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A SEMIOTIC ANALYSIS OF REPRESENTATIONAL IMAGERY USED IN A COLLECTIVE DESIGN TASK

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Abstract. Collective Design seeks to explore how new forms of Collective Intelligence, arising from the web, allows mass participation in design. Regarding design we have a well-established grounding for understanding how design works through the use of representations. Likewise, collective intelligence via certain crowdsourcing examples has demonstrated that a diverse crowd can trump ability groups, when the conditions are right. In the literature, crowdsourcing is the leading lens bridging design with collective intelligence. However in crowdsourcing design there is less focus on the role of shared representations, subsequently any collective diversity is mitigated by the models that govern the extraction of this intelligence. We propose that more effective design in collective intelligence lies in the crowd's ability to generate meaningful contributions via the content of shared representations. In order to investigate this, the current paper examines data collected from a pilot study in which a representationally rich online collaborative presentation tool is used to provide a shared design space. The analysis presented applies our previously established semiotic framework to identify potential patterns in the meaningful communication of image based design information.

Keywords. Collective Design; representation; semiotics.

1. Introduction

In order to better understand Collective Design (CD), researchers are increasingly leveraging crowdsourcing for insight. Underlining crowdsourcing is Hong and Pages' (2004) widely recognised axiom "diversity trumps ability". A theorem stating that a diverse number of opinions available from a crowd can outperform the smaller, higher ability group, when, as Surowiecki (2004) adds "the conditions are right". Current conditions for design

crowdsourcing rely on the simulated approximation of design phases and do not provide shared spaces for participants; consequently these simulated design phases require participants to contribute individually, at various stages, from work undertaken in isolation. A process which effectively reduces the essential assets that generate collective intelligence into a design oriented 'collected intelligence' (Maher 2010). While this 'condition' does successfully engage the crowd in producing larger volumes of design solutions, many are still disregarded. Those designs which are selected are still of no comparison to the results produced by expert design teams.

2. Background

The crowd by its' own definition is diverse, but the average member of the crowd is not expected to be as experienced as the expert designer/s. Even less possess collectively a shared understanding of the specific visual and linguistic conventions that govern expert/expert designer interactions. However, web based communities are part of a new cultural phenomenon whereby much of its communication is undertaken through adapting freely available online visual content to convey meaning. In the absence established design conventions crowd members will somehow need to share design information and are thought to rely on the meaning embedded in various images to communicate this information. An important first step in understanding this process is to provide the shared conditions for the crowd. From this we can investigate what representations non-experts use in a collectively open context and might better understand how representations are used to convey design meaning in a 'collective' and not 'collected' context.

As an activity, design is "bound to treat as real that which exists only in an imagined future and designers have to specify ways in which foreseen things can be made to exist" (Jones 1980). To this end the interaction with representations plays a pivotal role in foreseeing this 'what could be'. Given that the average member of the crowd does not have a fully developed vocabulary for communicating information in this context; it is thought that there will need to be some association between notational systems of representations in the encoding and decoding of design information. In order to begin looking at how notational systems are constructed by the crowd to convey design information we use semiotics. Semiotics provides a rational 'sign' based methodology for the analysis and evaluation of visual contents. It is widely used for analysing signs in images and provides a formalised interpretive framework for disseminating the meaning they contain. This occurs via an Interpretant / Interpretation relationship enacted through a sender (encoder) and receiver (decoder) relationship respectively.

Semiotic theory is a framework in which three types of imagery can be categorised, depending to how they allow for comprehension. These categories include icons, indexes, and symbols. Icon, Index and Symbol provide a coordinated way of talking about how meaning is expressed via the relationship between Representamen (the form a sign takes) Object (entity to which the sign points), and Interpretant (qualities expressed by the representamen) (Demsmedt, 2011; Chapman, 2004; DeGrassi, et al. 2008). Icons represent the 'signified' through the use of similarity and work by imitating the visual features of the object that it is representing. Indexes convey a relationship between the 'signifier' and the signified. Symbols operate, not by using visual or conceptual connections to the signified, but through a socially established convention (i.e., something that has to be learned before the meaning of the symbol can be understood) (Pierce, 1982; Mahin et al, 2001; Chapman, 2004; Chandler, 2005).

Design and Semiotics share several procedures which are directly related to the function of design representations; they both rely on descriptive notational systems to provide functional and generative – often in simultaneous combination – content (Nadin 1990). Descriptive representations often take the form of precedents or sketches to be recalled for comparative analysis (similar to the signified). These images can be relatively abstract in nature and easily disregarded in the design process in the search for more concrete functional diagrams or information (Wade 1977). Functional representations are based on defining structural characteristics (similar to the Signifier) and a more concrete in their nature. Lastly they can be Generative - where a knowledge base is constructed to generate new ideas, test, improve, and finalise in design (similar to the result of the Interpretant). The signs that convey contextual meaning in design can be categorized differently according to how they function in order to convey meaning or act as a cue in initiating further investigation.

3. Research Design

Using Prezi to provide an openly shared CD condition we conducted a pilot study whereby five participants were required to undertake an architectural design task. The brief was to design a beach 'getaway' cabin for a family of four. The web based design session ran over a three week period. Our participant backgrounds ranged from two warehouse workers, an IT consultant, a PhD student and an architect. This participant diversity allowed us to generalise their classification as either: Expert (architect) or Novice, a total of four novices and one expert. To reduce confusion and disorganisation, two formal requirements were established whereby each participants design work remained within a 'design circle' and not to delete another's work. There were

no identified or pre-established agreements regarding conventions for communication, nor did the participants know each other.

Previously, we presented a semiotic framework in order to provide initial evidence for the analytical power of semiotics in a collective design context (Phare et al. 2013). This enabled us to establish and describe how signs were used in a collective scenario to convey contextual information. We apply this semiotic framework (Phare et al. 2013) in a pilot study to further test our framework in analysing the meaning and potential patterns generated by the use of imagery by participant's when interacting with and through representations. This method has been applied across a variety of engineering and design environments (Hartmann and Vossbeld 2013, Wade 1977). In order to begin identifying meaningful data it was necessary to continue refining our framework and to incorporate a categorisation of representations most often used within design processes. This was achieved by incorporating the original notational tabular array presented by Wade (1977) in which the classification of design related notational representations are

Table 1 A semiotic characterisation of design notations (Wade 1977).

Class		**ICON**		**INDEX**	**SYMBOL**	
		Concrete	Abstract	Intermediate	Abstract	Concrete
		Person/Brief	**Purpose**	**Behaviour**	**Function**	**object**
FUNCTIONS BY	**Quantifications**	Human factors	Fiscal resource	Behavioural criteria	Parameter	Spatial measures
	Verbal statements	Concrete description	Abstract purposes	Operational description	Abstract function	Concrete description
	Diagrams with labels	Organisational charts	Objective hierarchy	Flow charts/Maps	Bubble diagrams	Construction documents
	Drawings	Realistic portrait	Idealised image	Diagram	Sketch (plans)	Realistic rendering
	Photographs	Photograph/Image	Stylised portrait	Action photographs	Moment of use	Progress photo
Interpretant		denotative	connotation	denote	connotation	denotative

semiotically organised as either concrete or abstract notations against a process oriented Person / Purpose / Behaviour / Function / Object categorisation processes (Table 1).

A limitation of the presented study was the reliance on a small group of participants for data. Within this data pool we observed three interactions although not recursive and each interaction type occurred only once without variation. Nevertheless they provided the opportunity to explore the potential patterns in representational use. We anticipate these interactions will be further enriched, verified and generalised in the upcoming main study.

4. Analysis

Thirty images in total were used in our pilot study, Figure 1 demonstrates, by category, the type of iconic, symbolic and indexical qualities employed to convey contextual design meaning in our collective design task.

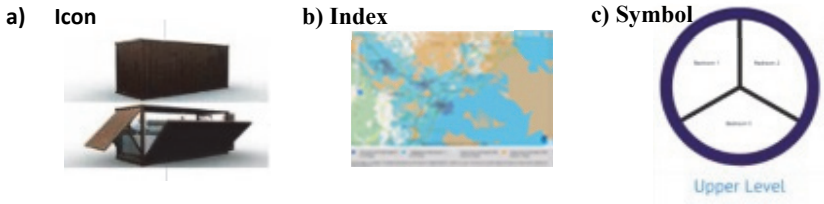

Figure 1 Examples of iconic, Indexical and Symbolic images used.

Seventeen directly **iconic** images where provided, each primarily as a precedent signifying various approaches to similar design problems. Ten directly **indexical** images where used, primarily geographical using Google maps. Indexical sketches were also provided and indicated reflexive design activity. These visualisations were mobile phone snapshots of sketchbooks. **Symbolic** imagery was provided via three images, a sketch plan, section and elevation, each constructed with Microsoft paint. Table 2 provides a categorisation of the above described signs to summarise the thirty images applied to convey meaning in our collective design task.

Table 2 Types of Contribution

	Types of contribution	Contributions
	Total Images used	30
	Digital Images of self-drawn Sketches	1 set
	Digital Sketches	3
Semiotic Class	Iconic Images (Photograph/Image)	17
	Symbolic Images (Sketch Plans)	3 SKETCHES
	Indexical Images (Diagrams (W/Labels))	10 MAPS
Interactions	Interactions generated by Index	0
	Interactions generated by Symbol	1
	Interactions generated by Icon	3
	Interactions generated by text only	1

Participants typically favoured contributing their work in bulk at the beginning, then continued to engage by interacting with the contributions of the other participants. All contributions were chronologically organised in order of insertion. This allowed for the recognition and isolation of the significant points where sign based events occurred. In our collective context there is no normal sender/receiver relationship associated with information

coding and decoding typically found in semiotic theory. For our purposes the individual remains the sender, the crowd becomes the receiver and any interaction with a 'sent' image was allocated a responder.

Based on the original contributions from our five participants we observed three sender / responder interactions. Using the Novice Expert classification we identified the type interactions as Expert - Novice, Novice – Novice and Novice – Expert. We did not identify any Expert - Expert interactions due to the presence of only one expert in our pilot. Our identified interaction types only involved one round of send and respond.

4.1. INTERACTION: EXPERT – NOVICE

Sender This expert participant provided a precedent by offering recalled images of similar, already existing' building. **Sign:** Image – icon / text - symbolic - (concrete – documentary photograph with concrete verbal description). **Functions by:** The sign itself functions as a concrete documentary photograph uploaded in JPG format. **Interpretant (Qualities expressed):** This image denotes False Bay Cabin by Olsen Kundig architects as the signified object. Whilst the primary function of this sign is as a precedent image, we also see the index and symbol. The index and symbolic elements function via quantification to provide a set of behavioural criteria (lock up, easy close panels, weekender) an indication of this participants point of reference. The image provides context and typology, scale and utility and provides a 'design' in its site context. It contains signs that can be interpreted as sunny, isolated, well ventilated, safe, secure and private.

Table 3 Expert Novice Interaction

Interaction	**Sender - EXPERT**		**Responder - NOVICE**	
Class	**ICON**		**INDEX**	
	concrete Similarity		Behavioural relation	
Functions by	PHOTO	Participant A 	TEXT	Participant C "Looking at these photos"
Interpretant	DENOTES: Typology		DENOTES: explicit action	

Responder Interpretation: The presence of this icon contained sufficient multiple layers of icon and index based information to generate a behavioural response of acknowledgement, or recognition by a novice member of group who provided a textual statement; a concrete personal description to indicate - "I am looking at these".

Potential pattern: Recognition. This pattern of interaction is concerned with a particular type of behavioural response that textually acknowledges the presence of the icon. There was no further direct exchange between these particular participants regarding this image after the responded acknowledgement, therefore it is difficult to measure the impact of this image on subsequent contributions by the novice participant who's contribution was the subject of the novice – novice interaction.

4.2. INTERACTION: NOVICE – NOVICE

Sender This novice contributed an image in regards to one particular component needed in the design task. **Sign:** Icon. **Functions by**: Functions via an image a documentary image (photograph) of Solar Panels as an isolated component required as an integral component in the design. **Interpretant (Qualities expressed):** The concrete photographic images are used to denote the practical functional behaviour as a necessity within the context of the design task. A second separate abstract indexical functional behaviour of the design component is demonstrated by the presence of the participants consideration for the need for storage and security to "perhaps secure the solar panels". The provision of the Icon representing the solar panel contributed as a generation of information which, conveyed as 'what will be needed', and the abstracted indexcial reference to storage brings the notion of storage into question.

Table 4 Novice Novice Interaction.

Interaction	**Sender - NOVICE**				**Responder - NOVICE**			
Class	**INDEX**		**ICON**		**INDEX**		**ICON**	
	Intermediate Behaviour		Concrete Similarity		Intermediate Behaviour		Abstract Purpose	
Functions by	TEXT	Participant C "Panels would probably be enough to run basic appliances"	PHOTO		TEXT	Participant D "As well as producing electricity, they could serve the function of creating shade for the structure."	PHOTO	
Interpretant	DENOTES Functional Behavior				DENOTES Abstract Purpose			

Responder Interpretation: - the presence of the iconic solar panels initiated a response whereby the novice responder decoded the original functional purpose of the Icon and applied abstraction by shifting an interpretant meaning from the literal object and its function to an interpretation of abstracted

function. As a result the solar panel 'could' now act as a shade device. The re-contextualisation, through interpretation and abstraction of the sign from operational description to abstract function presented an idea that might not have otherwise occurred without being prompted in the first instance by the presence of that particular sign image.

Potential pattern: Modification. Through the modification of existing meaning toward abstracted uses the concrete similarity of the original icons meaning was accepted by the responder and the meaning was subsequently adapted by the responder to produce abstract purpose of shade as well as power. Through the Icon – operational description to abstracted purpose – icon combination we observed the transition from the singular functional behaviour of the solar panel which was the original meaning in the use of the solar panel – to an abstracted functional purpose which was the alternative implementation of the initial solar shade component. The dual use of shade was abstracted from the original sign image, its meaning modified and re introduced into Prezi by the responder (becoming a sender) who uploaded an icon of a precedent structure in order to generate a visual reference for the new meaning (Table 5). No interactions occurred following this instance.

4.3. INTERACTION: NOVICE – EXPERT

Sender: This novice participant was the only participant in the pilot study who employed a convention typically associated with experienced designers. He provided three Symbolic Drawings in the form of abstract sketch plans **Sign:** Image – symbol. **Functions by:** The sign itself is an abstract symbol which functions via a digital sketch drawing uploaded in JPG format. **Interpretant (Qualities expressed):** This symbol denotes a functional layout of a circular floor plan, the accompanying symbols where an elevation and an upper floor plan. This novice participant took into consideration the fiscal and human factors, and subsequently developed an operational description in the form of a sketch plan. This was provided in response to the human factors and quantifications established by the brief. There is directness to the symbolism used by this participant which is dominantly denotative of a domed structure, which due to the high wind and shifting nature of the dunes seemed a sound choice in quantifying the behavioural criteria of the building typology suggested. Materials were not considered.

Table 5 Novice Expert interaction

Interaction	Sender - NOVICE		Responder - EXPERT	
Class	SYMBOL		INDEX	
	Abstract function		Behavioural relation	
Functions by	Sketch	Participant E 	TEXT	Participant A "Do we have any precedents that suggest this form will work in an environment such as this? "
Interpretant	DENOTES Behavioural Criteria		DENOTES quantification	

Responder Interpretation: Expert - This was the only digital symbolic plan sketch produced and was immediately engaged by the expert participant. He indicated a further need for more information regarding the suitability of the suggested building typology by asking "Do we have any precedents that suggest this form will work in an environment such as this"? By placing a text box next to this sketch our expert participant indicated that his question was directly related to this sketch. He directly denotes the need for more information that will justify the behavioural criteria established by the digital sketch plan.

Potential pattern: Questioning. The symbolic sketch contained sufficient information to engage the expert participant almost immediately. In providing sketch plans at a traditionally conceptual design stage this participant initiated a ‘questioning’ response from the expert participant who aimed to extract both reasoning and justification of suggestion. A questioning pattern could potentially generate dialogue and information respectively.

5. Conclusions and Future Directions

We used Prezi to replicate an environmental condition for crowdsourcing design. This aimed at producing data to enable us to study representations during a shared collective design task. As this was a pilot study, there were limitations in size of the group used. However, by applying our semiotic framework to analyse the data it was revealed that the meaning based movement of design information does occur via the use of representations in an openly shared web based context. We identified this information as potential patterns and categorised them as recognition, modification or questioning. The importance of which is twofold. Firstly within these three preliminary patterns we observed that multiple meanings have the potential to enable the crowd member to send and receive the necessary visual signs that will allow them to contribute meaningfully to a collective design process.

Secondly, these preliminary findings are important as they provide a basis for further exploration in a main study.

A main study will involve a more complex design task and more participants to better resemble a crowd. A key challenge in a main study is the generation and motivation of participants to ensure a greater pool of data. A denser data set will allow us to observe the potential of recursive interactions, interaction types and response / sender ratios. Furthermore a larger study would allow us review much wider combinations of interaction types and patterns and to verify any new patterns in addition to the patterns of recognition, modification and questioning. Additionally the communication and generation of design information in an openly collective context gives rise to the issue of information management. Future work may focus on how design information is being selected along with how/who selects it; and how is the value of the generated design information determined.

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