Integrating the Strengths of Cognitive Emotion Models with Traditional HCI Interaction Analysis Tools

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ABSTRACT
Norman’s Action Cycle has commonly been applied as an interaction analysis tool in the field of HCI. In wake of the recent shift of emphasis to user experience (UX), the cognition-based Action Cycle is deemed inadequate to explicate affective experiences such as happiness, joy and surprise. Model’s based on Appraisal theories, focusing on cognitive accounts of emotion, are more relevant to understanding causes and effects of feelings arising from interacting with digital artefacts. We aim to explore the compatibility between these two genres of model.

Keywords
Cognition; Emotion; Appraisal; Action; Design; User experience; Withdrawal

INTRODUCTION
This paper reports work towards integrating models of emotional factors from the psychology literature with applied models of cognition used in HCI design and evaluation. In particular it analyses compatibility between cognitive accounts of emotion emerging from, among others, the work of Scherer (2002), Ortony et al (1988), Coulson (2004), and established approaches, particularly Norman’s (1988) model of display-based, which are used to understand goal-based cognition in interaction and formative evaluation of usability factors, characterising reactions to interaction events, their causes and their effects.

The motivation for this work is to find useful theoretical tools that accommodate both analysis of traditional usability concerns such as comprehensibility of feature cues and feedback, and what are typically referred to as ‘experience’ factors, where an affective response emanates from encounters with technology. In doing so we hope to better explain the relationship between usability and user experience factors in design.

User experience research does not yet provide fine-grained diagnostic tools capable of pinpointing and understanding elements of designed systems that may undermine positive user experience. Typically UX evaluation tends to deal with overall reactions to the interactive experience. More fine-grained analysis may give designers a better insight for design iteration where a feature or interaction event has had a pivotal effect on user experience or behaviour. In turn this may help designers refine systems at the feature level, and repair what can be termed ‘UX bugs’ at the interface.

No method currently exists that supports a cognitive account of the emotion through analysis of interactive sequences. The nearest to this is the Sensual Evaluation Instrument (Isbister et al 2006), which stimulates user expression of emotion by interacting with objects. Other approaches try to trace critical incidents by measuring physiological changes in subjects through heart monitors and galvanic skin monitors. However, these provide no more than markers showing where something (in the design or otherwise) affected interaction. What our work aims to provide is a framework for analysing interaction, and linking observed (critical) incidents with antecedents and consequences, to truly understand the role of affect in user reactions to systems. It works on the assumption that a fine-grained causal account of design features’ influence on users is required to inform iterative design for optimised user experience.

TRANSFERRING CONTEMPORARY EMOTION THEORY TO COGNITIVE MODELS OF HCI
The exercise reported here is the exploratory integration of cognitive accounts of emotion with theoretical and practical tools for analysing cognition during interaction. The prima facie attraction of this exercise is that the two genres of model have complimentary strengths that can usefully integrate to produce effective user experience evaluation tools. To explain this notion we look in turn at the strengths of each genre.

Strengths of HCI Interaction Models
A key strength of interaction models such as the one described in Norman (1988) is that they facilitate an analysis of causal relationships when applied to interaction events, providing a baseline for understanding antecedents and consequences of system appearance and behaviour. In usability evaluation this contextualises the influence both of prior dispositions (user state of knowledge, background, expertise level etc), as tributaries of user behaviour. It also facilitates the investigation of problem genotypes (root causes of user problems) emanating from error phenotypes.
(overt symptoms of a problem detected during interaction). The expression of user and system actions as a connected sequence provides a dynamic mechanism for this. Existing models in the literature add accounts of key catalytic elements in this process. These include accounts of the nature of user mental processing, levels of expertise and experience and the knowledge resources recruited during interaction. Critically, this includes internal and external resources. A prima facie match between the projects of understanding instrumental usability factors in evaluations and affective episodes at the interface lies in this synthesis of internal and external factors. Just as usability problems can frequently be explained with reference to mismatches between the external (the image and behaviour of the machine) and the internal (the users cognitive) resources, a cognitive account of positive and, more critically, negatively valenced encounters can be understood in terms of a similar synthesis of the internal and the external.

Appraisal Theories of Emotion
There are two key elements of the class of emotion theories known as appraisal theories. One is that they reject the conventional taxonomy of distinct emotional states (Ortony et al. 1988). Common language tends to embed a naive theory of emotion as falling into distinct categories represented by linguistic tokens such as happy or angry. These are seen as being of little use in understanding the concept (see Boehner et al. 2007). The second element is the general belief that the emergent process, the genesis and consequences of emotional arousal are of interest, rather than the qualitative, experienced episode. Emotion is modelled in terms of contextual factors that determine action. The genesis, expression and time-course of emotion arises from a multiplicity of factors or contexts (Coulson 2004). Emotional arousal and the appraisals that may give rise to arousal are distinct and separate in nature. We argue that useful accounts of experience in human computer interaction are a matter of understanding the concept of appraisal and arousal. One crucial aspect is conscious experience of ‘emotion’. It is accepted that emotional arousal is felt, experienced and expressible by the individual. Appraisal, however, may not be conscious, it may occur without the individual being explicitly aware of it. This is a key consideration when applied to some phenomena of interest in UX research. Compare a sudden event in a video game for emergency response training to an accumulation of ‘concerning’ events in a social network encounter. In the former case the sudden onset produces a quick and compelling physiological reaction. By contrast, weakening trust in the identity and integrity of a chat room correspondent could emanate from gradual accumulation of appraisals.

Norman’s Model of Action Revisited
In Norman’s original model execution has three phases, goal generation, intention forming and translation into a sequence of actions (Norman 1988). The forming of an intention implies generating expectancy of the features that will be encountered. This is characterised as a matching process between internal representations and interface features. These include container metaphors and individual feature representations. A visual scan takes place involving a search for the best match between interface features and the user’s goals (Howes & Payne, 1990). The three stages of execution are: perceiving and understanding the state of the world, comparing the state of the world to the intention, and assessing progress towards a goal.

The use of the action cycle as a tool for identifying and characterising usability bugs is established in HCI literature (e.g. Hartson et al., 1999; Springett, 1998). Typical usability problem phenotypes are associated with individual phases in execution specification, physical performance of action, and evaluation. As such these serve as key staples in establishing the ‘story’ of a critical incident. The establishing of links between phenotype and genotype (root causes), or the tracing of ‘critical threads’, is key to gaining a deep understanding of usability problems. This trace of critical threads is central to error analysis both in contrived evaluation studies (e.g. think-aloud protocols) and in error studies in the field.

Where a system is ‘affect critical’ the cycle of action described by Norman (1988) can be seen as a legitimate, but incomplete account of cognition. The account of ‘mental actions’ has been used in accounts of HCI usability for several types of system. However, it requires a richer explanation of how the mechanics of goal-directed cognition combine with affective reactions to interface phenomena and events.

Events in the context of this analysis could be events occurring as system feedback in response to user action and interface events that isn’t directly a response to user action. An event can also be an appraisal as a result of the user scanning a visual image. Therefore we can think of appraisals as occurring at key points in this cycle, including visual scanning in early stages of the execution phase.
**Stimulus Evaluation Checks**

Scherer (1984) proposes taxonomy of ways in which individuals evaluate information and events. These are:

**Novelty check**: This is a check to see if external or internal stimulation has changed. Internal stimulation could be a triggered memory for a future event (e.g. an appointment). External stimulation may include a match between expectations of system behaviour and new system behaviour.

**Intrinsic pleasantness check**: This detects a positive or negative valence, determining approach behaviour or withdrawal/avoidance.

**Goal/need significance**: This is composed of evaluations of relevance, expectation, conduciveness and urgency. Assessment of relevance relates to the selection of features in action execution, and match to goals in the evaluation phase of Norman’s model. Expectation and conduciveness equally seem to express the phases of interpreting and matching to goals expressed in Norman’s model.

**Coping potential**: This evaluates causality, the level of control the individual has over its consequences, and the ability to adapt to cope with it.

**Norm/self compatibility check**: This involves normative judgments about the event. This may be a match between an internal standard or norm. In e-service use for example it may be a comparison of system design of behaviour to expectations of service or quality of design. It also has a socio-cultural dimension where the norms of others and accepted cultural norms are brought to bear.

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**Figure 2: Overview of Scherer’s Appraisal Model**

**Example – E-Commerce Trust Propagation**

In this example, we consider the influence of the novelty, intrinsic pleasantness and norm/self compatibility checks. Several studies (Riegelsberger et al. 2005; French et al. 2006; Sillence et al 2007) suggest that display factors have a significant influence on trust-related judgements. E-Commerce encounters involve the perception of signs (interface appearance) and events that may either positively or negatively reinforce trust in the competence of the system and the identity/integrity of the organisation it represents. Trust propagation in e-commerce is seen as a journey from initial expectations of the organisation encounter, through the first encounter with the website and the completion of service transactions (French et al 2006). Critical phases in which the e-customer’s relation is mediated through interface features and behaviour, including overt tangible trust signs, and sundry aspects of the interactive session that could potentially affect attitudes and behaviour.

The match between expectations and what is encountered (novelty check) may be pleasing revelation of positive trust re-enforcers such as trust seals or third-party associations. The ‘warmth’ of this re-assurance (intrinsic pleasantness) fortifies the relationship between individual and organisation. However, this could also emanate from aesthetic factors such as a pleasing colour scheme or familiar cultural references. In the negative case an event that infuriates, such as the deletion of input data, or unexpected task steps, may confound positive expectations of the organisation. This may also include the norm/self compatibility check, where the user compares the demands made by the system to their general perceptions of what is reasonable. Similarly, requests for personal information may cause a negative reaction when compared to culturally-mediated perceptions of the limits to invasion of personal privacy.

**A Reinterpretation of the Basic Model of Action**

Below we revisit key phases in Norman’s model of action, adding concepts referred to in the theories considered above.

**Goal formation**: Goal formation implies the generation of satisfaction criteria. These could be criteria such as safety/security that are not explicitly part of the task model.

**Intention Forming**: Implicitly involves expectations of system features and behaviour.

**Scan matching feature/operation** (Appraise image): The scan of the interface to find features must simultaneously imply appraisals that assess match with expectations, opportunities for action, and also assessment of ‘warmth/hostility’ and other terms often referred to in UX taxonomy. Positive valance emanates from detection of such positive qualities and negative from those suggesting threat, disturbance or disappointment. The former is likely to reinforce approach behaviour the latter withdrawal, dependency on the strength. A slight concern that the system image isn’t conveying honesty or reliability may not itself be sufficient to cause withdrawal, but may be an input into appraisal of future events.

**Perceive feedback/ primary appraisal**: At this level of immediacy, primal cognitive functions are likely to be most influential, whether sudden and high impact evaluation (e.g.
a shock reaction such as a loud noise) or a low impact evaluation (e.g. a transient awkwardness on completing a manipulation).

**Understand/interpret/appraise change**: Assessment and appraisal of the event is linked to Norman’s concept of understanding and interpreting feedback from the system as a result of user action. Again there may be affect with significant force that causes withdrawal (perhaps abandonment) or simply a re-evaluation of approach and the necessary conditions for continued action.

**Match to current/overall goals**: In strict terms the satisfaction of a goal is the completion of a recognised sequence of task-steps. However, if experience factors are an additional feature of this account, then it can be argued that this extends to a wider consideration of the overall conditions for proceeding with goal-directed action. From the ‘pure’ usability standpoint goals may be supported, as progress towards them is satisfactory supported through action cues and feedback. However, appraisals potentially lead to re-evaluation of user motivation and acceptance of system. If a sequence of appraisals, for example, has the effect of reducing trust in the system and those perceived as being personified by it, the likelihood of withdrawal increases.

**Figure 3: Integrated models of Norman’s action cycle and Scherer’s appraisal model**

**SUMMARY: EMOTION OR APPRAISAL-BASED ACTION?**

The indications both from literature studies and from the application of merged models to affect-critical systems are that emotion is something of a redundant notion in studies of experience within interaction. What is of greater interest is the series of cognitive appraisals that are applied to phenomena and events during interaction and the consequences that this has in terms of user behaviour and summative evaluation of experience. Norman’s action model was a baseline description of action which analysts and researchers could apply to assess gulfs of execution and evaluation (Figure 1) in usage of a number of products. Likewise a model that combines the key elements of this model with accounts of appraisal provide a baseline for understanding affect in the context of goal-directed user action. Immediate factors such as positive or negative valence and approach or withdrawal (if the stimulus has high intensity) are accounted for within the cycle of task-action. Also, accounts of learning by exploration and synthesis of examples accommodates key appraisals with less high intensity that contributes to a relatively slow affective onset.

The six contexts described in Coulson (2004) (i.e. Event, Agent, Interpersonal, Topographical, Historical and Embodied) emphasise the factors that become particularly relevant dependent on the type of design problem considered. For example, the interpersonal context explains...
appraisals in which the intentionality of e-commerce organisations is deconstructed and interpreted through encounters at the interface. The same context characterises the sense of self that emanates from assumed characters in game play.

Formative design and evaluation benefit from having runnable models that can be used, either in the form of an explicit procedure, or as a tool for thought. Theoretical tools that integrate actions of display-based cognition and appraisal can analyse both the pragmatic aspects of usability and the affective factors that influence user behaviour and judgement.

The integration of Norman’s theory of action with constructs from appraisal theories has the potential to produce useful and usable tools for understanding user experience factors during interaction. Questions relating to the true nature of the relationship between usability and user experience remain, but there is clearly value in understanding these factors in an integrated way. Future research can usefully be directed towards developing analysis tools that can facilitate the application of this in design and evaluation.

REFERENCES