TALES OF THE UNEXPECTED: UNDERSTANDING EMERGENCE AND ITS RELATIONSHIP TO DESIGN

Abstract. Today's techno driven society makes use of complex systems which are made up of multiple components or entities. These systems, and their interaction with the world around them, often gives rise to unpredictable, unexpected and unprecedented properties. These properties cannot be attributed to a single entity within the system, but the collective interaction of the system as a whole. This phenomena is termed emergence, and the resulting attributes emergent properties.

This paper looks at how user adoption and design envisioning contribute to the recognition, interpretation and utilisation of emergent properties within the design life cycle. This life cycle encompasses not only the actual design activity but extends into consideration of user adoption and consumption. The stages in this design (and emergence) life cycle can be identified as: pre-design emergence; design activity; post-design emergence. The value to the designer of an enhanced understanding of emergence and emergent properties is considered, and the way in which designers engage with emergent properties discussed. Models of these engagements are presented.

Designer's ability to understand and utilise emergent properties in their creative endeavours provides an enhanced opportunity to develop solutions that are more responsive to user requirements and acknowledge subsequent modes of user adoption. The exploration of the 'mindset' of the user through the use of future scenarios is developed and a consideration of the value of Episodic Future Thinking (Atance and O'Neill 2001) to design and emergence discussed. An awareness of the implications of emergence may provide opportunities for designers to develop intuitive and simplified methods of utilising complex systems and technologies. The paper uses a case study, of the ubiquitous mobile phone, to illustrate the role of emergent properties to design activity, user behaviour, and user adoption patterns.

1. Introduction

Designers do not understand emergence. They do not need to. It is not part of their vocabulary. If you ask a room full of designers, a minority will have heard of emergence and emergent properties. An even smaller minority will be able to articulate a clear understanding. This identifies a problem. Designers use emergence. It informs design activity. The manner that users

(ab)use products and services in a way that was not intended, considered or expected, informs subsequent design activities. This pattern of unexpected use and adoption can actually trigger New Product Development (NPD) by providing insight into unexplored areas.

Understanding the nature of this adoption allows designers to formulate user insights that in turn assist in the development of new products and services. The recognition of actual user adoption, as opposed to intended, desired or predicted user adoption, is key to utilising emergence in a design context. Identifying and acknowledging the way that users actually use products and services, and incorporating this information into future scenarios of use is intrinsic to the design activity. Thus, it may be claimed that designers engage with emergence as an integral element of their design activity.

2. Definition of Emergence

Before developing the theories within this paper, a consideration of emergence in broad terms is necessary. Numerous definitions and interpretations of emergence prevail, we offer the following:

Emergent properties are those features of a system that cannot be anticipated or understood by a complete analysis of the system. When the whole is greater than the sum of the parts, indeed, so great that the sum far transcends the parts and represents something utterly new and different, we call that phenomenon emergence (Johnson 2003).

The hallmark of emergence is much coming from little, with the behaviour of the whole being much more complex that the behaviour of the individual elements or agents. Emergent behaviour occurs without direction from a central executive but is the result of uncovering quite unexpected possibilities via collective interactions (Holland 1998).

An emergent property can appear when a number of simple entities or agents operate in an environment, forming more complex behaviours as a collective. The property itself is often unpredictable and unprecedented, and represents a new level of the system's evolution. These behaviours are not a property of any single such entity, nor can they easily be predicted or deduced from behaviour in the lower-level entities. An entity is something that has a distinct, separate existence, though it need not be a material existence (nationmaster.com 2005).

3. Design and Emergence

In the context of design, emergence can be described as unexpected properties that evolve during the use of products and services that include user interaction. The system with which interaction occurs represents a level

of adaptability or series of ways in which we can determine the same result. No one approach is paramount, rather a multiplicity of approaches are adopted dependant upon the users cognitive responses.

A number of stages in the relationship of design and emergence have been identified, with these forming a Design and Emergence Spiral (figure 1). The stages in this spiral are represented as: pre-design emergence; design activity; and post-design emergence.

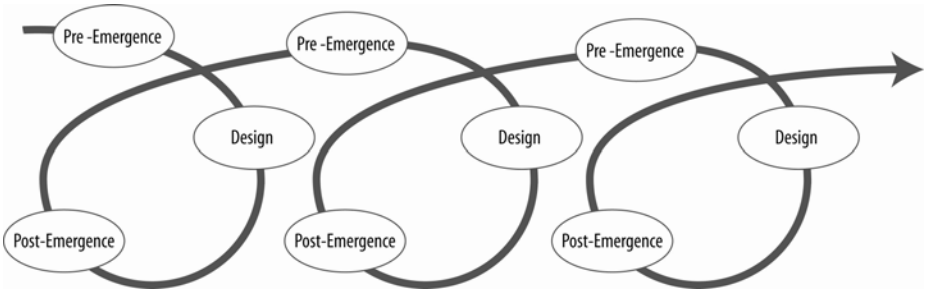

Figure 1: Design and Emergence Spiral

The design and emergence spiral provides a generic model of the design and emergence interface. The user/designer relationship is central to this interaction. A feedback loop between post and pre-design emergence stages allows user behaviour to inform design undertakings. The designer utilises this information to explore potential behaviour patterns and ultimately design opportunities. The following provides a more detailed consideration of design and emergence in the form of the Design and Emergence Cycle (figure 2).

The interrelationship of design end emergence is comprised of the following stages:

- Pre-Design Emergence: *where potential user behaviour and adoption patterns are envisioned by the designer in the form of future scenarios*
- Design Activity: *where design opportunities and explored and developed in relation to specific contexts*
- Post-Design Emergence: *where actual user behaviour and adoption patterns are studied by designers and utilised in the development of future strategies*

The above stages form a Design and Emergence Cycle. This will be considered in more detail.

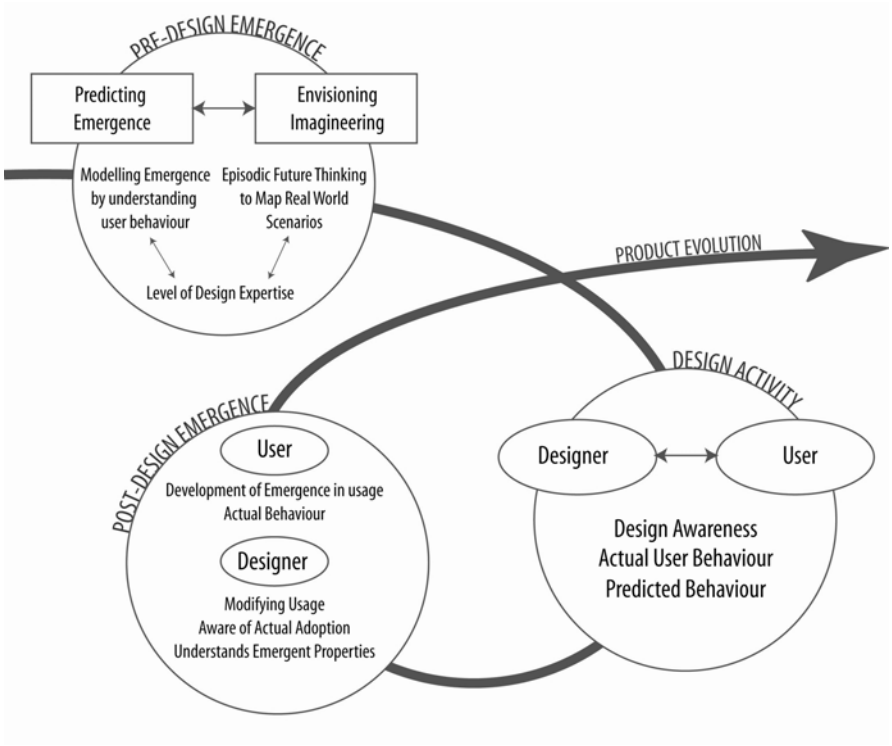

Figure 2: Design and Emergence Cycle

4. Pre-Design Emergence

Designers attempt to predict expected and unexpected behaviour within specified contexts, and utilise this information within subsequent design undertakings. The likelihood that unexpected behaviour will occur is explored by modelling emergent properties via an understanding of user behaviour and adoption patterns. The understanding of user behaviour is based upon a prediction of how a product or service is likely to be adopted. These predictions are informed by experience of adoption patterns and the outcome of tailored research undertakings.

Designers envision future scenarios as part of their design activity. The envisioning process is informed by the creation of simple (or complex) visions of future scenarios. Consideration is given by the designer to preferred and possible user behaviour in a given context. This may include multiple (ab)uses of a proposed product or service. Here the designer is considering possible user behaviour and adoption patterns. These patterns are the designer's vision of what is likely to occur. These activities are

undertaken before the design activity stage is commenced. We call this stage Pre-Design Emergence.

4.1. THINKING ABOUT THE FUTURE: FORECASTING

Designers utilise many approaches to consider, develop and evaluate potential futures. These approaches are collectively known as forecasting. Forecasting approaches are employed across all design domains and include methods such as backcasting, cross-impact matrices, Delphi surveys, scenario building, trend analysis, visioning, and time line extrapolations (Slaughter 1996).

Thinking about the future events and their consequences is described as prospective thinking (Atance and O'Neill 2001). This is defined as how we remember to engage in an intended action at a specific point in the future, for example remembering to give someone a message. The process of using prospective thinking can be split into three stages:

(1) The development of a plan
(2) Remembering that plan
(3) Remembering at to execute the plan in the future

Within the context of this paper we will predominately be considering the development of a plan (1).

In the context of design and emergence, effective prospective thinking allows the pre-experience of a future event. Designers project themselves into the future, pre-experiencing an event or situation before it has occurred. This process is called Episodic Future Thinking (Atance and O'Neill 2001; Atance and O'Neill 2005).

4.2. EPISODIC FUTURE THINKING

Episodic Future Thinking is defined as projection of the self into the future to pre-experience an event. It used to envisage future scenarios, and plan for them accordingly. The use of episodic future thinking is based on experience of similar events and the knowledge we may have gained from that experience. Humans have the ability to re-experience situations and project them into the future, applying them to events that we perceive to have similarity (Atance and O'Neill 2001; Atance and O'Neill 2005).

To understand how the experience gained from an event is utilised in episodic future thinking, we must consider how human memory functions. Human memory can be split into two distinct systems: Episodic and Semantic Memory (Tulving 2001):

- Episodic Memory: *the system that allows us to remember personally experienced events, and to travel back in time to re-experience those events*
- Semantic Memory: *is our knowledge of the world, with respect to memories related to the self*

The distinction between semantic and episodic memory can be described as the difference between knowing information explicit to one's existence, such as the name of the school you attended (semantic memory), against a memory specific to a particular experience or episode you recall at school, such as embarrassing situation during your school life (episodic memory).

4.3. THE USE OF EPISODIC FUTURE THINKING IN PRE-DESIGN EMERGENCE

Designers create visions of possible futures, using episodic future thinking as a method of pre-experiencing future events. This allows designers to consider a multitude of possible futures or scenarios. In this context, scenarios are a descriptions of events that might possibly occur in the future (Cornish 2004), or descriptive narratives of plausible alternative projections of a specific part of the future (Fahey and Randall 1998). Scenarios allow consideration of the prospective actions of potential users, rationalising solutions in real world contexts. By carefully developing scenarios that envisage user behaviour, designers have a tool that assists in the identification of potential emergent properties before design activities have been commenced, i.e. pre-design emergence.

4.4. THE EFFECTS OF EXPERTISE ON EPISODIC FUTURE THINKING

Insight into how successfully designers can consider future user scenarios to map emergent properties can be gained by analysing the content of scenarios which people generate before making their prospective plan. Several scenarios may be created, analysed (Atance and O'Neill 2001).

Scenarios can be considered in terms of possible, probable and preferred future states (Horton 1999). The key to the development of appropriate user scenarios is experience, and the development of expertise in specific knowledge and expertise domains relevant to the design task. Domain specific knowledge plays a significant role in the design of products and services, distinguishing the novice designer from the expert. Two distinct types of expertise can be identified: (1) Routine Expertise and (2) Adaptive Expertise.

Routine Expertise allows the ability to use knowledge to solve familiar problems quickly and accurately, where as Adaptive Expertise allows the utilisation of knowledge, adjusting to varied circumstances, and applying

new procedures. Designers use Adaptive Expertise: using both creative and analytical ability to extract, conjugate and apply knowledge.

The following table demonstrates the distinction between novice and expert designers in terms of articulating modes of knowledge.

TABLE 1. Levels of Expertise in Designers

Novice Designer	Expert Designer
Weak goal limited strategy Smaller informational gathering Weak domain specific knowledge A lot of assumptions Limited experience General strategies very weak	Rich content of goal-limited strategy Large informational gathering High level of domain specific knowledge Few assumptions High level of experiential knowledge Developed general strategies

An experienced designer demonstrates adaptive expertise. They are proficient at engaging with episodic future thinking due to an enhanced level of understanding of given contexts. This experience provides user scenarios that are informed and appropriate to a given situation. These scenarios consider emergent properties during their development.

5. Design Activity and Emergence

An examination of the design development cycle allows an understanding of how emergent properties can be incorporated into design activities. The identification of emergent properties, and their incorporation as constraints, can provide more effective design approaches. The design development cycle is thus (Kryssanov, Tamaski et al. 2001):

(1) Identification of user's needs – generation of basic user scenarios
(2) Conceptualisation of design requirements to meet the needs identified
(3) Transformation of requirements into performance and function specification. Detailed user studies
(4) Elaboration of cost, resources and other critical elements
(5) Mapping and converting the specifications into feasible design solutions
(6) Development of more detailed user scenarios from design solutions presented, prediction of emergence
(7) The optimisation of solutions
(8) Prototyping and testing
(9) Manufacture of product

(10) Implementation of various control, logistics and marketing procedures
(11) After sales services and maintenance
(12) Obtaining and utilising feedback concerning products utility, operation and market value. Identification of user initiated emergence
(13) Product re-development - design evolution

During the design development process, research is used to determine what the problem is, which of the ideas proceed and how they are rationalised, given constraints identified. In short, the designer uses information which allows them to draw a mental picture of the current situation, a complex vision, considering many aspects factual and perceived; experiential and domain specific.

This approach assists the designer in an understanding of the triggers within the design decision making process and supports the development of the design to an optimal state. This process is iterative, as in general, each stage is intended to be an improvement.

Using the design development process, the designers task is to produce a solution to a given problem, beginning by understanding of user needs and identification of market opportunity (1). The information gathered and initial research and information that can be used to generate initial user scenarios and begin generation of realistic concepts (2). As the concepts are rationalised through constraints identified, such as materials and manufacture (3,4,5) and more detailed research is gathered via user studies, the development of more detailed user scenarios can be produced (6). By using an informed or ‘real world’ visions of user scenarios which feed into the design process, the designer can imaginer the use of complex systems and develop an understanding of potential emergent properties, leading to improved final designs (8,9). Analysis of actual user behaviour and usage is monitored post-design, identifying apparent emergent properties that may be useful in product re-development, developing improved solutions (13). It is a cyclic process of continual product evolution, particularly relevant to sustained product development.

The identification and utilisation of emergent properties both pre and post-design, can enhance the usability of complex, increasingly integrated technologies by simplifying interaction systems or creating more intuitive use.

6. Post Design Emergence

User behaviour and adoption patterns do not always follow the projections or expectations of the designer (or user). A multiplicity of expected and

unexpected uses are undertaken by the designer in the development of a product or service during the pre-design emergence and design activity stages. When a product or service has been developed and is experiencing 'consumption', analysis of user behaviour is possible. This analysis allows the designer to identify actual user behaviour and adoption patterns. This will identify use (and abuse) of the product or service and will include patterns that were not anticipated in any former stages. We call this Post-Design Emergence.

Where user behaviour has not followed the projected path of use, an analysis of the underlying reasons for the deviation is possible. This is retrospective (as opposed to prospective) and may uncover the reasons for this deviation. The difference between forecasted user patterns and actual user patterns is called Forecast Deviation. There are often a number of reasons for this deviation (as opposed to a single reason) and the interaction of these reasons can contribute to this change. Holland describes this in terms of the behaviour of the whole being more complex than the behaviour of the individual parts, or as he indicated, much coming from little (Holland 1998).

The analysis of actual user behaviour or 'reality' can be assistive in developing future strategies. This may require additional design activities (in terms of new product development) or revisions to existing offerings due to the knowledge gained in the Post-Design Emergence stage.

7. Case Study: The Secret Life of the Mobile Phone

To understand the effect of emergent properties within everyday culture, the following is a case study of the mobile phone: a product that has exhibited identifiable emergent properties during its life cycle.

The development and consumer take-up of the mobile phone has a long and protracted history. This paper does not intend to provide a critique of this history, but looks at the numerous developments in relation to unexpected use and proliferation of the consumption of the mobile phone.

The history of mobile communication extends beyond the recent introduction of what we think of as a mobile phone. Numerous 'wireless' attempts were made in the last century to provide users with mobile communication. They were often limited, cumbersome, usually expensive and ultimately unsuccessful (Rheingold 2002).

Our modern mobile phone system is based upon a framework that re-uses radio frequencies in a pattern of 'cells' developed by Ring and Young, engineers at Bell Laboratories in the US in 1947. It was not until the 1980s that a series of standards were adopted that allowed the development of a more integrated communication network. In the early 1990s, technical trends, especially miniaturisation, led to a qualitative change in mobile

terminal design (Agar 2003). Mobiles became small and light enough to routinely carry round. New designs attracted new customers, and the mobile became less a business tool as originally envisaged, and much more an everyday object. In addition to technological developments, an important factor in the take up of mobile phones was their cost. In the UK competition between mobile network suppliers, keen to ensure they secured business from customers brought prices down. The mobile became affordable: no longer was it a status symbol – signifying privilege and wealth – but instead the universal accompaniment of (particularly) the young and old (Katz and Aakhus 2002; Agar 2003).

One of the most identifiable presences of emergence in mobiles, in terms of unpredicted user behaviour and adoption, was in fact an afterthought – text messaging, or SMS (Short Messaging Service) as it is officially known. When the first text message was sent in 1993 by Nokia engineering student Riku Pihkonen, the telecommunications companies thought it was not important. Like many technologies, the power of text was – indeed the power of the phone – was discovered by users. In the case of text messaging, the users were the young in the West and East (Agar 2003).

The unprecedented consumer take-up of text messaging surprised the telecommunication companies. Until 1998 the service was free but in September 1998 the traffic threatened to overwhelm the normal mobile voice system. It was at this point that a tariffing system was introduced.

A number of interrelated factors contributed to take-up of text messaging and the resulting phenomenon. By far the largest single group of text message users are the youth (and in particular teen) market, who have inextricably integrated mobile phones into their lives (Ling and Yttri 2002; Aldridge 2004). They use their mobiles for security, spontaneous coordination of everyday events, interaction, and as a status symbol. SMS is employed for social and emotional communication. The pre-paid or pay-as-you-go system has greatly fostered mobile use among youth. In this system payment is made in advance for telephone access. Once the allotted sum has been consumed, one cannot call out to other (non-emergency) numbers although calls and text can be received for a certain period. Text messaging is generally cheaper then voice calls and so is quite popular among cost-conscious teens who pay for their own mobile use. Each message is unit priced and is usually two to three times cheaper than voice calls especially when calling another network (Kasesniemi and Rautiainen 2002).

The widespread adoption of mobiles points to the importance of availability for teens. Unlike adults, who often feel stressed by the mobile's impact resulting in them being 'constantly available', teens thrive on access and interaction. To receive a message is a conformation of one's membership in a group (Ling and Yttri 2002). Teens feel that accessibility is

an important factor of their social life. To be available to friends and to know what one's peers are doing is central. Adolescence is a period in life where the focus is upon peers rather than parents and family. The mobile provides a personal communication away for the eyes and ears of parental view (Agar 2003).

The development of a dedicated text language is perhaps one of the biggest changes mobiles have brought. The language – Textsperanto – the amalgam of abbreviated words, acronyms and coded punctuation that teens developed so that they can fit more words into their space-limited text messages was designed to be impenetrable to adults (Aldridge 2004). Dedicated dictionaries have been developed to assist users understand the multitude of coded exchanges utilised. As a SMS test message contains only text, and the maximum length of a message is only 160 characters, teens have developed an abbreviated language to make maximum use of precious character space (Kasesniemi and Rautiainen 2002).

As mobile technology has developed, so has the ways that consumers utilise these new features in a manner not intended by the developers. A by-product of Bluetooth, a short distance wireless communication system, has been the proliferation of Bluejacking. Bluetooth enabled devices can send things like phonebook book contacts, pictures and notes to other Bluetooth enabled devices. Using a phone with Bluetooth, you can create a phonebook contact and write a message, e.g. 'Hello, you've been bluejacked', in the 'Name' field. Then you can search for other phones with Bluetooth and send that phonebook contact to them. On their phone, a message will popup saying 'Hello, you've been bluejacked'. Most victims they will have no idea how the message appeared on their phone (bluejackQ.com 2005). This form of emergence is undesired as well as unpredicted.

Enhancements in mobile phone technology have spawned a host of new and sophisticated forms of bullying. In the latest craze, happy slapping, youths use their mobile phone's video streaming function to film attacks on innocent bystanders. As a result, following a number of playground incidents, schools in the UK have imposed a total ban on camera phones. The development, part of a larger trend in cyber bullying, is increasing due to the ease of greater dissemination of the abuse. The use of mobile to send abusive text messages is also been identified. Some school have installed a confidential mobile number for pupils to report bullying by test message (Hoare 2005).

The development in mobiles has been greeted with numerous unexpected and unpredicted consumer application of the available technology. The case study has identified a number of occurrences of unexpected user behaviour and adoption patterns. This information is identified in the Post-Design

Emergence stage but is utilised in subsequent stages including Pre-Design Emergence and Design Activity.

8. Concluding Remarks

Emergence has an important role in design. This is demonstrated by the possibilities made available by the recognition and utilisation of emergence properties in design undertakings. An enhanced awareness and understanding of the role of emergence in design provides the designer with a powerful design development tool. This tool is particularly appropriate for fast moving consumer markets that exhibit complex interactions where unexpected and unpredicted properties are common place.

The difference between forecasted user patterns and actual user patterns is Forecast Deviation. This allows analysis of unexpected properties and adoption patterns and provides information that may inform strategy and NPD activities. The awareness of actual, as opposed to projected user behaviour patterns is important to effective management of the design life cycle. The primary role of the mobile phone, for example, was to enable voice communication while mobile. This has developed greatly into a communication device that enables a multitude of ‘communications’. The way that users have adopted mobile phones has been instrumental in subsequent design activity. Strategic direction has been influenced by the role of the user in this process.

The presence of emergent properties within a given system changes the status of that system. It is an evolving system where the behaviour of the whole is much more complex that the behaviour of the individual elements. The interactions within the system contribute to its evolution. These interactions are said to be synergetic – the whole being more than the sum of the parts.

The role of episodic future thinking is central to considering proposed user behaviour patterns. The pre-experiencing of events and situations is valuable to designers as it allows multiple scenarios to be modelled, developed and evaluated. Within pre-design emergence, episodic future thinking is an effective tool for the consideration of possible user behaviour patterns. This provides opportunities to develop intuitive interaction approaches as the mindset of the user is being (pre)experienced.

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