in the periphery and operate without providing explicit cues or explanation; as such, the data mappings should not require users to aimlessly perform mental gymnastics in order to discover mapping relationships, and to the contrary, individual data representation should be reinforced through redundant coding of low level perceptual features which ideally are pre-attentively processed and intuitively grasped. Another reason to use redundant coding is that when multiple data attributes are integrated into a single glyph, more information can be held in visual memory (40, p. 355)

As a corollary, it should also be noted that it is important to preserve *consistency* of data mapping in IA applications as well. When focusing on an artistic goal and especially when "adhering to a visual template that has been determined without concern to the information that is to be visualized" (4), there can be a tendency to selectively map data to different visual features inconsistently. For example in Holmquist's Bus Schedule application, some black lines are mapped to data while others are not. Although the researchers concluded that "the

design was still considered intuitive" (4), it is presumably desirable to avoid this form of selective coding to aid in comprehension and reduce misreading.

If the expressive scope of Informative Art is to be expanded to include a diverse range of artistic styles, including object based styles such as portraiture and landscape art, an understanding of *object coding* can be elucidating. Especially in peripheral awareness applications where information should be easily accessible, it is important to work within the established limits of visual working memory and design applications which can take advantage of perceptual mechanisms. In general, three to five simple objects is the capacity of visual working memory and if color, shape, and texture are distributed over more objects, memory declines for each attribute (40, p. 355). In other words, by mapping various data to the different primitive visual features of objects uniquely, we can ensure that those features are processed in parallel. In this way, object based art has the potential to be used to good effect in informative art by "employing a 'single contoured object' to integrate a large number of separate variables" (40, p. 239). This not only has the benefit of lessening cognitive load but also reduces visual clutter, which is often a desirable attribute for artists pursuing a minimalist aesthetic and simultaneously contributes to low visual density which can help avoid unwanted distraction (23).

Consistent with the previous discussion regarding the need for intuitive mapping of low-level visual features to data, "object display will be most effective when the components of the objects have a natural or metaphorical relationship to the data being represented" (40, p. 239) and this can reduce the incidence of accidental misreading. Having direct or intuitive mapping of images to data may also be beneficial in conveying information quickly by activating *gist* or "properties that are pulled from long-term memory" (40, p. 356) which can trigger semantic meaning in as little as 100 msec. In fact, by exploiting the fact that we may store the gist of whole environments, it may become possible to depict increasingly complex data sets in IA applications, especially *localized awareness data* sets which are grounded in the specific environment of the application.

This allows us to suggest a general principle for data mapping in Informative Art: namely, that information conveyance, irrespective of artistic style, is likely to be enhanced through direct or metaphorical mapping to visual features. IA applications that make use of visual objects, as opposed to abstract visual features, have the benefit of being "most useful when the goal is to

give an unequivocal message about the relationship of certain data variables" (40, p. 257). Abstract art styles, like abstract representation in information visualization, will "more readily afford multiple interpretations" (40, p. 257) which may be advantageous in the context of specific artistic or informational agendas.

Metadata is another type of data which must be carefully designed for to avoid the potential for breakdown in comprehension in IA. While it may be advantageous to explore the representation of metadata in IA given the limits on informational capacity, there must be an effort to avoid distorting raw data in an arbitrary or randomized manner. Redstrom et al. found that in their Chatterbox application, users found "recombination of material as more of a degradation of information" (1) than as legitimate metadata. Their application randomized the recombination of strings of email text, and semantically there is a breakdown that will inevitably occur when treating linguistic structures in this way. IA may be best suited for representing metadata that is either pre-generated, perhaps using traditional information visualization techniques, or at the very least generated by the IA application in a way that preserves representational relationships and fidelity to the data. Metadata has the benefit of being able to directly convey relationships within raw data, but it is important to ensure that the structural rules used to generate metadata reflect the true relationships within the raw data set.

Lastly, within the literature, there is generally a consensus that IA applications have inherent constraints on informational capacity given the fact that they reside in the periphery and are meant to convey information quickly, without explicit cues. Despite these limitations, it may be possible to enhance the informational capacity in specific contexts by exploiting the concept of *chunking*. Since IA largely relies upon visual memory, there are prescribed limits on the number of effective usages of color, object, and spatial coding. For this reason, enhancing informational capacity of these systems is not as straight forward as simply increasing display size or the dimension of time, although large displays appear to have some benefit on performance for spatial tasks (38). A possible way to increase the informational capacity of IA is to take advantage of *chunking* by exploring representation of "contextual sets of information [which] may be useful for ambient systems in specialized environments" (14). Although we are capable of relatively few elemental visual queries at a time, it may be possible to query patterns of "greater complexity as we become expert in a particular set of graphical conventions" (40, p. 376). In these contexts, it becomes possible to enhance informational capacity by referencing

high level concepts in *visual query construction* for "rapid evocation of the semantic network" (40, p. 369).

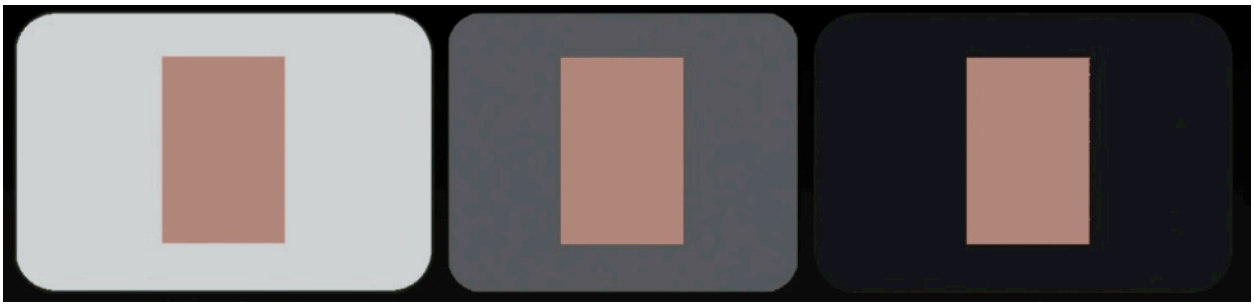
The Aesthetics

As the underlying visual framework of IA, an appropriate aesthetic style when used effectively, has the capacity to enhance information conveyance as well as gracefully mediate attention from the periphery. Despite the fact that "aesthetics is considered a primary property, both in design and during use" (10), IA applications have generally expressed a limited range of artistic styles and aesthetics. This may be partly due to the lack of research on the specific tradeoffs between aesthetics and visualization within this field, but is also a result of a lack of involvement by practicing artists in designing these applications (2, 39). Many IA applications have explored abstract aesthetics, often mimicking the styles of previous artists (1-4), while others have explored collage and textual designs (7-11). Pousman and Stasko predict "radical change" in aesthetic approaches to data representation, as designers explore the affordances of different mappings (14).

Art is Information

First, it is instructive to note that one of the consequences of a design approach that prescribes strict adherence to an aesthetic template without consideration of the information represented is that the potential exists for the resulting display to be informationally compromised. An example is seen in an application designed by Redstrom et al. to display notions of objective and subjective time. Mimicking the monochrome artwork of Yves Klein, the application aesthetic appears as a rectangle in the middle of an outer field. The "darkness of the [outer] field will show what time of day it is, and the nuance (i.e., slightly red, blue or green) of the field will show how much of the hour has passed" (1).

Although Redstrom et al. insist that IA is not intended to convey quantitative information, there is still a fundamental problem in the aesthetic basis. The color of the inner rectangle changes in the exact same way as the outer field, except that it responds to email events as opposed to the passage of time. The same shade of gray in one field may appear darker or lighter on a given day depending on the brightness of the adjacent field due to *simultaneous brightness contrast* effects. This is a kind of built-in mechanism which results in misreading of information and illustrates some of the pitfalls of arbitrarily selecting aesthetic styles and pairing data sets to those styles. It is clear that there is a need for more investigation of diverse artistic styles of representation and a description of benefits associated with specific aesthetic approaches.



Toward a New Aesthetic

By exploring visualization science, it may be possible to uncover synergies that exist between aesthetics and information conveyance, which may lead to new design directions.

At a crude level, there are implicit tradeoffs in visualization potential when considering abstract versus non-abstract forms of art. Namely, abstract images are harder to recall since "it is important that visual information be meaningful and capable of incorporation into a cognitive framework for the visual advantage to be realized" (40, p. 304) For this reason, abstract aesthetics in Informative Art must effectively code pre-attentive visual features in order to be capable of conveying information in the periphery. Strangely, a non-abstract art aesthetic has been under-represented in IA applications; nevertheless, this aesthetic can take better advantage of visual memory and the mechanisms which underwrite object perception. In order to open up the design space of Informative Art, it may be useful to suggest some examples of non-abstract artistic styles and their perceptual and informational affordances.

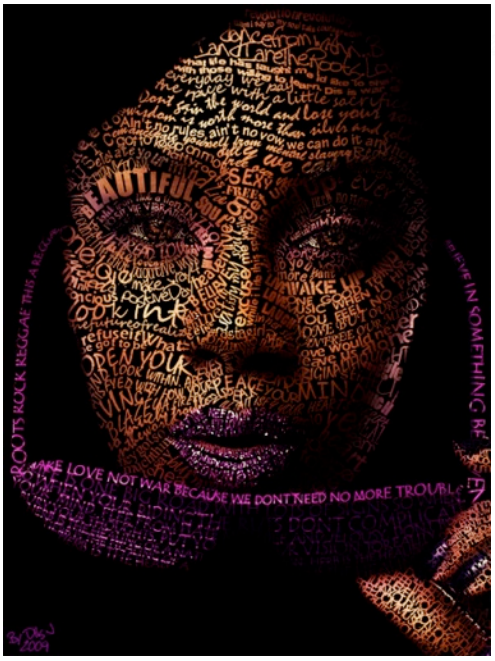
One artistic style which formed the basis for much of the exploration throughout the history of art is realism. For millennia, faithfully representing reality through art was considered the height of artistic expression presumably because of the emotive and reflective connection that all people have to the world. Today, there are a wealth of aesthetic approaches which have realism at their core. From an a informational standpoint, depicting people, places, and objects from the real-world can take advantage of object processing and the fact that although we can only process a few objects at a time "all features of that object are processed together" (40, p. 257). The ability for objects to be processed in this way makes them "the most powerful way of grouping disparate data elements together" and this can enhance the informational capacity of IA displays. This suggests that by mapping various object attributes to data in IA, it may be possible to explore non-abstract, object based artistic styles such as photorealism, caricature, vector art, pointillism, and line drawings. It has been shown that simplified images such as line drawings are recognized more rapidly than photographs (40, p. 237) which may help users to quickly obtain information from the display peripherally. One of the "consequences of structural theories of perception is that certain simplified views should be easier to read" (40, p. 233) and there seems to be some confirmation of this within the field (19). Alternatively, since Informative Art is unlike some other peripheral awareness systems in that it may become the explicit focus of attention at times, more complex visual depictions may also be acceptable and could potentially contain more detail, both visually and informationally.

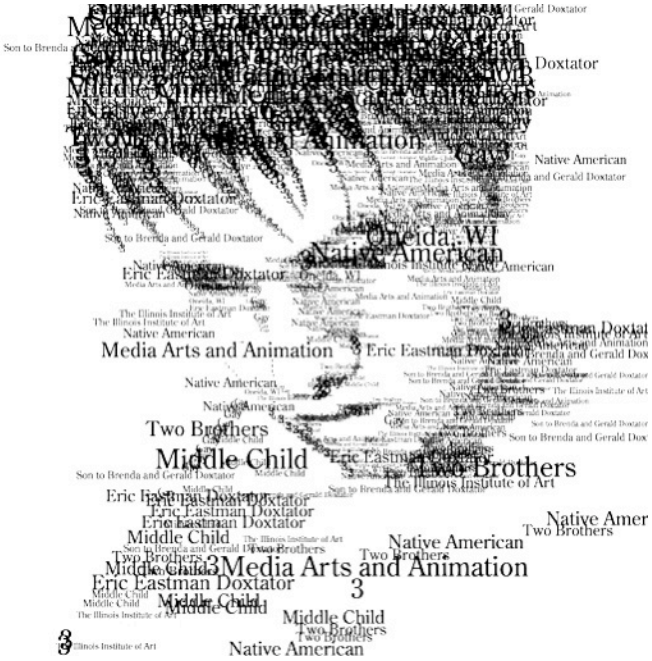
Artistic styles that make use of *faces* (as in portraiture), *animate motion*, and *silhouettes* may also be particularly interesting. Silhouettes are "especially important in determining how we perceive the structure of objects" (40, p. 233) and so may be used to selectively draw attention or to dynamically represent information in artistic ways. A slowly animating display based on contour generation could morphologically fluctuate between different silhouette representations in ambient ways, depicting different data events or attributes. An added benefit of silhouettes is that since contour generation can be animated and morphological, this could potentially amplify the dimensionality of the data since one can imagine a scenario in which multiple silhouettes become additive or merge to reveal new data dimensions. City skyline art, which is also a popular artistic aesthetic, shares this capacity and a 'morphological skyline' application could also take advantage of our perceptual ability to recognize canonical silhouettes.

Similarly, IA applications which pursue a portraiture aesthetic could take advantage of the "obvious importance in communication" (40, p. 238) that faces have. It may be possible to map data qualitatively to a range of facial expressions since "certain human expressions are universal communication signals, correctly interpreted across cultures and social groups." (40, p. 238) Given the fact that "faces are special objects in human perception" (40, p. 237) it may also be possible to use faces to selectively draw attention from the periphery, perhaps to signal some data event or change. Also, since people are also "highly sensitive to motion that has a biological origin" it may be possible to represent data and convey meaning through the use of patterns of animate motion. Although text is generally better for conveying abstract concepts, Heider and Semmel found that animate motion "could express such concepts as kindness, fear, or aggression" (40, p. 224) across cultures which suggests that the representational capacity of animate motion could be exploited by IA applications to convey qualitative or abstract data.

Given the natural synergy between text and the direct signifying of data (14), in some cases it may be desirable to find aesthetic approaches that will allow for the artistic inclusion of alphanumeric or textual elements into an IA application. The visual appeal of previous approaches has been deficient (11, 12). While it is important to maintain the look and feel of the application as a visual object and not a traditional information visualization system, there are many artistic styles which incorporate words and number gracefully into their aesthetic. Especially in cases where there is an attempt to represent quantitative data, some users of IA application may prefer "more exact, number-based information" (4) instead of abstract representational mapping. Various forms of typographic art, including collage, graffiti art, and calligraphy offer an attractive approach to incorporating textual elements into IA without

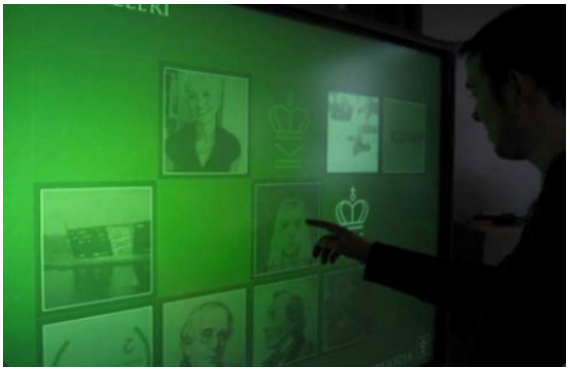
compromising aesthetics. In fact in some cultures, calligraphic paintings which make use of highly stylized script are considered to represent a pinnacle of visual art. Even more interesting, some calligraphic and typographic styles exploit the fact that “we can choose to attend to a particular pattern that is a component of another pattern, even though the patterns overlap spatially” (40, p. 360) by using highly layered writing to form images or silhouettes. If we also consider the fact that we can “attend to a particular attribute if it is pre-attentively distinct”, it is possible to design a visual display that appears image based at a distance but is actually composed of textual, and thus directly signified, data when one explores the granular detail. By making using of direct as well as symbolic or metaphorical mapping concurrently, it is possible to increase the information capacity of IA in this way, as well as explore new aesthetics styles.

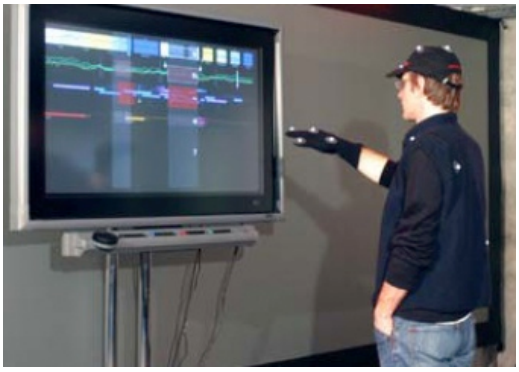




The Interactivity

One of the benefits of peripheral information systems is that they are able to convey information ambiently without capitalizing on the cognitive load of users. If a 'wealth of information creates a poverty of attention' as Herb Simon states, it becomes necessary to find meaningful ways to reduce the saturation of information density, preferably without reducing its availability. Informative Art and peripheral information systems seek to serve this need. It is important, however, to consider that peripheral or lightweight awareness information "often causes the user to initiate communication by more heavyweight means" (8). Currently, much of IA does not support this multimodal function, and *interactivity* holds promise in the design of more robust applications with increased information capacity, aesthetic appeal, and functionality. The ideal of interactivity can be instrumental to the design of IA that is "akin to what Umberto Eco calls 'visual icebergs' - minimal points of information on the surface, hinting at a wealth of data below." (28)



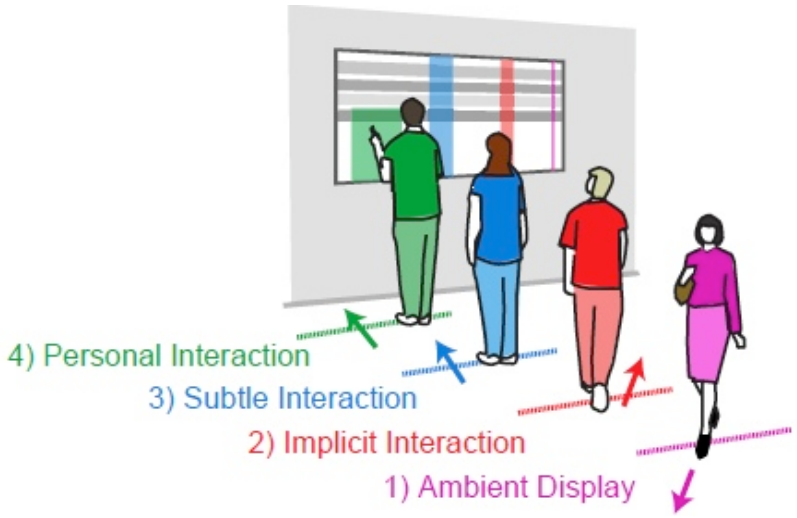


An Interaction Model

Vogel and Balakrishnan have suggested an interaction model within the context of peripheral or ambient information systems that can "support the transition from implicit to explicit interaction" (15). They have achieved this by taking advantage of simple hand gestures and touch screens for explicit interaction, as well as body orientation and position cues for implicit interaction. They have identified design principles such as calm aesthetics, ease of comprehension, socially acceptable notification, short fluid interactivity, and immediate usability. In order to effectively reside in the periphery but also support periodic explicit interaction, interactive IA "should reveal meaning and functionality naturally" as well as possibly discover cues for interruptability with socially appropriate and context-aware strategies. Further, they

should support “quick information queries rather than involved activities” to preserve the ambient nature of the display with seamless interaction.

The interaction framework consists of 4 continuous phases with fluid transitions: Ambient Display, Implicit Interaction, Subtle Interaction, and Personal Interaction. A similar framework has also been suggested elsewhere in the InfoGallery (16). These interaction frameworks suggest a model by which attention can be gracefully mediated from the periphery by taking advantage of implicit cues, such as proximity and body orientation, in order to provide subtle notification, all while ultimately providing minimal disturbance, calm feedback, and user control (15). Informational capacity is also augmented by interactivity since personal interaction can selectively reveal more detailed data through user control, all without disrupting display function. This is partly accomplished through size and placement of the display to avoid body occlusion, but also by linking visibility of the “proxy bar” or interaction zone to the implicit cue from the user. In other words, depending on body orientation and level of interaction from the user, the width, opacity and saturation of the interaction zone is controlled. It is important to note that in keeping with the necessity for Informative Art application to not approximate traditional computer-terminal type interactions, the authors have used simple and gestures to control interactivity, although voice recognition could also be used in the future. Although there is a need for motion tracking technology to advance before this interaction model can fully be realized (16), the framework is still promising and boasts appropriate properties for an interactive peripheral awareness system.



User Control

Another major advantage of introducing interactivity is the prospect for user customization of IA applications, as is seen in InfoCanvas (7) and InfoGallery (16). In general, it has been noted that user customization of both aesthetics and informational sources and mapping is a desirable trait of IA (7, 14). In fact, there is a strong correlation between interest in scope of information and finding an application useful (4, 17). Also, by allowing the "possibility to tailor the visual expression" of the application "by means of the GallerySkin concept", InfoGallery is able to enhance aesthetic versatility and interest (16). Furthermore, Miller et al suggest that "comprehension and recall would benefit" from user control of mapping (19) and Pousman et al. indicate that user configured applications "have even greater information capacity" (14). Indeed, by taking advantage of familiar concepts and gist through deep semantic networks, it should be possible to enhance comprehension and information conveyance through increased user control. Obviously, user control has the potential to be a double-edged sword so it is important for a defined customization framework to be in place to prevent conflicts between aesthetics and information, as explored earlier.

THE VERDICT

Informative Art has the "ambitious goal of presenting information without distracting or burdening the user" while at the same time seeking to fulfill the role of visual art within its environment. This has made IA "difficult to design for and difficult to define in measurable terms" (17) and for this reason, the "majority of ambient displays that have been published have not been evaluated" or "report only short evaluations with few details or informal feedback". Understandably, evaluation of these hybrid applications is a complex issue and a comprehensive evaluative framework has not been identified, although Mankoff et al. have proposed a set of heuristics (17).

The Challenge

Part of the challenge of evaluation stems from the fact that unlike traditional information visualization systems, IA applications are meant to be "lived with rather than used" (4) and therefore "have to be studied in situ and in actual use rather than in a lab environment". In addition, since the applications reside in the periphery of awareness but are not task-based, this makes them "inherently difficult to evaluate formally since they are designed not to distract the

user" (19) and their usage is low intensity (21). Further, more than other information displays, there is a need to evaluate these displays in context and over the long-term in order to meaningfully evaluate usage (17, 21). The other complicating issue is that as a hybrid artwork and information display, "success of a peripheral/ambient display involves more than simple information acquisition" (19) and presumably should include the "reflection and critical analyses" (1) which characterize art criticism.

The Current Approach

Due to the diverse evaluative needs of IA application, to date there has been a rather amorphous approach within the field. The literature is often weakened by the inclusion of unevaluated statements such as "Reactions to these weather displays have been exceptionally positive" (29). Formal evaluative techniques have been "limited to formative ethnographies and iterative "living laboratories" or within-lab studies (17, 18) which are often costly and time-consuming. In other cases, self-reporting as well as motivation and incentive have been found to confound attempts to rate levels of distraction in peripheral awareness systems (11). Since there have been more efforts to evaluate peripheral awareness systems, which are often in dual-task situations or work-place contexts, there is a need for studies specific to Informative Art with respect to factors such as distraction, attention, and comprehension.

Mankoff et al. have offered a set of heuristics, modified from the Nielson system (17). Heuristic evaluation is quick and inexpensive way to get feedback about possible issues in usability, without determining if issues will actually impact usage. For this reason, heuristic evaluation is "rated as one of the top techniques currently in use in a survey of usability practitioners" (17). Since Nielson heuristics assume interactive, productivity-oriented systems, Mankoff et al. offered a new set which "support monitoring rather than efficiency". Their study found that evaluators using the modified set of ambient heuristics identified more problems, and problems of greater severity than those using the Neilson system. Although it could be argued that this is a modest measure of success because of the general inapplicability of the Nielson set to ambient displays, the authors combined aspects of both sets into a final heuristic in order to maximize the number of issues that could be identified. The final set of 12 criterion encompass the four design dimensions identified by Pousman and Stasko in their taxonomy, and is a promising technique within the evaluative repertoire for IA applications.

Holmquist has also introduced a model for evaluating comprehension in IA applications (21). He proposes three levels of comprehension: *that* information is visualized, *what* information is visualized, and *how* that information is being represented. All three levels must be satisfied before usage can be expected to occur. In another of their studies in which this model was used to evaluate a bus scheduling IA application, it was noted that people who did not take the bus "did not know that some data was visualized on the display" (4). This suggests that at the first level of comprehension, context and relevance of informational scope may influence adoption. Further, one user who knew *that* and *what* was being visualized "claimed that she was unable to read it, but in fact, when asked to explain the visualization, she could read it correctly". This suggests that in the absence of cues for understanding or "self-revealing help" (15), the perceived affordance of an application may be limited and without understanding *how* information is represented, users will not have "enough understanding to actually use" (4) the display. Ultimately by exploring these three levels of comprehension, the authors suggest that it may be possible to generate different diagrams to show the learning curves of various applications, which may be useful in identifying when designs are too difficult to learn or too difficult to remember.

New Directions

Interestingly, ambient information systems have been described as "minimally attended" in contrast to alerting systems which are "maximally attended" (14). This describes a valence between *peripheral awareness* and the domain of *situation awareness* which may form the basis for meaningful comparisons. Namely, the three levels of comprehensions proposed by Holmquist are analogous to the three states of knowledge in situation awareness. The first level - "perception of elements in the current situation" (34) - can be related to the notion of '*that'* in Holmquist's scheme. Although in situation awareness, operators obviously know that information is being visualized, this level of comprehension is contingent on their *perception* of the display in much the same way that IA users "do not use these displays as they would computers, they perceive the displays" (17). Understanding *that* information is being visualized is therefore a factor of perception since "attention controls what visual information is held and stored" (40, p. 353). The second level - "comprehension of the current situation" (34) - is closely related to an understanding of *what* information is a factor in the situation being managed. The third level - "projection of future status" - is predicated on an understanding of *how* that information will factor into the situation. Despite the fact that peripheral and situation

awareness occupy two ends of an attentional spectrum, there is a common need to satisfy these three roughly analogous levels of comprehension in order to be successful. In one case, attention is limited and distraction, notification, representation, relevance and other factors affect comprehension. In the other case, attention is maximized and individual factors such as "goals and objective, preconceptions, long term memory stores, information processing mechanisms, automaticity, abilities, experience, and training" (34) affect performance and comprehension.

It may be possible for evaluative methods in situation awareness to inform future approaches toward evaluation of IA. Namely, Situation Awareness Global Assessment Technique (SAGAT) operates by administering questionnaires spontaneously during situation awareness activities, either by freezing the activity or without freezing them (34). Post facto questionnaires are also used with the "obvious limitation that much of what is sought consists of the contents of working memory which has changed after the conclusion of the activity" (34). By employing an analogous approach in IA, it may be possible to evaluate levels of comprehension in a similar way. Skog et al. have already used a kind of random on-the-spot surveying in order to ascertain the various levels of comprehension among people within the vicinity of their IA application (4). This sort of intrusive and spontaneous assessment may offer the advantage of providing more representative results regarding the awareness and comprehension levels of potential and actual users of IA application in context, since studies from task-based peripheral awareness systems often presuppose user monitoring of the application. By combining post facto and 'during activity' assessment, it may be possible to assess the recall and intuitiveness of data mapping, or the success of representational fidelity and information conveyance within these systems.

But Is It Art?

The involvement of practicing artists, curators, and art professionals within the field of Informative Art will also undoubtedly help to coalesce a meaningful evaluative framework for the aesthetic and artistic assessments that will become instructive for continued progress of the field. Part of the problem of evaluating the aesthetics of IA lies in the fact that currently the notion of *aesthetics* is limited to the visual appearance of the display and its ability to blend into the surrounding as opposed to to being "intimately tied to use and instrumentality" (32). In order to realize a greater artistic purpose, IA must expand its concept of aesthetics to include "artistic criteria like the emotion raised or the readability at different semantic levels" (28).

The New Aesthetics

Peterson et al. have expressed this dissonance as being between *analytic aesthetics* and *pragmatist aesthetics*, advocating for the latter. Instead of operating from the notion that "aesthetics of interactive systems can be evaluated based on visual perception of pictures" (33), they suggest that "aesthetic is not inherent in the artefact itself but rather a result of the human appropriation of the artefact." Considering that it may be "meaningless to think of the aesthetics of artifacts in themselves", the authors suggest that although aesthetic potential may exist, it is only released in context and through use. This expanded notion of aesthetics has important implications for the expressive scope of IA, as well as for possible avenues of visualization science that can be employed to this end.

Within a pragmatist aesthetic framework, the strict adherence to artistic templates becomes de-emphasized. We can not express the full aesthetic range of the original work or the aesthetic potential of IA merely by replicating visual look and feel since the aesthetics of Mondrian's work is inextricably tied to its socio-historical context, as well as to its medium and use. This points to the idea that the aesthetics of the application are "not confined to be in line with the intentions of the designer" (33) but emerges from use, in context.

Similarly, Otjacques et al. have proposed the concept of Artistic Computing in the realm of Informative Art. They suggest that "some authors take the pieces of art as starting points and enrich them with computer aspects" (27) while other seek to augment computing artefacts through artistic considerations. The "purpose as well as the evaluation criteria significantly differ in the two contexts". In fact, the goals of artistic expression in technology relies on context and people's expectation of art. Whereas "the concept of pleasure is often associated" with artistic success of these applications, the authors suggest that although many novices believe that art should be beautiful, "subversive and questioning power may act as a substitute for the pure beauty to rate the quality of art." Based on this notion, IA may adopt a broader aesthetic approach in data representation, including those which are more audacious, unsettling, or less concerned with visual pleasantries. The implications of this approach for the visualization of IA is to open up a range of perceptual mechanisms and visualization techniques to make IA more visually impactful or affective in this way. One example is to exploit *perceptual illusions* or *vection* to enhance "the emotions, attraction, and affect invoked by design" (33). By playing on

other perceptual mechanism such as *atmospheric depth, occlusion, depth of focus* and *motion parallax,* it may be possible to confound or confuse. Through this broadened framework, IA will be able to express "an expansion of ideals ... to include subtle poetic elements exciting imagination" in order to realize a greater expressive capacity as art.

Why So Slow?

A last note is in order regarding the persistent notion of Slow Technology in Informative Art. Slow Technology has been invoked almost since the beginning of IA as a way to "actively promote moments of reflection and mental rest" (3). Unfortunately, it seems that too often the "invitation for reflection inherent in the design" is accomplished through design strategies that decrease comprehension or usability. Although it is true that "in an art exhibition, we're prepared for confrontation with the incomprehensible, but we have come to associate the computer screen with the rational and 'user friendly' with help readily accessible" (28), the main challenge of IA "consists in finding the right trade-off between cognitive efficiency and artistic interactivity" (27). Redstrom concedes that "unintentional slowness often results in frustration" (3) which raises the question of whether it is possible or desirable to express 'intentional slowness', especially in the periphery. Otjacques et al. question whether difficulty in understanding is "an intrinsic property of an artistic computing artefact" and conclude that while "these elements can be part of artistic computing they are not mandatory" (27). Indeed, there is a profound difference between reflecting on a computing artefact between one is baffled by its function or is struggling to understand it, and reflecting because it expresses a sense of mystery, intrigue, or beauty.

There are other ways in which Informative Art can promote reflection without necessarily damaging comprehension. Redstrom agrees that "delicate handicraft and design" (3) can also inspire reflection while Peterson argues that aesthetic interaction can help to establish new relationships with digital material and encourage 'play'. The trend toward straightforward and transparent domestic technologies will result in homes that "do not contain secrets" (32) or "stimulate our imagination and fill it with expectation and excitement". By exploring Spool's idea of "seducible moments" (16) in encouraging visible and playful modes of interactivity, we can create intrigue. Also, Gaver et al. suggest that "ambiguity of context and physical design may intrigue the user and engage him/her in use" which promote reflection without necessarily damaging the comprehension of underlying data representations. Ultimately, if Informative Art is

ever going to have an application in real world domestic environments, it is desirable to find other ways of promoting the *ideal* represented in Slow Technology without compromising the comprehensibility of the applications.

CONCLUSION

Informative Art represents a promising field within the emerging domain of ambient information systems, which is particularly suited to domestic environments. In order to progress toward *an ideal in Informative Art*, it is necessary to de-constrain the various definitions imposed on it, and at the same time to define some of the visualization approaches and design strategies which will be fruitful to explore. Although the intent of Informative Art has been defined since its inception as "not to create art pre se, but to explore the design space of information presentation from a different point of view" (3), it stands to reason that in order to realize its highest potential, there must be efforts made to enhance not only the aesthetic framework of IA, but also to bring its informational strategies within the umbrella of visualization science in order to allow for more deliberate function. By employing strategies that effectively mediate attention and distraction from the periphery of awareness and enhance representational fidelity and informational capacity, IA has the potential to become more robust, interactive, and relevant. Ultimately, regardless of the specific design strategies employed and artistic agendas pursued, Informative Art has the capacity to become a form of true technology art as well as a powerful addition to the information visualization repertoire.

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