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Emotions and continued usage of mobile applications

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Abstract

Purpose – A pressing issue with mobile applications (apps) is continued use. The expectancy disconfirmation theory is employed as the theoretical basis for most studies on continuance. Recognising the experiential aspects of using mobile apps, the purpose of this paper is to extend the existing disconfirmation model to account for the emotional experiences and their influences on continuance. In particular, the authors are interested in the factors that drive the experience of emotions, and how these cognitive drivers differ in shaping distinct emotional experiences (i.e. positive vs negative).

Design/methodology/approach – Structural equation modelling was applied on 271 valid responses collected from an online survey conducted among mobile app users.

Findings – Disconfirmation affects emotions in a non-linear fashion through arousal, and both positive and negative emotions influence continuance intention. Furthermore, positive emotions tend to be influenced by inherent benefits, whereas negative emotions are more likely to be influenced by instrumental benefits.

Research limitations/implications – The generalisability of this study may be enhanced by collecting data from more diverse samples and validating the model on more mobile app categories.

Originality/value – This study progresses from the demonstration of a mere impact of emotions on continuance as in several recent empirical inquiries to more nuanced understandings of the role of emotions in forming continuance intention.

Keywords Emotion, Mobile apps, Continuance, Disconfirmation, Perceived benefits

Paper type Research paper

1. Introduction

After years of rapid development following the debut of the iPhone, Apple's trademark "There's an app for that" seems truer than ever before. Millions of mobile applications (hereafter "apps") have greatly expanded the capability of our mobile devices. Such transformation of mobile services has attracted many companies and entrepreneurs to venture into the app business, leading to a very crowded market. However, typical app users are less patient as too many apps and other media are competing for their attention. According to Flurry (2011), only about one third of the users continue to use an app one month after its first trial, and this number shrinks to just 4 per cent after one year. If the retention of app users drops off so fast, the sheer volume of downloads is perhaps no longer relevant. Although we have seen increasing interest in mobile services in the field of information systems research (e.g. Zhou, 2014), most of them focus on adoption. This leads to a pressing issue on continued use, and calls for an in-depth understanding of the factors affecting it.

The importance of continued use for driving productivity and achieving sustained success has been recognised, especially in organisational settings (e.g. Huang *et al.*, 2013; Venkatesh and Goyal, 2010). However, mobile services are differentiated from the

traditional IT systems due to a unique combination of characteristics: ubiquity, interactivity, and versatility (Larivière *et al.*, 2013). These characteristics together present mobile app users a unique value proposition that integrates instrumental, experiential, identity, and social elements. As a result, mobile devices have become personal companions. Emotions are inherent to this intimate relationship between a smartphone and the user. In light of this, conventional wisdom of continued use that is largely based on cognition-oriented frameworks may be inadequate in the context of mobile apps (Lin and Bhattacherjee, 2010). Although several recent empirical inquiries into emotions have shown the impacts of emotions on adoption or continuance (e.g. Kim *et al.*, 2007; Wu and Holsapple, 2014), the factors that affect the experience of emotions are less explored. In particular, are positive and negative emotions influenced by the same set of factors? If not, how do they differ? In this study, we will investigate the relationship between the distinct types of benefits (i.e. instrumental, experiential, identity, and social) and emotional responses. The overarching purpose is to extend the existing cognition-oriented disconfirmation model to account for the emotional responses during IT use, including their triggers as well as influences on continuance.

2. Literature review
2.1 Expectancy disconfirmation theory (EDT)
Inspired by customer satisfaction research, Bhattacherjee (2001) adapted the EDT (Oliver, 1980) to study the continued use of information technologies. Central to this theory is the disconfirmation process that starts with initial expectations prior to the actual use of a technology. These expectations reflect the anticipated outcomes due to past experiences or external information such as advertisement and word or mouth. The expectations establish the basis against which actual performance after usage is compared to reach a judgement on the level of disconfirmation. Positive disconfirmation occurs when performance exceeds expectation, negative disconfirmation occurs when performance falls short of expectations, and zero disconfirmation means the performance is as expected. Bhattacherjee (2001) used perceived usefulness as a proxy of expectation and found positive relationship between disconfirmation and perceived usefulness. Further, a positive relationship between disconfirmation and satisfaction was also found in his study. However, this conclusion was recently challenged by Venkatesh and Goyal (2010) who argue that disconfirmation is undesirable since both positive and negative disconfirmation have equivalent adverse effects on continuance intention.

Overall, EDT has greater theoretical appeal than those based on traditional adoption frameworks, such as the technology acceptance model or theory of planned behaviour. The disconfirmation construct accounts for the experience accumulated through repeated use after initial adoption and, consequently, the potential psychological and behavioural changes that differentiate continuance from acceptance. Therefore, EDT is one of the most widely used theoretical frameworks to understand IT continuance or retention in such diverse areas as world wide web (Limayem *et al.*, 2007), blogs (Shiau and Chau, 2012), online shopping (Lin and Lekhawipat, 2014; Mohamed *et al.*, 2014). However, the role of emotions in IT continuance remains overlooked although users are not always "rational logical beings" (Zhang and Li, 2005; Zhou, 2014), especially when playing with his or her personal IT systems. Anecdotal evidence suggests that a user is very likely to experience emotions when encountering high discrepancy between his or her expectation and the outcome instead of just a cold rational judgement. However, to the best of our knowledge, this has never been studied in information systems research. Hence, EDT can be enriched by incorporating the emotional

responses that disconfirmation may trigger (Zhang and Li, 2005; Ortiz de Guinea and Markus, 2009).

2.2 Emotional experiences

According to Holbrook and Hirschman (1982), "emotions form an important substrate of consumption and that their systematic investigation is a key requirement for the successful application of the experiential perspective". Previous research has shown that emotions have sustained effects on decision making and behaviours (Han *et al.*, 2007). Increasing emotional attachment can lead to a longer period of retention (Fullerton, 2003). Some researchers even claim that emotions are better predictors of loyalty than cognition (Yu and Dean, 2001). Based on the converging findings regarding the critical role of emotions across different research areas, emotional experiences should be viewed as a promising research direction that will further our understanding of continued IT use.

Emotions are complex in nature as you may infer from the vast number of descriptors in the English vocabulary. Some psychologists view emotions as discreet because there are some universal basic emotions such as anger, disgust, happiness, etc. (Izard, 2007); while others argue for a dimensional model by which emotions are described as combinations of valence and arousal (Russell, 2003). Despite the enduring debate about these two models of emotions, empirical analyses based on descriptors from either model suggest that the three-dimensional solution (i.e. positive and negative emotions and arousal) is superior to a two-dimensional one (i.e. positive and negative emotions) (Holbrook and Batra, 1987; Westbrook and Oliver, 1991; Oliver, 1994). Positive and negative emotions refer to positively or negatively valenced emotional responses to a stimulus, and arousal refers to the degree of activation in response to stimulation. Arousal is valence neutral, and it mobilises one's attention to the stimulus. Hence, it is usually positioned as an antecedent to positive and negative emotions. The three dimensions of emotions are adopted in this study.

In the field of information systems, an examination of recent studies reveals that researchers have mostly focused on only two types of emotions when examining experience with information technologies: anxiety (Brown *et al.*, 2004) and perceived enjoyment (Koufaris, 2002). IT-related anxiety is posited as a major inhibitor of use intentions. However, with increasing prevalence of information technologies, the influence of anxiety may not be as prominent. Moreover, the impact of anxiety is limited to the initial stage because one major source of anxiety is perceptions of low self-efficacy, which will improve as more experience is accumulated through repeated use (Agarwal *et al.*, 2000). Perceived enjoyment is one aspect of positive emotion. It is intended to capture the hedonic benefits of IT use. These two types of emotions only give a relatively narrow account of emotions in IT use. The emotions experienced during the course of IT usage are far richer than just anxiety and enjoyment. A more comprehensive investigation of emotions arising from IT use and their relationships with cognition and intentions is required.

2.3 Perceived benefits

Based on the recent study by Larivière *et al.* (2013), four types of benefits from mobile apps are proposed, including instrumental, experiential, identity, and social benefits. Instrumental benefits refer to better task performance or enhanced productivity when using a mobile app (Yoo, 2010). The notion of instrumentality implies that an objective exists external to the interactions between an app and a user, such as a calendar app for organising schedules or a dictionary app for translation, both of which enhance task

performance. From this perspective, a mobile app is regarded as a means that enables a user to achieve the intended objectives. Higher cognitive involvement is expected when a mobile app is judged on its functionality (Voss *et al.*, 2003).

In contrast, the other three types of benefits (i.e. experiential, identity, and social) are of and in an app itself rather than realisation of certain external objectives (Yoo, 2010). The experiential benefits construct is defined as the extent of fun a user experiences when using a mobile app (Venkatesh *et al.*, 2012). Identity benefits are defined as the extent to which using a mobile app is expressive of one's social or personal identity. Social benefits refer to the extent to which an individual is connected with others through a mobile app. We call these three types of benefits inherent benefits. They are not about what the app is for, but more about what the app is. These benefits are naturally related to higher affective involvement (Holbrook and Hirschman, 1982). In addition, it is such inherent benefits that set mobile apps apart from traditional IT applications, notably those used in business organisations. Such categorisation of instrumental and inherent benefits has important theoretical implications for the relationships between cognition and emotions, which will be discussed in the hypothesis development section.

3. Hypothesis development
One useful framework to facilitate the understanding of emotions and cognition is the discrepancy-arousal theory (Cappella and Greene, 1982). It links cognition and emotions through arousal triggered by discrepancy. The concept of discrepancy is equivalent to disconfirmation in the EDT, and thus the two terms are used interchangeably in this study. The discrepancy-arousal theory assumes that a user has expectations about the performance of a product or service, and the discrepancy between the expected and the actual creates arousal, which further leads to affective responses. This theory offers a useful theoretical lens to investigate the potential emotional consequences of disconfirmation. Further, this theory suggests that affective changes are followed by action tendencies, either behavioural avoidance or approach, partly depending on the valence of the emotional experiences. Next we elaborate the hypothesised relationships in our conceptual model.

3.1 Perceived benefits and disconfirmation
Disconfirmation is a function of expectations and perception by definition. This study only examines the relationship between perceived benefits and disconfirmation as the inclusion of the expectations construct is not essential to our research questions. Further, the absence of this construct is not likely to affect the substantial meaning of disconfirmation. The effect of perception of benefits on disconfirmation is quite established in the literature: higher benefits leads to positive disconfirmation, and lower perception of benefits leads to negative disconfirmation (Patterson *et al.*, 1997). Therefore, we posit the following hypotheses:

H1a. Instrumental benefits of mobile apps are positively related to disconfirmation.

H1b. Experiential benefits of mobile apps are positively related to disconfirmation.

H1c. Identity benefits of mobile apps are positively related to disconfirmation.

H1d. Social benefits of mobile apps are positively related to disconfirmation.

3.2 Disconfirmation and arousal
Arousal is the extent to which one is feeling engaged or energised. The discrepancy-arousal theory suggests that arousal is a function of discrepancy. Little or no discrepancy

(i.e. just confirmed) is supposed to be non-arousing and large discrepancy to be highly arousing regardless of its directionality (i.e. positive or negative). In other words, the greater the deviation from the expectations, the greater the arousal. Hence, the relationship between disconfirmation and arousal can be non-linear because high discrepancies in both directions (i.e. high negative disconfirmation or high positive disconfirmation) can be highly arousing. Therefore, we hypothesise:

H2. Disconfirmation and arousal follow a U-shaped relationship. That is, the degree of arousal increases when the extent of disconfirmation increases in either positive or negative directions.

3.3 Arousal and emotions

Arousal is a prime component in emotion (Katz, 1980). It orients an individual's attention towards the stimulus and subsequently shapes the intensity of positive or negative emotions. Therefore, emotions are to some extent determined by arousal and experienced as positive or negative according to the context. Higher level of arousal is more conducive to emotional responses. When people are more aroused by a stimulus, such as an excellent experience with a mobile app, they feel more energised and their concentration on the current activity (e.g. using the app) increases, which then shapes a psychological state that is more conducive to emotional responses. However, the extent of arousal does not affect the valence of emotions as the valence is aligned with cognitive evaluations. Therefore, we propose the following:

H3. Arousal is positively related to positive emotions.

H4. Arousal is positively related to negative emotions.

3.4 Perceived benefits and emotions

In addition to discrepancy-generated arousal, subjectively experienced emotions are the results of cognitive appraisals as well (MacDowell and Mandler, 1989). Empirical studies in consumer research have shown that cognitive evaluations such as service performance are necessary for affective responses (Price *et al.*, 1995). This cognitive evaluative process shapes the quality of an emotional experience. In other words, when an evaluation of a product or service experience is generated, emotions with a similar valence will be evoked. Therefore, it is expected that an individual's perception of benefits from using mobile apps can evoke valenced emotional reactions (i.e. positive and negative emotions).

As discussed before, the four types of benefits can be classified into two distinct categories: instrumental and inherent benefits. Among the three types of benefits under inherent benefits, experiential benefits encompass various elements of pleasure, fun, and enjoyment, which are very conducive to positive emotions. Identity benefits are usually related to pride and self-esteem (Seidah and Bouffard, 2007), which can evoke feelings of pleasure. Social benefits are about interpersonal interactions, which are always a rich source of emotional responses. Therefore, higher affective involvement is expected in the evaluation of inherent benefits, while higher cognitive involvement is expected in instrumental benefits. As a result, realisation of inherent benefits tends to make the experience more emotionally charged compared to the realisation of instrumental benefits. Hence, we conjecture that inherent and instrumental benefits can lead to differentiated effects on emotional reactions.

Furthermore, a user's evaluative threshold varies in relation to instrumental and inherent benefits (Chitturi *et al.*, 2008). Instrumental benefits generally refer to the more

mundane and better-informed outcomes of an app, such as taking notes and receiving e-mail. These outcomes are seen as ought-to-be-met, thus achieving them may not be highly regarded. Nevertheless, any failure of delivering such benefits could be very painful. For example, a person will be very frustrated if his or her e-mail app fails to send messages. Hence, fulfilment of functional needs may merely evoke mild emotional reactions, whereas their failure may trigger negative emotions with high intensity such as anger because it is a violation of the status quo. On the contrary, inherent benefits are more experiential and personal, users tend to be more tolerant of its failure but more positively evoked if such benefits are realised. Therefore, we hypothesise that the effects of instrumental and inherent benefits on positive and negative emotions are differentiated:

H5. Perceived benefits of mobile apps are positively related to positive emotions, and the influence of inherent benefits (i.e. experiential, identity, and social) on positive emotions is higher than that of instrumental benefits.

H6. Perceived benefits of mobile apps are adversely related to negative emotions, and the influence of instrumental benefits on negative emotions is higher than that of inherent benefits (i.e. experiential, identity, and social).

3.5 Emotions and continuance
Emotional changes are followed by behavioural avoidance or approach depending on the valence of the emotional experiences. The coping theory suggests that an individual tends to continue to use an app to reinforce positive emotions if the experience with it is satisfactory, but stop using it to avoid negative emotions if the app turns out to be low quality (Lazarus, 1991). Therefore, we hypothesise that positive and negative emotions will affect continuance intentions of app usage:

H7. Positive emotions are positively related to continuance intention of mobile app usage.

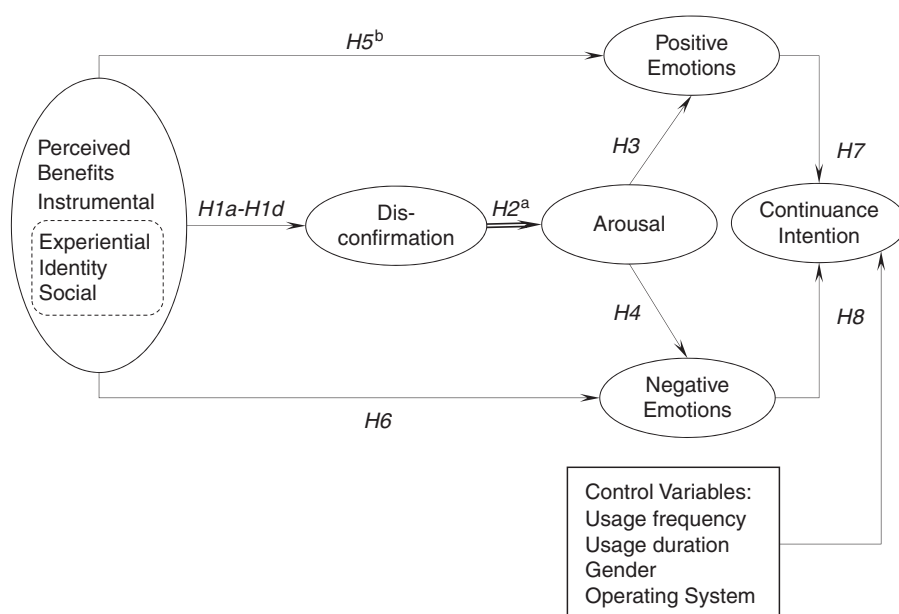*H8.* Negative emotions are adversely related to continuance intention of mobile app usage.

3.6 Control variables
Four control variables were included to obtain a clear understanding of the effects of emotions on continuance. Frequency and duration of app usage were used as control variables since more experience with an app (i.e. higher frequency and longer duration) may limit the influence of other factors on continuance when usage becomes routine (Huang *et al.*, 2013). A third control variable is the mobile operating systems because their performance is inevitably linked to the experience with an app. In addition, the gender of the respondents was also controlled (Figure 1).

4. Methods
4.1 Research design
Note-taking and photo-sharing apps were selected as the context of our research. Both types of apps have achieved enormous success on mobile platforms. Some of them are exclusive to mobile devices, especially photo-sharing apps, which further sets them apart from computer-based applications. To delineate the scope of these two categories, a few guidelines were provided in both the invitation letter and the instructions at the very beginning of the questionnaire. A note-taking app should have the ability to take text and image notes (and other formats if possible), sync seamlessly across devices

Figure 1. The conceptual framework

Positive Emotions — H5[b]

Perceived Benefits
Instrumental
Experiential
Identity
Social

H1a-H1d → **Dis-confirmation** → H2[a] → **Arousal**

H3 → Positive Emotions

H4 → **Negative Emotions**

H6

Continuance Intention — H7, H8

Control Variables:
Usage frequency
Usage duration
Gender
Operating System

Notes: [a]The double-line path represents a non-linear relationship; [b]Effects from perceived benefits to positive and negative emotions are hypothesised to be different (*H5* and *H6*)

(PC, tablets, mobile phones), and share notes with others. A qualified photo-sharing app can be used for simple photo editing (e.g. filters, crop, resize, etc.) and photo sharing. Examples of popular apps belonging to these two categories were also provided for reference. These qualification criteria imposed were intended to ensure that all respondents had adequate experience with the targeted apps in the survey.

Two preliminary questionnaires for both types of apps were designed based on existing scales from the literature. They were largely identical and only differed in the type of apps referred to in each question. They were pretested using 18 subjects who were either highly experienced users of the two types of mobile apps or experts in our research domain. Feedback regarding the face validity of the questionnaire and other potential issues was gathered for further refinement of the questionnaire.

The web-based survey was administered through an online learning platform of an Asian university that students frequently visited for class information and current events. An invitation with embedded links to the two questionnaires was posted on the electronic bulletin board to solicit participation over a one-month period. At the start of the survey, the respondent was required to indicate the corresponding app he or she was using as a qualification check. If the "none" option was chosen, the respondent would be immediately taken to the end of the survey.

In total, the post was viewed 722 times, and this was translated to 295 responses. The response rate is 40.9 per cent. In all, 24 of the responses were dropped from further analysis due to non-completion. This resulted in 271 valid responses overall, including 130 from note-taking app users and 141 from photo-sharing app users. In total, 39 per cent of the respondents were male, and the average age of the respondents was 22.5; 53 per cent of the respondents were using iPhone or iPad; 37 per cent were using

Android phones; and the rest were using others such as Windows phones, BlackBerry, etc. On average, the duration of app usage was half a year, and almost 80 per cent of the respondents used the apps two to three times a month or more.

4.2 Measures

Each construct was measured by multiple items which were mainly adapted from prior research. All items were measured on a seven-point scale, but multiple formats were used including the Likert scale, frequency scale, and semantic differential scale, which could to some extent reduce common method biases (Podsakoff *et al.*, 2003).

The instrumental benefits scale was adapted from Davis (1989), and the scale for experiential benefits was adapted from Venkatesh *et al.* (2012). Identity benefits were measured with four items based on the work of Thorbjørnsen *et al.* (2007). The social benefits scale was modified from Smock *et al.* (2011), and one new item was added to capture the increased connections with a community through mobile apps (e.g. photo lovers and a dedicated online forum for photo sharing) besides the enhancement of personal relationships (e.g. meeting new friends). The disconfirmation scale was adapted from Limayem *et al.* (2007), and one additional item measuring the overall experience besides the benefits and problems was included. The emotion constructs, i.e., arousal, positive and negative emotions, were adapted from Oliver (2010). Continuance intention was measured by three items adapted from Thong *et al.* (2006). The measurement items for each construct can be found in the Appendix.

5. Results

5.1 Measurement model analysis

Common method variance (CMV). Potential common method bias may exist because a cross-sectional survey was used to collect data although preventative measures have been taken in questionnaire design. To examine the potential bias, a model integrating both trait and method factors were tested following the procedures adopted by Liang *et al.* (2007) using SmartPLS (Ringle *et al.*, 2005). In this model, each indicator was explained by its corresponding latent construct (i.e. trait) as well as the method factor shared by all of the indicators. It directly compared the significance and magnitude of trait factor loadings and method factor loadings. As shown in Table I, all trait factor loadings are significant (mean = 0.894), much higher than method factor loadings (mean = 0.063). In contrast, most method factor loadings are insignificant. Additionally, the variance of each indicator explained by the corresponding trait factor (i.e. squared trait factor loading, mean = 0.803) is substantially greater than the method factor (i.e. squared method factor loading, mean = 0.005). Therefore, CMV is unlikely to substantially bias the hypothesis testing results, and thus the method factor will be excluded from subsequent analyses.

Confirmatory factor analysis, validity, and reliability. Confirmatory factor analysis was conducted to evaluate all of the measures by AMOS 21. One item measuring experiential benefits was dropped due to its cross-loading on another construct (modification index = 42.7, item of experiential benefits ← instrumental benefits). Despite the deletion, the remaining items were deemed sufficient to capture the construct domain. Overall, the final measurement model demonstrated an acceptable model fit ($\chi^2 = 1,064.50$, df = 555, χ^2/df = 1.92, $p < 0.001$, NFI = 0.90, IFI = 0.95, TLI = 0.94, CFI = 0.95, RMSEA = 0.058). In regard to factor loadings, except for one of the disconfirmation items ($\lambda = 0.546$), all others were high (from 0.717 to 0.972) and significant at the 0.001 level (see the Appendix).

Construct	Item	Trait factor loading (TL)	TL^2	Method factor loading (ML)	ML^2
Continuance intention	CONT1	0.956***	0.914	0.026	0.001
	CONT2	0.980***	0.961	−0.049	0.002
	CONT3	0.955***	0.912	0.023	0.001
Disconfirmation	DISC1	0.784***	0.614	0.092	0.009
	DISC2	0.846***	0.715	−0.186**	0.034
	DISC3	0.854***	0.730	0.060	0.004
Experiential benefits	EXPB1	0.933***	0.870	−0.002	0.000
	EXPB2	0.981***	0.962	−0.021	0.000
	EXPB3	0.949***	0.901	0.023	0.001
Instrumental benefits	INSB1	0.890***	0.793	0.028	0.001
	INSB2	0.974***	0.950	−0.070*	0.005
	INSB3	0.908***	0.825	0.041	0.002
Identity benefits	IDEB1	0.954***	0.910	−0.109*	0.012
	IDEB2	0.832***	0.693	0.072	0.005
	IDEB3	0.849***	0.720	0.038	0.001
	IDEB4	0.894***	0.799	0.001	0.000
Social benefits	SOCB1	0.919***	0.845	0.013	0.000
	SOCB2	0.899***	0.809	0.045	0.002
	SOCB3	0.945***	0.893	−0.009	0.000
	SOCB4	0.897***	0.805	−0.079	0.006
	SOCB5	0.852***	0.727	0.025	0.001
Negative emotions	NEEM1	0.791***	0.625	0.079	0.006
	NEEM2	0.838***	0.702	0.039	0.002
	NEEM3	0.780***	0.609	−0.051	0.003
	NEEM4	0.875***	0.765	−0.011	0.000
	NEEM5	0.886***	0.786	−0.040	0.002
	NEEM6	0.843***	0.711	−0.014	0.000
Arousal	AROU1	0.877***	0.769	0.056	0.003
	AROU2	0.905***	0.818	0.030	0.001
	AROU3	0.917***	0.840	−0.095	0.009
Positive emotions	POEM1	0.854***	0.730	0.081	0.007
	POEM2	0.931***	0.867	0.016	0.000
	POEM3	0.911***	0.830	−0.109	0.012
	POEM4	0.990***	0.981	−0.063	0.004
	POEM5	0.811***	0.658	0.106	0.011
	POEM6	0.995***	0.990	−0.135*	0.018
	POEM7	0.825***	0.681	0.086	0.007
Mean		0.894	0.803	0.055	0.005

Notes: ***$p < 0.001$; **$p < 0.01$; *$p < 0.05$

Although the disconfirmation item was relatively low in factor loading compared with the other two, it has been retained because the decision to drop or keep it also depends on its theoretical meaning (Byrne, 2009). Cronbach's α values range from 0.760 to 0.961 and the composite reliability indexes are all above 0.860, indicating excellent reliability. To further validate the measurement model, both convergent and discriminant validity were examined. The former was assessed by the average variance extracted (AVE), and the values were all higher than the 0.50 cut-off point. Thus, strong internal consistency is evident for all of the constructs. Discriminant validity is also achieved since the square root of each construct's AVE is higher than its correlation with any of the other constructs (Table II).

|	ME	SD	AVE	CR	CA	INSB	EXPB	IDEB	SOCB	AROU	POEM	NEEM	DISC	CONT
INSB	5.40	1.15	0.853	0.946	0.915	0.924								
EXPB	5.13	1.22	0.911	0.968	0.951	0.587	0.954							
IDEB	4.57	1.21	0.802	0.942	0.918	0.459	0.712	0.896						
SOCB	3.89	1.43	0.815	0.956	0.943	0.190	0.516	0.634	0.903					
AROU	3.02	1.32	0.813	0.929	0.885	0.282	0.527	0.571	0.509	0.902				
POEM	3.97	1.40	0.812	0.968	0.961	0.386	0.606	0.601	0.420	0.718	0.901			
NEEM	2.23	0.97	0.699	0.933	0.914	-0.171	-0.033	0.063	0.150	0.288	0.105	0.836		
DISC	4.47	1.00	0.675	0.860	0.760	0.517	0.483	0.393	0.185	0.355	0.496	-0.244	0.822	
CONT	5.53	1.33	0.928	0.975	0.961	0.708	0.572	0.430	0.219	0.244	0.363	-0.184	0.458	0.963

Notes: ME, mean; SD, standard deviation; AVE, average variance extracted; CR, composite reliability; CA, Cronbach's α; INSB, instrumental benefits; EXPB, experiential benefits; IDEB, identity benefits; SOCB, social benefits; AROU, arousal; POEM, positive emotions; NEEM, negative emotions; DISC, disconfirmation; CONT, continuance intention. The diagonal elements are the square roots of AVE; the correlations with absolute values larger than 0.150 are significant at $p < 0.01$ level; the correlations with absolute values larger than 0.110 are significant at $p < 0.05$ level; the rest are insignificant

Table II.
Construct validity
and correlations

5.2 Structural model analysis

Structural equation modelling (SEM) method was used to test the hypotheses. The results based on data collected from both note-taking and photo-sharing app users are shown in Figure 2. The potential differences between different app types and gender groups, if any, will be examined later. The two-step procedures recommended by Ping (1996, 2004) were adopted to test the curvilinear relationship between disconfirmation and arousal. First, a model without the quadratic indicators is analysed. The results are then used to compute parameters of the measurement model of the quadratic indicators. These parameters include the variance of latent quadratic variables, the factor loadings and measurement error variances of its indicators. The second step adds the latent quadratic variables into the model, and the calculated parameters obtained from the first step are then specified as fix parameters. The hypothesised linear and quadratic effects can be estimated from this model.

Overall, an acceptable model fit was achieved ($\chi^2 = 1{,}048.29$, df $= 422$, $\chi^2/\text{df} = 2.48$, IFI $= 0.91$, NFI $= 0.86$, TLI $= 0.90$, CFI $= 0.91$, RMSEA $= 0.074$). An individual's intention to continue using a mobile app is positively affected by positive emotions ($\beta = 0.29$, $p < 0.001$), but adversely affected by negative emotions ($\beta = -0.21$, $p < 0.001$), even after controlling for previous usage behaviours, gender, and the operating system. Both positive and negative emotions are affected by the level of arousal ($\beta = 0.74$, $p < 0.001$; $\beta = 0.28$, $p < 0.001$, respectively). The results also confirm the U-shaped relationship between arousal and disconfirmation ($\beta = 0.15$, $p < 0.01$). Thus, H2, H3, H4, H7, and H8 are supported.

With respect to the influences of perceived benefits on disconfirmation, the coefficients from instrumental, experiential, and identity benefits are significant ($\beta = 0.36$, $p < 0.001$; $\beta = 0.31$, $p < 0.001$; $\beta = 0.20$, $p < 0.01$, respectively). Thus, H1a and
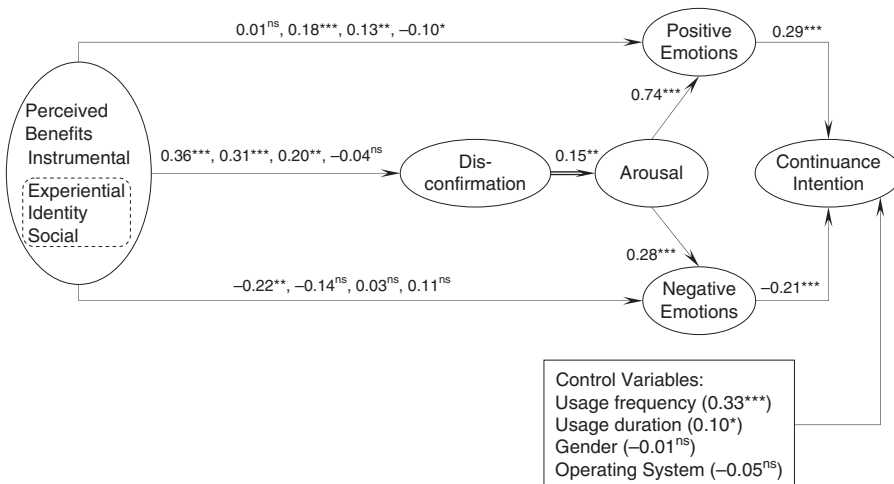
Notes: ns, not significant. The double-line path represents a non-linear relationship; the path coefficients from perceived benefits to disconfirmation, positive emotions, and negative emotions, respectively are in the same sequence as the four-value dimensions. $\chi^2 = 1{,}048.29$, df $= 422$, $\chi^2/\text{df} = 2.48$, IFI $= 0.91$, NFI $= 0.86$, TLI $= 0.90$, CFI $= 0.91$, RMSEA $= 0.074$. ***$p < 0.001$; **$p < 0.01$; *$p < 0.05$

Figure 2.
Results of
hypothesis testing

H1b are supported. Perceived benefits also influence emotional experiences. Positive emotions are affected by experiential ($\beta = 0.18$, $p < 0.001$), identity ($\beta = 0.13$, $p < 0.01$), and social benefits ($\beta = -0.10$, $p < 0.05$). Negative emotions are only significantly affected by instrumental benefits ($\beta = -0.22$, $p < 0.01$). These results confirm our hypotheses (i.e. *H5* and *H6*) about the differences between the effects of instrumental and inherent benefits on emotions. However, the direction of the relationship between social benefits and positive emotions is opposite to what is hypothesised.

5.3 Post hoc analysis

To probe further, we conducted a *post hoc* analysis to examine the potential differences between the two types of apps. The data set were split into two groups (i.e. note-taking: $n = 130$; photo-sharing: $n = 141$), and the multi-group analysis procedures recommended by Byrne (2009) was employed. First, all factor loadings were constrained equal between two groups, and no significant difference was found ($\Delta\chi^2 = 10.41$, $\Delta df = 15$, $p = 0.79$). Then, each pair of structural relationships was compared, and again no significant difference was found. Therefore, we conclude that model equivalence can be established between both app types. That is, the proposed conceptual framework is applicable to both types of apps.

In addition, to test the potential mediating effects of arousal on disconfirmation and positive/negative emotions, we followed the approach recommended by James *et al.* (2006). Two models were compared: the full mediation model and the partial mediation model. The latter adds a direct path from the initial variable (i.e. disconfirmation) to the outcome variables (i.e. positive/negative emotions) in addition to the disconfirmation $\rightarrow$ arousal $\rightarrow$ positive/negative emotions relationships shown in Figure 2. The significance of these additional paths and the difference of model fit are examined to test the potential mediating effects. In the partial mediation model, the direct effects of disconfirmation on positive/negative emotions are significant (disconfirmation $\rightarrow$ positive emotions $\beta = 0.26$, $p < 0.001$; disconfirmation $\rightarrow$ negative emotions $\beta = -0.35$, $p < 0.01$). The relationship between disconfirmation and arousal remains significant ($\beta = 0.15$, $p < 0.01$). Further, the model fit change from the full mediation model to the partial mediation model is also significant ($\Delta\chi^2 = 21.95$, $\Delta df = 2$, $p < 0.001$). Hence, the relationship between disconfirmation and positive/negative emotions are partially mediated by arousal.

6. Discussion

6.1 Perceived benefits and disconfirmation

Although EDT has been widely adopted in the information systems literature, the specific performance attributes that influence disconfirmation have not been adequately investigated. Existing research mostly focuses on generic attributes such as perceived usefulness and perceived ease of use which are inherited from the technology acceptance model (Bhattacherjee 2001; Thong *et al.*, 2006; Shiau and Chau, 2012). Out study examines more specific attributes reflecting the unique characteristics of mobile apps. Of the four types of benefits proposed, instrumental, experiential, and identity benefits are relevant to the disconfirmation process. This suggests that users primarily focus on the functionality and experience of apps during cognitive evaluation. The effect of social benefits appears to be context specific. It may be more salient in such settings as multimedia messaging (Thorbjørnsen *et al.*, 2007) and Facebook (Smock, 2011), but less so in the context of photo and note-taking apps in this study.

6.2 Disconfirmation and emotions
Disconfirmation is found to be a source of emotional arousal. Higher level of
disconfirmation leads to higher level of arousal regardless of the valence (i.e. positive or
negative) of the disconfirmation; while low level of disconfirmation is non-arousing.
A user in a state of arousal is more likely to experience heightened emotions (either
positive or negative) because arousal adds intensity to emotions. For example, a user
may be delighted rather than just be happy with a newly added app feature that takes
her or him by surprise. The significance of this finding lies in its ability to effectively
link cognitive evaluations and affective responses, which is a step forward from
viewing the two processes as parallel. Further, a recent study on EDT suggests that
neither positive nor negative disconfirmation is desirable (Venkatesh and Goyal, 2010).
Consumers are most satisfied with a good match between expectations and actual
outcome. With arousal mediating the relationships between disconfirmation and
emotions, Venkatesh and Goyal's finding may imply that positive disconfirmation does
not necessarily lead to positive emotions, and negative confirmation does not
necessarily lead to negative emotions. This would be an interesting question for further
investigation.

6.3 Perceived benefits and emotions
Our study has also identified the specific benefits that affect positive and negative
emotions. In addition to arousal, positive emotions are a function of experiential,
identity, and social benefits; negative emotions are only affected by instrumental
benefits. These differential effects on positive and negative emotions are
noteworthy because they suggest that positive and negative emotions draw on
different appraisal sources. An interesting observation is the negative effects of
social benefits on positive emotions. Puzzled by this, we have examined the recent
research on this topic. It is suggested that although social sharing is considered
desirable for a mobile app when possible, excessive publicity on the social networks
may be annoying sometimes for multiple reasons such as privacy concerns (Son and
Kim, 2008) and information overload (Jones *et al.*, 2004), especially when a plethora
of social apps and web sites compete for user attentions nowadays. Hence,
the positive benefits from sociability may only last up to a certain point, and
further increase may be perceived undesirable. This indicates the possibility of a
curvilinear relationship between social benefits and positive and negative emotions.
Following the same method for testing the curvilinear relationship between
disconfirmation and arousal, an addition quadratic social benefits construct was
added to the model. The coefficients representing the curvilinear relationship
between social benefits and positive emotions and between social benefits and
negative emotions are -0.11 ($p = 0.01$) and 0.09 ($p > 0.1$), respectively. The former is
significant. Hence, social benefits seem to be beneficial to the users only to a certain
extent after which it becomes too overwhelming to handle. The consequences of
social benefits warrant further examination.

7. Conclusions
This study extends the existing disconfirmation model to account for the emotional
responses during the usage of mobile apps, including their triggers as well as
influences on continuance. It progresses from the demonstration of a mere impact of
emotions on continuance as in several recent empirical inquiries to more nuanced

understandings of the role of emotions in forming continuance intentions. The key findings are summarised as follows:

- emotions do have an impact on continuance intention of mobile apps;
- disconfirmation influences emotions in a non-linear fashion;
- higher disconfirmation, either positive or negative, evokes higher degree of arousal, which subsequently affects the intensity of positive and negative emotions; and
- positive emotions tend to be influenced by inherent benefits (i.e. experiential, identity, and social), whereas negative emotions are more likely to be influenced by instrumental benefits.

7.1 Theoretical implications
This study examines continued use in the context of mobile apps, which have hardly been examined before. The unique characteristics of mobile devices and apps render the cognition-oriented perspective of continuance inadequate. One theoretical contribution is that we have extended the EDT to account for users' emotional experiences. It represents a positive response to a call for research on experiential computing that is embedded with inherent benefits that "make us human and different from other species" (Yoo, 2010, p. 227). Approximately equal influences of positive and negative emotions on continuance intentions are found in this study. Nonetheless, an asymmetrical pattern is also possible. As mobile apps were a relatively new phenomenon when this study was conducted, users may be more likely to be amazed by the new features and capabilities while less intolerant of unfavourable experiences. However, this may change over time as both users and the industry become mature. In this case, the effect of negative emotions on continuance may be more salient. A longitudinal research design can shed insights on this issue.

A second contribution to the literature is the identification of the U-shaped relationship between disconfirmation and arousal. Although the EDT has been widely adopted in the information systems literature, the influence of disconfirmation on emotional experiences is rarely investigated. This study fills this gap and links the cognitive and emotional processes. Further, our research contributes to a more nuanced understanding of the differential impacts of benefits on emotions. Four types of app-related benefits have been identified based on the characteristics of mobile apps. Although the significance of each benefit to a particular app may vary, they are commonly desirable in most apps for personal use. More importantly, the differentiated effects of these four types of benefits on positive and negative emotions could have profound implications on the concept of "usability" in system design. The usability-oriented mindset emphasises avoidance of negative feelings (e.g. no crash, fast download) over elicitation of positive emotions, such as pride, excitement, or surprise. This may be one of the reasons that negative emotions have attracted much more attention in the literature. Our findings suggests that understanding aspects of pleasure-engendering experience is equally important, if not more so, as it may become the principal differentiator in customer experience. Overall, the empirical results suggest that the proposed model is one more step to appreciate the richness of our mental life (Storbeck and Clore, 2007), and can better represent the decision making process.

7.2 Managerial implications
This study is very relevant in a time when mobile services are increasingly pervasive. Although it is a lucrative market and expected to continue flourishing in the coming years, mobile apps are extremely competitive as the barrier to enter the market is relatively low. Currently, too many apps are competing for users' attention. Therefore, it is imperative for a business to go beyond adoption and learn their customers' continuance intentions to achieve long-term sustainability.

To achieve this, app companies should strengthen their competency at delivering benefits that encompasses instrumental, experiential, identity, and social aspects. Traditionally, only the first aspect is considered because IT was once primarily used for improving efficiency and effectiveness at workplace. However, IT today has gone far beyond this role as it reaches a much wider population. Emotional experiences are increasingly salient as information technologies become more personal, interactive, and hedonic. The experiential, identity, and social elements should be adequately considered in the design and promotion of apps as they are particularly effective in enhancing positive emotions. Some possible methods have been proposed for each of the three elements.

From a practical perspective, an experiential app is interactive, easy to use, and sometimes fun. Enhanced interactivity adds attractiveness to apps, and thus more positive emotions (Vodanovich *et al.*, 2010). A well-designed interface is particularly relevant here. For instance, selective use of colours can elicit different emotional experiences. Another method is gamification. This method should not be limited to game or entertainment apps. If used appropriately, it can increase user engagement for a broad range of activities. For example, apps like foursquare apply game mechanisms to transform relatively tedious functions (e.g. check-in to a place) into more enjoyable experiences.

The social elements can enhance emotional attachment to an app and thus higher stickiness. Well situated between the physical and the virtual with constant internet connection and location identification, the smartphone is an ideal platform for firms to further evolve the "social" concept. A typical example is the fitness apps. By sharing activities through apps, sometimes real time (e.g. jogging), one receives comments and support from a community with common interest. Such social interactions motivate him or her to keep pursuing higher goals. Emotional attachment to the social community is the most valuable to the users compared to many features offered by these apps such as recording daily activities and diet. In fact, the act of keeping a diary of daily activities and diet itself is difficult to sustain without a supportive community. Therefore, encouraging healthy social interactions should be an important design consideration for apps.

The identity element is to some extent related to the social element. Constant sharing of information online shapes a person's virtual social world and online images. Many apps provide tools to easily customise user profiles such as photos and colours to express one's unique identity. Hence, the ability to personalisation is useful for identity formation. In addition, some apps are similar to fashion items. Users are very sensitive to trends. People who used to find Facebook interesting may suddenly switch to twitter, and then to WhatsApp. Staying up-to-date is critical to apps' survival. This can be done by internal innovation or acquisition. For example, Facebook acquired WhatsApp and an important reason was that many users had grown disinterest in the social networking giant.

Firms should also be reminded that failure to meet the basic requirements is highly detrimental to customers' feelings (i.e. negative emotions) and consequently customer

retention, although achieving them may not be as rewarding. The key takeaway is to do the basic things right. Many companies are competing to exceed customer expectations and trying every means to delight them at the price of compromising the basics. Despite all the costly efforts, delighting customers may not always pay off especially when an idea is easily imitable (Dixon *et al.*, 2010).

7.3 Limitations and future research

The data used in this study were mainly collected from university students and thus may not be representative of the entire population. Although this might not be a serious concern as smartphone app users are generally younger, future research can include samples with more diverse profiles. In addition, a longitudinal method can offer more insights. For instance, we may find growing impact of social features on mobile app continuance, and negative emotions may be a more critical determinant of continuance in the long term as we discussed before. We also acknowledge the issue involving the choice of apps. The apps selected may be inadequate to capture the heterogeneity of mobile apps. An important dimension characterising technology-mediated services is the degree of interactivity because it indicates the level of customer participation when using a technology (Wünderlich *et al.*, 2013). Qualitative differences between high- and low-interactivity apps may exist. For instance, it is possible that apps requiring higher participation are more likely to evoke emotional responses. This can be one avenue for future research. A second research direction is the possible effects of task difficulty on arousal. In general, the level of arousal rises as task difficulty increases until the task is believed to be impossible to accomplish (Wright and Brehm, 1984). This can be particularly relevant for the usage of complex information systems, or the adoption of information technologies among different demographic groups (e.g. young vs old). User expertise may play an important role in this relationship because it is supposed to influence the assessment of task difficulty.

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(The Appendix follows overleaf.)

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Appendix

Construct[a]	Measurement item[b]	Loading
Instrumental benefits (Davis, 1989)	The app is useful to me	0.882
	The app enhances my efficiency	0.874
	The app makes my life easier	0.896
Experiential benefits (Venkatesh et al., 2012)	Using the app is enjoyable	0.957
	Using the app is entertaining	0.972
Identity benefits (Thorbjørnsen et al., 2007)	I use the app to express who I want to be	0.882
	The app fits my personality	0.856
	Using the app is well regarded by my friends	0.838
	I use the app to express my personal values	0.859
Social benefits (Smock et al., 2011)	Using the app makes me feel closer to my friends or family	0.921
	The app is one way to stay in touch with friends or family	0.916
	The app helps me meet new people	0.940
	The app keeps me up-to-date on people or events I am interested in	0.781
	Through the app I feel connected to a community of people who shares common interests	0.820
Arousal (Oliver, 2010)	Recall your experience with the app, how frequently you felt […] (surprised, aroused, astonished)	0.909
		0.735
		0.780
Positive emotions (Oliver, 2010)	Recall your experience with the app, how frequently you felt […] (delighted, excited, happy, cheerful, relaxed, content, enthusiastic)	0.940
		0.963
		0.748
		0.911
		0.878
		0.820
		0.866
Negative emotions (Oliver, 2010)	Recall your experience with the app, how frequently you felt […] (anxious, annoyed, disappointed, upset, bored, tired)	0.740
		0.796
		0.717
		0.862
		0.878
		0.799
Disconfirmation (Limayem et al., 2007)	The problems encountered with the app were […] (1 = much more serious than expected; 7 = much less serious than expected)	0.780
	Overall, the benefits received from the apps were […] (1 = much less than expected; 7 = much greater than expected)	0.546
	My overall experience with the app was […] (1 = much worse than expected; 7 = much better than expected)	0.848
Continuance intention (Thong et al., 2006)	I plan to continue using the app in the next 3 months	0.969
	I intend to keep using the app as regular as I do now	0.907
	I predict that I will keep using the app in the next 3 months	0.958

Table AI.
Measurement items and factor loadings

Notes: [a]Reference sources in the parentheses; [b]instrumental benefits, experiential benefits, identity benefits, social benefits, and continuance intention are measured on a seven-point Likert Scale. Arousal, positive and negative emotions are measured on a seven-point frequency scale

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