Affective computing in the design of interactive systems

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INTRODUCTION
1. Background

Jordan asserts that human factors were once seen to add value by enhancing usability; in light of technological advances, usability is now expected as opposed to valued. This research apprises designers on how to go beyond the expected parameters of good usability, in order to design interactive systems capable of providing profound and affective experiences. In considering affective products and services, subjectivity must be addressed as it is inherently difficult to quantify an emotional state with any degree of certainty. This notion resonates within Riggan's appraisal of Jordan's 'Consumer Needs Hierarchy' (Riggan, 2009) wherein it is stated that pleasure-based approaches are derived by celebrating human diversity.

Affective computing provides a potential solution to the above; as an inter-disciplinary cognitive science, it exploits advances in technology in attempt to create systems with the capacity to recognise affect state and respond accordingly. Hitherto, accommodating for subjective emotional response has been largely impossible in the design of physical products; affective computing allows for more tailored and pertinent experiences. As stated by Maslow :"Coping is most often learned; expression is most often unlearned or released or disinhibited."

Such assertions infer that design for emotion is possible on interactive systems. In the context of Human-Computer Interaction (HCI), Maslow's "expression" (Ibid) can be understood as the input from an individual; "coping" (Ibid) constitutes how machines adapt to, are adapted by and transform in relation to such stimuli. This research explores the aforementioned connection in light of recent technological advances.

1. Aim of this Research

The aim of this work is to validate and quantify the principles of affective computing; provide objective reasoning as to how HCI can invoke emotive responses comparable with those of physical artefact interactions. Furthermore, to use this information as a means to apprise designers of the practices available in the implementation of affective digital design.

2. Objectives

The objectives of this research attempt to explore existing debate surrounding affective computing so as to identify...
what constitutes affective computing methodology and how can they be best implemented as an emotive catalyst. Furthermore, how technology may be used to invoke empathy, dependence and believable sentience? To conduct relevant stakeholder interviews so as to deduce: to what extent is the digital industry able to replicate the emotional bonds experienced with physical products? How is affective-responsive technology implemented in a commercial context. What are the limitations and concerns of affective implementation? Conduct a survey so as to deduce: what are the levels of consumer engagement with interactive systems? What is the impact of empathy, dependence and perceived sentience?

3. Affective Computing

As an emergent principle of HCI, where emotional interactions are facilitated, affective computing denotes a fusion of UX design and psychology in which machines are perceived to express and recognise affect. Not only is technology now able to deduce the affect state of an individual, it is able to adapt, emulate and transform as a result of it; a notable progression in the emulation of machine sentience.

Affective computing is principally concerned with the objective and empirical transitions of input to output during HCI; the output typically exhibiting aspects of cognition. There are several ways by which this can be achieved, governed by the autonomic nervous system and its influence on bodily function. The physicality of an emotional sentiment (facial features, vocal tonality and gesticulation) is quantified by an affect sensing device whereby it is translated to an appropriate output. This then utilises data dependent systems with complex algorithms. Contextualised, the detection and interpretation of such functions is made increasingly seamless by the sophistication and miniaturisation of consumer electronics. Such devices typically interpret speech descriptors as the predominant stimuli; accounting for speech rate, stress frequency, loudness, pitch discontinuity, accent pitch and breathiness. The range of distinct descriptors is variable and dependent on the complexity of the study. Where more complex deduction is required, facial affect detection is achieved through optical flow, the Hidden Markov Model (HMM) and neural network processing.

It must be noted that it is easy to falsify a facial expression or vocal tone. Modalities should be combined where possible so as to create multimodal affect recognition. With such a system, the validity of estimation can be increased by quantitatively analysing consumer emotional behaviours. The necessity of such sensing technologies are surmised in assertions that the human behavioural spectrum is fundamentally multimodal and characterised by variability.

Irrespective of the advances in this industry, affect sensing technologies remain largely unrealised in a commercial context. A product's perceived emotional significance remains to be governed by the aesthetic pleasures derived from it.

3.1 Implementation as an Emotive Catalyst

A difficulty with implementing large scale affect sensing in consumer electronics is the inability to derive holistic invariant features; inferring a high likelihood of frequent inaccuracy. This sentiment is echoed insofar as the idea that emotions and their perceivable manifestations are difficult to categorise and distinguish. In order to facilitate genuine progress in this domain, computational overheads and significant infrastructure change are necessary.

Existing research into affective computing has focused on social, economic and commercial interests such as healthcare and behavioural sciences; wherein emotional stability and consistency are paramount. Perceived sentience is a powerful means of invoking empathy in HCI. If employed in the aforementioned contexts, meaningful emotional design experiences can be facilitated without the necessity for a physically beautiful artefact. However, in order to create a meaningful and emotionally stimulating design experience in a system, it must first and foremost be perceived to be so by the individual using it. This is resonated somewhat in the prominence of virtual assistants and the feature set developments which serve to subjectively cater for the user. The inference here is that
beauty remains in the eyes of the beholder, irrespective of context or platform. The emergence of machine learning and recent growth of the Internet of Things (IoT) can be seen to transcend such concerns. There is increasing pressure on designers to create content which is capable of objectively measuring consumer engagement and responding accordingly. Such added value through machine learning will see the birth of comprehensively responsive systems whereby user preferences can be learned, emulated and adapted to. Within a commercial context, these principles are becoming increasingly prevalent through the use of predictive analytics across a range of technology platforms. The adoption of progressive user experience methodologies is seemingly a necessary component of success within today's market.

3.2 Relevance to the Current Climate

It is estimated that there will be 23.3 billion active IoT devices by 2019, suggesting a degree of negligence on the part of the design industry to quantify and implement affective practices in a way that emotively reflects the market. Reinforced by the falling cost of internet-connected sensors (from $1.30 to $0.60 in the last decade), there is an evident transition towards a digital age. Emphasis therein should be placed on enhancing consumer experiences; something which is achievable through the implementation of affect-sensing technology in data dependent systems.

Difficulties reside in the standardisation of the technologies and components which allow for compatibility and ease-of-use. However, once implemented, such infrastructures would allow for improved operational efficiency and enhanced capabilities in all aspects of consumer engagement. With affective computing practices, the transition toward a digital age is capable of driving new capabilities with a degree of perceived empathy and compassion; reflecting the experiential bonds invoked by physical product solutions.

3.3 Defining the Parameters of Interactive System Design

Design constitutes the acquisition of a desirable outcome through a course of action; it is therefore an activity which everybody inherently engages with, albeit unwittingly. To give an example, the process of walking to the shops is designed in relation to multiple factors; the fastest route, the most scenic, a desire to avoid or encounter something for example. The process can be reduced to a series of necessary components which must be present in order to facilitate good design. This is echoed in the book ‘The Sciences of the Artificial’ by Simon wherein it is argued that the fundamental elements of design are as follows; a goal of achieving satisfactory rather than optimal solutions; a concern with finding alternative solutions to choose between; a reliance on hierarchic subdivision of the problem; its dependence on representations; and a use of simulations to predict possible outcome.

As an extension of Simon’s aforementioned criteria, Newan and Lamming proposed a set of measures specifically relevant to interactive system design. These principles will now be addressed. Firstly, it is essential to "represent constraints" (Ibid, p3) – with constraints being the software platform and context of use. Secondly, we must adopt a "mental model” (Ibid, p3) – this addresses the use of a familiar interface which is intuitive to engage with. Thirdly, "simulation and testing” (Ibid, p3) of the mental model are fundamental in the identification of usability issues. Finally, an “expansion of the mental model with the aid of heuristics” (Ibid, p3) – application of experiential factors which enhance emotional engagement and usability. Affective computing can be implemented at this final stage; transcending the constraints that inhibit the ability to connect emotionally with an interactive system.

3.4 Consumer Engagement

To understand how designers can implement affective heuristics, it is important to recognise levels of consumer engagement. It is this increased level of engagement, coupled with technological advance which has made affect-sensing not only possible, but a necessary component of successful user experience design. This will be reviewed in light of three technological developments; empathy, dependence and perceived...
sentience.

3.5 Facilitating Empathy: Machine Learning

3.5.1 An Overview

Machine learning has been in implementation for some time; Microsoft added learning capacity to its flagship Business Intelligence (BI) engine, SQL Server Analysis Services in 1999. However, it is now at the forefront of discussions concerning emotional design. Technological advance has facilitated the implementation of devices capable of exhibiting perceived understanding and personalised response. Such perceived understanding is evident in the SwiftKey application whereby word prediction becomes tailored to an individual with increased accuracy over time. This has enhanced experience and encouraged return engagement.

The implementation of learning systems has led to the advent of predictive analytics, whereby personalisation and empathy are inferred. At its most primitive, this can be seen in the use of the Google search engine, or the recommended purchases on an Amazon account. Despite seamless integration into our digital lives, this tool has proved invaluable in promoting empathy during HCI and encouraging the belief that there is a connection between the consumer and their network.

The capacity to learn from, understand and predict consumer preferences has scope to delight, affect and influence the user of an interactive system. This is reinforced by Transparency Market Research's findings that the global predictive analytics market is forecast to propagate a 17.8% compound annual growth rate.

3.5.2 Implications for Designers

The information surfaced in the previous section is important given that benefits are predicted to lay in the development of applications as opposed to technology wholesale. Ostensibly, as is outlined by Wagner, we are branching into a digital marketspace wherein “having a website is simply not enough”. Designers are now required to explore more innovative and effective means of harnessing the powers of the industry.

3.6 Facilitating Dependence: Wearables

3.6.1 An Overview

Research by Samsung indicates that the wearables sector is about to make significant economic impact. Not only are wearables becoming an industry sector of exponential growth, but they constitute a pertinent topic at the forefront of the research and development concerns for technology giants. When discussing the prominence of human factors in the design of products, Jordan identifies three key stages of integration: being ignored; bolt-on human factors; and integrated human factors. In the context of successful design, integration of pleasure-derivatives has become inseparable from the design process. An example at the forefront of the contemporary design industry is the first Apple Macintosh computer. It was the earliest interface that “relied on direct manipulation, rather than command lines”; challenging the parameters of conventional HCI. This was the first time that technology was seen to mimic anthropomorphic cues within a commercial space, facilitating the emulation of human-like interaction.

3.6.2 The S-Curve

An ‘S-Curve’ has been used conventionally to illustrate trend adoption over time, and is easily applicable to the wearables market. Figure 1 shows the S-Curve of adoption.

In order to transcend the plateau at the peak of adoption, designers need to innovate and introduce something which actively adds value to the proposition. When considering digital devices such as wearables, consumer adoption and acceptance is at an all-time high. Christensen's model of the S-Curve infers a need to further innovate and add value; whether developmental, transitional or transformational. The application of affective interfacing will add significant value to the experience, surpassing the plateau of interest and
consumer engagement.

3.6.3 Physical Chassis vs Digital Interfacing

There are arguments to suggest that emotional connections between consumer and device remain grounded in aesthetic components. Research submits that wearable devices remain "gadgets for geeks", as they are not considered to be visually appealing. The aesthetic of a wearable device plays a significant part in denoting its functionality. Failure to resonate with a clearly defined set of functions can inhibit the success of such a product and should not be ignored. Notwithstanding this, claims that wearables are the most personal kind of technology emphasise the importance of affective design within the underlying systems, through increased consumer interest in tailored experiences. Equal worth should be bestowed on the design of both physical chassis and digital interface; ideally with a degree of coherence between the two.

A study by GFK illustrated levels of consumer expectation regarding wearables; 38% expected to be able to control a television whilst more than a third were interested in home automation and car control. Despite these statistics coming from 'technology-friendly' respondents, they infer high expectations from the target demographic.

3.6.4 Privacy Concerns

When contending with the affect state of an individual in light of a permanently connected IoT device mounted on their person, privacy becomes a fundamental concern. Information concerning an individual's emotional state is extremely personal; arguably more so when obtained through seamless affect-sensing technologies. This sentiment is explored further in section 2.6.6.

3.7 Facilitating Believable Sentience: HCI Virtual Assistance

3.7.1 An Overview

Virtual assistance has risen to commercial prominence recently as a result of Microsoft and Apple's involvement in the market space. Affective computing can be seen to be relevant in such a context given that the use of affect-recognition can inform the interaction and response. A Virtual Personal Assistant (VPA) is principally a piece of software which has the capacity to answer to human input stimuli, gathering information from, learning from and responding to an individual. It is able to act on your behalf with the rest of the electronic world. Given that the VPA is fundamentally channeling your persona in the digital domain, emotional factors must be accounted for and given significant worth. One may question how to integrate these seamlessly. The following will seek to address the contended matter.

3.7.2 Current Climate

Apple's mobile VPA Siri will soon attain a high-tech upgrade; greatly enhancing voice recognition capabilities whilst adopting the latest neural network algorithms; boosting accuracy by upwards of 20%. This information ties in with affective computing wherein such capabilities encompass a significant component of affect-recognition, extending to accent and tonality. Hiltbrand asserts that automation and smart machines are taking on a more advanced role than ever before; permeating areas which have conventionally been exclusive to human interaction. Machines are beginning to assume some of the human roles in our lives; they should therefore be capable of exhibiting anthropomorphic responses. Not withstanding Hiltbrand's claims, there are arguments to suggest that even with content-aware support, truly personal assistants are still missing. By further investing in affect-recognition, it would be more likely that VPAs can transcend such concerns and exhibit more believable levels of perceived...
sentience.

3.7.3 Implicit Personalisation and Explicit Personalisation

It is noted that implicit personalisation allows machines to learn naturally about a consumer through language and accumulated information; explicit personalisation is a self-implemented setting (a PC remembering a default browser for example).

3.7.4 Geo-Location

Location services are becoming synonymous with interactive experiences on mobile and tablet. In the context of VPAs, it is possible for your assistant to gather understanding of locations that are likely to be your home, place of work or favourite restaurant (Ibid). With access to this information, it is easier to provide more personalised response and enhance the bond between consumer and device.

3.7.5 Data Sourcing

Implicit personalisation from an array of sources allows for emulated cognition which is genuinely believable. For example, Spotify will be aware of your mood when you select a melancholic playlist, but will not have access to this information prior to selection. A VPA using implicit personalisation would gather a degree of understanding by your prior activities, vocal cues or even the fact that your favourite football team lost that day (Ibid).

3.7.6 Privacy Debate

Despite the obvious benefits of implicit personalisation, it also blurs the lines of information rights and an individual’s capacity to keep their sentiments personal. In order to work effectively, implicit personalisation relies on the sharing of personal data between multiple platforms and applications (Ibid). This means that the affective capacity of an interactive system is arbitrated by what information a user is willing to share.

3.7.7 The Future of VPAs

Moving forwards for virtual assistants and perceived machine sentience, we are unlikely to see one assistant to rule them all. It is instead likely that we will see a team of VPAs, each aware of its strengths and weaknesses; collaborating, delegating and stratifying. This will create an efficient network of digital intelligence with the capacity to emulate sentience believably and respond accordingly. In doing so, consumer judgements concerning the worth of information digital mediums provide with increase.

3.8 Literature Review Overview

Ostensibly, the literature review infers a need to focus efforts on emotional design within interactive systems. The digital industry now necessitates innovation above and beyond the design of a good user interface; designers should strive to invoke empathy, dependence and believable sentience. Affective computing has the capacity to enhance the aforementioned criteria and create digital experiences with scope to affect and influence.

When coupled with the increasingly available devices capable of interpreting and recognising affect states, implicit personalisation and predictive analytics will constitute powerful design tools. Despite this, the literature review has revealed notable constraint and issue with their implementation. Affective methodologies must be employed with ample tact and sufficient infrastructure; ensuring that privacy concerns are dealt with pragmatically. Privacy is at the forefront of industry concerns currently and becomes increasingly significant when the information concerns affect state and is obtained without explicit user input.

Moving forwards, the research will now focus on understanding the levels of consumer engagement with the aforementioned systems; gaining insight as to how such practice can be implemented seamlessly and discreetly whilst adding significant emotional worth.

4. Primary Research Design

4.1 Survey

A survey was produced to ascertain a consumer voice regarding levels of engagement with interactive systems. The findings were correlated with respondent demographic; offering insight as to how such practice can be implemented seamlessly and discreetly whilst adding significant emotional worth.

4.1.1 Ethical Considerations

Participants of the survey piloting exercise were asked to sign an ‘Informed Consent Form’ (Ibid) and were provided.
with a ‘Participant Information Sheet’ (Ibid) detailing relevant information about Loughborough University’s ‘Research Misconduct and Whistle Blowing Policy’. Participants were advised to make contact through the outlined channels in the instance that they felt mistreated or mislead at any point. With regard to the published online survey, the first page outlines the purpose of the study alongside all relevant ethical information.

The introduction requires the respondent to confirm that they understand and wish to continue. Contact information is provided for both the investigator and the supervisor should they have any further queries or concerns. The survey asks for information concerning age and gender for categorisation purposes; aside from this, it is wholly anonymous.

4.1.2 Survey Piloting
Survey piloting facilitated an early insight as to how questions were perceived and understood. Ostensibly, it gave the opportunity to minimise anomalous results due to misinterpretation. Two participants were selected to pilot the survey before it was published online. Participant A was a 22-year-old Masters Research student in International Crisis Management; Participant B was a 52-year-old receptionist. The two pilot participants were not encouraged to partake in the final published survey.

4.1.3 Survey Advantages and Disadvantages
An online survey is an effective, efficient and cost-free way of attaining collective insights within a comparatively short period of time. They are notably easy to distribute through social media and other relevant platforms. Surveys take steps toward transgressing the limitations of subjective opinion that one-on-one interviews necessitate. Furthermore, by removing the interviewer from the process, personal prejudices and inclinations are detached; giving the participant the opportunity to offer more visceral responses. It is important to note that with an online survey such as this, there is nothing whatsoever to prevent an individual from falsifying response or providing improper information. This is a commonplace source of misinformation which must be considered in the analysis of data.

4.1.4 Using the Likert Scale
In order to facilitate a response which is not solicited or lead, the Likert Scale provides a visceral means of

![Figure 2. Likert Scale Implementation in this Survey](image-url)
questioning whereby a respondent's attitudes and opinions can be measured. It uses multiple choice formatting to present the respondent with a statement with which they indicate a degree of agreement or disagreement. The addition of a 'Neutral' category, typically coupled with an odd number of selectable criteria transcends binary yes/no responses and provides a psychometric measurement which is more indicative of the participant's actual convictions.

Despite this, it must be noted that the responses attained from such questions are arbitrated by a respondent's understanding of the notions of agreement and disagreement. As a result, participants will rarely select the extremities of the scale; even if it constitutes the most appropriate choice. Figure 2 shows the Likert Scale questions used in this Survey.

4.2 Survey Overview

The survey aimed to identify the levels of engagement which consumers have with various interactive devices. Beyond this, the survey questioned levels of dependence, understanding, empathy and trust that consumers feel toward such systems. The first two questions were included for contextual purposes; providing demographic information on age and gender to be used in the identification of trends. Question numbers three and four aim to identify the prevalence of certain devices in a respondent's digital life. The addition of an 'Other' option provided the opportunity for participants to answer beyond the limitations of the selected choices, if they thought it relevant to do so. A Likert Scale was used therein to ascertain the levels of dependence and emotional empathy felt toward selected devices. Figure 3 shows the questions aimed at eliciting technological dependence.

The final question concerns sensitive information and privacy. In light of concerns surfaced in the literature review, it was necessary to further understanding of
consumer relationships with data collection. Figure 4 shows questions relating to sensitive information and privacy.

5. Findings
All data to be reviewed constitutes quantitative responses as opposed to qualitative text-based information. This was intentional so as to avoid the predispositions of this author influencing the clarity of findings. There is no need to use data tagging in order to quantify the information.

5.1 Respondents and Response Rate
In order to comply with university ethical procedures, the survey was not advertised to anybody under the age of 18. Surveys typically receive a low response rate alongside poor engagement in the giving of thorough and considered responses. As such, the information presented should not be considered a wholly accurate consumer voice, more so a general consensus of the collective demographic attained over a short period of time. The survey was primarily distributed via social media by the author; meaning that a vast majority of respondents were between the ages of 18 to 24. In order to avoid potential prejudices and inclinations, it would have been preferable to have received responses from a more even spread of demographics. Figure 5 shows the distribution of age of respondents.

The 18-24 range of respondents constituted a 90.91% share of all participants; inferring a significant skew in results toward the younger generation. Overall, the survey attained 43 responses, within which there was a relatively even split between male and female respondents; 22 and 21 respectively. There will not be a result bias in preference of either gender.

5.2 Survey Findings
As the literature review implied, survey responses indicated a high percentage of individuals that interact with their devices on a daily basis. Predictably, 100% of respondents claimed the daily use of a smartphone, whilst laptops and desktop computers received 90.48% and 50% daily usage respectively. Despite assertions that consumer adoption of wearables is at all-time high, wearable devices such as smartwatches and fitness aids received comparatively low rates of use, totaling 4.76% of respondents combined. This information is perhaps reflective of the aforementioned claims that such devices remain “gadgets for geeks”.

Not withstanding exponential growth and consumer adoption, dependence levels do not currently solicit daily usage. Surprisingly, virtual assistants received a 7.14% daily use rate, inferring a swift uptake of the technology; such services were unavailable prior to recent years.

Figure 4. Sensitive Information and Privacy
Figure 6 illustrates levels of consumer engagement. Only one respondent chose to add an ‘Other’ option; stating their daily use of a smart heating control. This helps to validate the assumptions made in the literature review that machine learning is beginning to play a part in the home lives of some consumers.

Participants were asked to indicate using a Likert Scale their level of agreement with six statements. As aforementioned (see section 3.2.4), participants seemed largely reluctant to select the extremity options. However, it is apposite to note that 57.14% indicated strong agreement with the claim that they are dependent on
their devices. With such high levels of use and dependence, digital devices should strive to positively affect consumers. Figure 7 shows results relating to dependence and empathy.

Interestingly, despite over half of the research population indicating high levels of dependence on their digital lives, only 21.43% felt strongly that the devices they use have the capacity to emotively affect them. Returning to Rogers’ S-Curve of ‘Target Market Penetration’, it appears that consumer-facing emotional design within interactive systems is less explored and could offer scope to innovate and add value.

The survey identified certain trends in what consumers understand about privacy and data collection. The most pertinent piece of information being that 60.98% of respondents strongly agreed implicit personalisation is a concerning practice. Overall 90.25% of respondents agreed with the sentiment to some degree. Further to this, nearly a third of respondents felt unaware as to what information their digital devices collect. This implies a void of information which is potentially damaging to the consumer’s relationship with a device. Nevertheless, one could argue that lacking consumer understanding is a positive finding. It could imply that implicit personalisation is becoming an expected component of digital design, with less negative connotations from a consumer-facing perspective. Moving forwards, significant worth should be accredited to enhancing the transparency of privacy infrastructures. By seamlessly integrating such features, the experience will appear less intrusive. Figure 8 shows results relating to sensitive information and privacy.

Ostensibly, the survey indicates unprecedented levels of technological dependence; manifested in the required daily use of certain devices (predominantly smartphones and laptops). It defines opportunity to increase the perceived emotional worth that is attributed to digital devices. However, if realised through affect-sensing and responsive technologies, there is an inferred need for enhanced clarity of privacy and data handling.

5.3 Stakeholder Interviews

Interviews were conducted with relevant stakeholders to validate the insights attained thus far in light of the defined objectives. This methodology proved effective at this stage of research; the literature review and survey had

![Figure 7. Dependence and Empathy](image-url)
produced sufficient insights so as to facilitate a genuinely progressive discussion. Prior to interview planning, procedures were reviewed in light of Kahn and Cannell’s book ‘The Dynamics of Interviewing; Theory, Technique, and Cases’.

5.3.1 Ethical Considerations
No names are used in this section. For the purposes of this research, stakeholders will be known as Participant C and Participant D.
Participants had the purposes of the study fully explained to them prior to the interviews. They were given the opportunity to read the ‘Participant Information Form’ and were asked to sign an ‘Informed Consent Form’ (Ibid). Furthermore, Participant C and Participant D have both had prior experience regarding the requirements of the research module and were familiar with the process.

5.3.2 Participant Selection
The first interview was with Participant C; a senior lecturer in usability and user experience design at Loughborough University. Participant C is able to call on years of industry experience in the validation and refutation of claims surfaced in the literature review. The second interview was with Participant D, a recent Loughborough University graduate who now works as a user experience designer at Samsung. Participant D was able to use an industrial design background to contextualise the difference between affective interfacing and an emotionally evocative product solution.

5.3.3 Interview Advantages and Disadvantages
It is understood that discussions will consist of subjective opinion with a questionable degree of validity. Notwithstanding this, the relevance of the participant’s experience qualifies them to offer insights which will hopefully further the nature of the investigation.
It is also important to note that during physical one-on-one interviews, the investigator must take particular care to not inadvertently solicit a desirable response. Discussions must be grounded impartially at all times so as to avoid interfering with the clarity of answer provided. Neutral questions were drafted prior to the interview with a view to mitigating this circumstance.

5.3.4 Interview Discussion Points
The interviews aim to validate, criticise and discuss the insights attained thus far with focus on three key research questions.
1. The design industry is evidently transitioning toward a
digital one. To what extent do you feel that digital devices have the capacity to reflect the emotional bonds which we have with physical products?

2. Implicit personalisation constitutes the harvesting of data without it being explicitly provided, in order to provide personalised response. Do you feel that this could be an effective tool in creating emotional design experiences on digital products?

3. How would you advise tactfully dealing with the privacy issues which arise from a digital device having the capacity to learn about a consumer without them explicitly providing the information?

5.3.5 Participant C: Discussion Overview

It is Participant C’s opinion that emotion fundamentally comes from meaning. In many respects, this qualifies digital devices to provide affective experiences greatly surpassing those of physical products.

Breaking interaction design down to behaviours, Participant C asserts that in order to influence an individual, you must first persuade them that what you are showing them is meaningful and worthy of a reaction. In order to establish such relationships between consumer and device, a degree of trust is necessary. Participant C undertook a workshop with O2 whereby the primary focus constituted the acquisition of consumer insight and understanding. With a digital device, Participant C believes that there is ample opportunity to reflect this understanding back to the user.

Participant C was also able to clarify the aforementioned survey findings. Regarding the privacy concerns expressed by users, Participant C asserts that, when prompted (in a survey for example), an individual is highly likely to express a degree of concern about privacy. This expression is unlikely to be indicative of their real convictions. In reality, our data is being picked up all the time and our devices are constantly responding to it. The issue, for Participant C, concerns the design challenge of establishing sufficient trust to encourage cooperation.

If sufficient cooperation is facilitated, it would unlock a host of opportunities for designers and developers. Participant C refers specifically to a mobile phone chip with learning capacity. If predictive analytics were incorporated across the entirety of a digital mobile experience, the benefits would be plentiful. By gathering an understanding of when a consumer uses the device and how they use it, basic enhancements such as the prolonging of battery life would be made possible. Despite this, Participant C voiced concerns about machine learning capabilities, stating that there is a high likelihood of failure and misinterpretation in the early stages of use. This will likely manifest itself in a consumer deciding to abandon the software.

5.3.6 Participant D: Discussion Overview

Participant D stated without doubt a belief that digital devices are capable of eliciting emotional responses; specifically responses which relate to the owner of the device. It is noted that such responses are already being invoked on a primitive level with online services such as Netflix, wherein user preferences are stored and used to populate recommended channels. This can be seen to enhance the overall experience and encourage empathy between consumer and device.

Participant D stated without prompt that a degree of machine learning is necessary if affect-sensing is to be implemented effectively. Participant D drew comparisons to Microsoft’s ‘Cortana’ VPA whereby a learning service is able to present information in such a way which is emotionally evocative; reminiscent of anthropomorphous response. Participant D goes on to say that without emotional attachment to a product, it is discernibly easy to put it down. In light of survey findings (Section 3.2.8) that indicate high levels of interaction and dependence with digital devices, we can assume that emotional bonds have been established in this context. With regard to privacy concerns, Participant D asserts that there is a need to overcome the barrier of repeat consent and integrate implicit personalisation more seamlessly. This then becomes a challenge of convincing society that the benefits outweigh the negative connotations with regard to data collection. This is arguably a task which lays outside of the grasp of user experience designers and increasingly in the hands of the media and public forums.
If a user wishes to consent to systemic gathering of information, they should only be asked to do so once. Thereafter, the issue becomes one of data security as opposed to privacy. It is Participant D’s opinion that privacy concerns can be overcome by bestowing the capacity to review, download and delete all information which is gathered by an interactive system.

6. Analysis and Discussion

6.1 Brief Overview of Key Findings

There was notable consistency between the insights attained in the literature review and the sentiments expressed during stakeholder discussions. With regard to the privacy debate, interesting conflicts of opinion were presented between the thoughts of the consumer and the convictions of the designers. A majority of survey respondents voiced a concern at the notion of implicit data collection. Notwithstanding this, stakeholders indicated that the challenge lies within establishing consumer trust and encouraging understanding of data collection benefits.

Overall, research findings have inferred a need to continuously innovate within the digital industry in order to succeed. It is this author’s opinion that affective computing is not a necessary development within this field, but it is one with the capacity to add significant value.

6.2 Broader Implications of Findings

Findings were reviewed in light of Gartner’s ‘Hype Cycle’; a set of technological decision-making tools consisting of five key stages. This will offer insight as to the current market climate regarding machine learning, wearables and virtual assistance; facilitating predictions moving forwards.

The first stage is the innovation trigger (Ibid); typically when the media draws attention to a promising new technology. The literature review has revealed prominence in the media regarding the scope for affective digital devices. It appears that emotional design within interactive systems is already at the forefront of industry concerns; supported by the fact that Samsung are channeling research and development resources into enhancing the technology in wearable devices.

The second stage is the peak of inflated expectations. At this stage, multitudes of failures are inherently ignored and the media plays up the successes of such devices. This is evident in the review of wearable devices. The prominence of claims that wearables are about to vastly impact society economically and socially vastly overshadow the consumer privacy concerns surfaced in the survey.

Thirdly, there is the trough of disillusionment wherein dwindling levels of interest necessitate a ‘survival of the fittest’ market landscape. The stronger products which innovate and affect to a greater degree are typically the more successful. Returning to the notion of Rogers’ ‘S-Curve’, there is an inferred need to innovate quickly and efficiently in the digital industry or risk an unsuccessful product proposal.

The fourth stage is the slope of enlightenment whereby the benefits of such technologies become better known. Arguably, affective implementation has not reached this stage; implicit personalisation reaps huge benefits in user experience, though consumers are quick to reject it as a result of privacy implications. Were the benefits more succinctly communicated commercially, adoption of affective digital interfacing may reach new ground.

Finally, we can expect to see a plateau of productivity (Ibid). At this stage, the technology sees mainstream adoption and its values are widely accepted.

Notably, speech recognition is the only affect-sensing tool to have reached the fifth stage of the ‘Hype Cycle’. Despite this, it is a versatile technology with a host of practical opportunities which are so far unexplored in a commercial context; speech rate, stress frequency, loudness, pitch discontinuity, accent and breathiness. There is sufficient scope here to innovate and add value at the relevant cycle on the ‘S-Curve’.

The Economist notes that some technologies mature faster than others in light of such a progression. Wearables are seen to mature comparatively slowly as a result of three factors: necessity for mobile coupling; failure to be viewed as ‘cool’; a lacking ‘killer’ use-case (Ibid). Affective
implementation has been seen to transcend some of the aforementioned concerns. Upon integration with a wearable device, affect recognition and implicit personalisation tools have the opportunity to delight and profoundly influence consumer behaviours. Despite the benefits outlined of implementing affect-sensing and recognition devices commercially, it will fundamentally necessitate significant infrastructural change. Figure 9 shows the Hype Cycle chart.

The ‘Hype Cycle Chart’ illustrated in Figure 9 implies that affective computing is expected to reach a plateau of consumer acceptance in 5 to 10 years. By investing time and effort into affective practice such as implicit personalisation and predictive analytics, designers can gain a competitive industry edge.

6.3 Research Constraints and Limitations

Whilst survey piloting ensured that questions were pertinent and understandable, the results imply limitations on factors beyond the control of this author. The survey findings made it evident that access to individuals above the age of 24 was particularly limited. This was a result of the sharing platforms used to publicise the questionnaire; meaning that a thorough analysis of opinions differing across demographics was not possible. Conducting interviews at the latter stage of the process facilitated the progressive discussion of insights attained. Despite this, it is likely that such an approach will have influenced the responses as a result of the investigator’s predispositions.

Conclusions

This research does not submit with any degree of certainty that affective computing is the future of the digital industry. However, it does infer a need to innovate above and beyond the parameters of good usability and a beautiful interface. This is demonstrated by Wagner’s claims that having a website is no longer sufficient to establish your product or service in the digital market. This is especially the case in the design of digital experiences that aspire to emotionally engage a consumer. The research goes some way to illustrate how affect-sensing and responsive technologies have the capacity to achieve this commercially.

The ‘Hype Cycle’ and Rogers’ renowned ‘S-Curve’ both
infer a need to transgress the imminent plateau at the peak of consumer adoption. This is achieved through varying levels of innovation; developmental, transitional or transformational. Affect-sensing and recognition software has the capacity to be implemented on all three levels; facilitating scalable execution based on consumer feedback and uptake.

Gartner’s ‘Hype Cycle’ illustrates the developments necessary for affective computing to reach a peak of consumer acceptance within a 5 to 10 year period. This can be achieved through the management of consumer expectations, disillusionment and enlightenment from within the design industry (Ibid). Further to this, Figure 9, indicates that affective computing, VPAs and smart robots are working toward a peak of expectation, whilst wearable devices are already on the decline. To surpass the decline of expectation regarding wearable devices, integration with affect-sensing and responsive technologies could prove instrumental in redefining consumer interest positively.

Survey findings indicated that consumer engagement levels are exceptionally high; 100% of participants noting daily interaction with at least one device. Notwithstanding this, respondents indicated low levels of agreement with the claim that their devices had the capacity to emotionally influence them. There is a need to innovate within the digital space wherein the affective market has been less explored for consumer-facing products.

Despite the necessity for significant infrastructural change, designers should focus efforts on enhancing levels of accessibility, versatility and usability. Affective computing does not necessarily have to be implemented solely within individual devices; Lauren Barack’s article ‘Can Technology Tell You When a Client is Worried?’ explored affect-sensing with in a macro-environment. Implementation as a global service has the capacity to inform larger corporations in developing further integration of emotional design elements.

The most notable hindrance in the implementation of the above constitutes consumer privacy concerns. The research concludes in light of stakeholder interviews that these should be addressed as a matter of trust as opposed to privacy. The capacity to review, download and delete data within a seamless user interface will encourage engagement. The benefits of implicit personalisation and predictive analytics will be made increasingly apparent, facilitating positive progression through Gartner’s ‘Hype Cycle’ of acceptance.

Ostensibly, there is a degree of negligence on the part of the design industry in failing to create emotional design experiences which reflect the technological capabilities available. By addressing privacy concerns pragmatically with the relevant infrastructures in place, interactive devices can and will develop the capacity to emotionally-influence.

Further Study Recommendations

It is this author’s recommendation that in further study, it would be necessary to obtain insights from a wider demographic of individuals and conduct supplementary interviews in an environment less conducive to bias. Research should focus on how the design industry can influence consumer privacy concerns through the capacity to review, download and delete. In doing so, the findings of this research infer a heightened degree of consumer acceptance regarding affective technologies; facilitating the design of emotionally-engaging experiences in interactive systems.

References


ABOUT THE AUTHORS

Tom’s background is in avionics worked as a development engineer for Ferranti Defence Systems Ltd. in Edinburgh. In 1990, he took up a two-year fixed-term research assistantship at the Engineering Design Research Centre in Glasgow. Upon completion of this role, he taught Computer-Aided Engineering at the University of Hertfordshire in Hatfield. Since moving to Loughborough University in 2003, Tom has taught electronic product design, interaction design, design and manufacturing technology and physical computing. His research interests are in engineering design, design education, technology education and electronic design automation. He is the organiser and co-ordinator of all design and prototyping activities required for the Engineering Education Scheme (EES) workshop and is the outreach and widening participation co-ordinator within the Design School. Tom’s work has been widely published in the form of journal papers, book contributions, refereed proceedings, refereed conference papers and technical papers. He has supervised research students, acted as external examiner on undergraduate and postgraduate programmes, examined PhDs and MPhils and has acted on the reviewing panel of a number of key journals and conferences.