Usability Factors Affecting the Continuance Intention of Disaster Apps

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ABSTRACT

Multiple disaster mobile applications (apps) already exist for public use; however, availability does not automatically translate to continued usage. Limited research has explored whether disaster apps are usable and whether the apps' usability affects users' intent for continued use. The paper presents a work-in-progress study that aims to test a usability-continuance intention model for the specific context of disaster apps.

The study theorises seven usability factors that influence continued intention to use. An online usability survey was used to gather user experience data on disaster apps. Initial findings, through structural equational modelling, showed that five of the seven usability factors have a significant relationship to continuance intention. Although the relationships have different weights and directions, key influencers to users' intent to continue usage are app utility, app dependability, interface output, interface input, and interface graphics.

The next step of the study will investigate the mediating effects of the factors and the moderating effects of users' experience and technological comfort.

Keywords

disaster apps, usability, continuance intention

INTRODUCTION

Disaster applications (apps), developed for emergency preparedness and disaster response, are becoming popular among the general public (Bachmann et al. 2015). Disaster apps have the potential for improving the public's response to disasters, but can be hazards if not designed in the context of its users. Lack of usability may cause apps to become useless (Hoehle and Venkatesh 2015); more so in a disaster scenario. Disaster situations create conditions of extreme time pressure and high stress where individuals may experience degradation in information-processing and decision-making abilities (Sarna 2002). The field of safety-critical systems have highlighted the importance of usability (Kwee-Meier, Wiessmann, and Mertens 2017); however, most studies have been on tools for responders and not on technologies readily available to the public. Limited research has been conducted on disaster apps' usability and the effect of usability on users' continued usage intention.

Hundreds of disaster apps are available for download to the public (Gómez et al. 2013). However, availability of technology does not automatically translate to continued use. Market analysis of apps has shown that after the first download, 1 in 4 mobile applications are abandoned (Localytics 2017; Deloitte 2012). For disaster apps, continued usage is a particular concern; for the apps to be useful, users must accept and acquaint themselves with the app before the disaster event (Tan, Prasanna, Hudson-Doyle, et al. 2017). Users must familiarise themselves with technology meant for use during disasters; otherwise, it will be of limited use during a complex disaster situation (Nilsson & Stølen, 2011). Even if a user downloads the app, but consequently abandons it, then the app will be of no value when a disaster strikes.

In the domain of disaster apps, this study looks at usability and its relation to continuance intention of use. The research in progress seeks to answer the question: What usability factors affect users' intention to continue using disaster apps?

Disaster apps, in this paper, are mobile apps that aid the public in retrieving, understanding, and using time and location critical information to enhance their decision-making process during a disaster situation. User behaviour towards disaster apps may be different in comparison to apps that are used day to day (e.g. social media apps); the frequency of use for disaster apps may not necessarily be daily but only for critical situations (Tan et al. 2016); hence impression on usability at initial use may impact users' decision whether to keep or abandon the app.

Usability and Continuance Intention

Information systems (IS) continuance intention, differentiated from technology acceptance, is the "users' intention to continue using an IS after its initial acceptance"(Bhattacherjee 2001). Research on continuance intention particularly on mobile technology is scarce (Nascimento, Oliveira, and Tam 2018). The prior papers on mobile application continuance intention are often based on the wider IS based literature. Past literature on mobile app continuance intention is summarised in Table 1. Theories such as unified theory of acceptance and use of technology (UTAUT) and its extended version (UTAUT2), and expectation-confirmation theory (ECT) have often been on workplace-based systems; and thus may not have captured the context of mobile technologies (Lu, Liu, and Wei 2017).

Table 1. Past Literature on Mobile App Continuance Intention

	Prior papers		Factors studied influencing continuance	
	Author, Year	Type of apps studied	Factors	IS Base Theory
1	(Kang 2014)	Social media apps	Performance expectancy Effort expectancy Social influence Facilitating conditions	UTAUT
2	(Okumus et al. 2018)	Diet apps		
3	(Hew et al. 2015)	Various	Performance expectancy Effort expectancy Social influence Facilitating conditions Hedonic motivation Price value Habit	UTAUT2
4	(Chen, Meservy, and Gillenson 2012)	InstaFind	Satisfaction Perceived usefulness Confirmation	ECT
5	(Hsiao, Chang, and Tang 2016)	Social media apps		
6	(Oghuma et al. 2016)	Instant messaging apps		
7	(Lu, Liu, and Wei 2017)	Not indicated	Performance expectancy Effort expectancy Mobility Enjoyment Satisfaction Post-usage attitude	UTAUT UTAUT2 ECT
8	(Ozturk et al. 2016)	Hotel booking app	Utilitarian value Hedonic value	--
9	(Hoehle and Venkatesh 2015)	Social media apps	App design App utility Interface graphics Interface output Interface input Interface structure	
10	(Hoehle, Zhang, and Venkatesh 2015)	Social media apps		
11	(Tarute, Nikou, and Gatautis 2017)	Not indicated	Functionality Design solution Interaction Information quality	

In the studies on other mobile technologies, such as for wearable technologies (Nascimento, Oliveira, and Tam 2018) and e-textbooks (Baker-Eveleth and Stone 2015), both cases had extended traditional continuance intention models with the factor of usability; to accommodate the mobile context of the technologies.

In mobile apps continuance intention literature, usability has also become a point of interest. Tarute, Nikou and Gatautis's study (2017) on mobile apps, although focussed on consumer engagement and its effect to continuance intention, found that positive perception of usability of apps leads to positive engagement therefore also to continued intention to use. Ozturk et al. (2016) study suggested that improving the usability of apps increases the perception of value of apps that subsequently affects continuance intention. Hoehle and Venkatesh study (2015) found that usability accounts for continuance intention for social media apps.

Among the few studies in mobile app continuance intention literature, only Hoehle and Venkatesh (2015) defined usability in more detail. They introduced a holistic mobile app usability conceptualisation defining usability to have six factors. The six factors are as follows. (1) *App design* – the degree to which users perceived the app to be well designed, (2) *app utility* – the degree to which users perceive that app delivers its purpose, (3) *user interface (UI) graphics* – the degree to which users perceive that the interface graphics is effective, (4) *UI input* – the degree to which users perceive that app allows easy input for users, (5) *UI output* – the degree to which users perceive the app displays information effectively, and (6) *UI structure* – the degree to which users perceive the app is structured well (Hoehle and Venkatesh 2015). Moreover, an extensive four-country study (Hoehle, Zhang, and Venkatesh 2015) used the usability-continuance intention model, further validating the influence of usability factors on continuance intention moderated by espoused cultural values.

The limitation of usability-continuance intention studies on mobile apps (e.g. Hoehle, Zhang, and Venkatesh 2015; Hoehle and Venkatesh 2015) is that it has only been applied to the context of social media applications. Further research on usability and continuance intention is encouraged whether to see if the research work on mobile app continuance thus far is translatable to different types of application (Tarute, Nikou, and Gatautis 2017; Hoehle and Venkatesh 2015). This study builds on Hoehle and Venkatesh's (2015) conceptualisation on usability.

A study that investigated user reviews from disaster apps (Tan, Prasanna, Stock, et al. 2017) determined that *app dependability* is an important consideration for disaster apps. In crisis situations, *app dependability* contributes to how users perceive the usability of technology; a crash in an IT system could prohibit users from trusting and using the technology (Mills and Chen 2009). The overarching concept of *app dependability* is that users perceive that the app can operate dependably during the app usage cycle (Tan, Prasanna, Stock, et al. 2017). Considering this additional factor, we proposed a usability-continuance intention model specifically for the context of disaster apps (See Figure 1).

Research Hypothesis

This study tried to answer the research question "What usability factors affect users' intention to continue using disaster apps?" by testing the theoretical model (Figure 1). Through analysing the results of a usability survey with actual disaster app users, we determined the level of influence each usability factor attributes to continuance intention for disaster apps use. The hypotheses are stated as follows:

- H1: App design has a significant positive influence on continued intention to use
- H2: App dependability has a significant positive influence on continued intention to use
- H3: App utility has a significant positive influence on continued intention to use
- H4: UI graphics has a significant positive influence on continued intention to use
- H5: UI input has a significant positive influence on continued intention to use
- H6: UI output has a significant positive influence on continued intention to use
- H7: UI structure has a significant positive influence on continued intention to use.

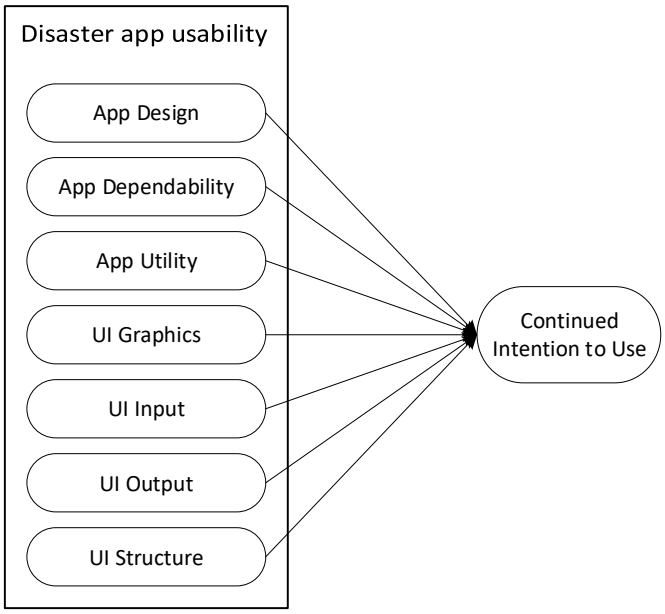

Figure 1. Theorised usability continuance intention model for disaster apps

METHOD

According to Preece (1993), a common method to evaluate usability is through user surveys. Questionnaires are useful tools to collect information about users and their usage of an artefact (Richter and Flückiger 2014). We developed a survey instrument and conducted an online usability survey of actual disaster app users. The primary objective of this paper was to identify usability factors influencing user's continued intention to use a disaster app on their mobile phones.

Instrument Development

The survey was built using Qualtrics Survey Software, distributed online to disaster app users. Questions developed for this research project asked users about their perception of the usability of an existing disaster app that they had or were using at the time they completed the survey. The usability questions were based on constructs drawn from Hoehle and Venkatesh (2015) and Tan et al. (2017). We conducted a pilot study with 30 participants, to refine and contextualise the questions in the context of disaster apps. The questions included items that reflected continued intention to use and all seven usability factors. Each item asked respondents' level of agreement to the statement on a 5-point Likert scale. We then tested this refined instrument with another set of 20 participants, resulting in minor changes in the item wording and questionnaire format. The final list of items used for the study is in Appendix-A. Before data collection, this study went through an ethical approval process for human participation.

Sampling and Data Collection

The sampling frame for this research project was developed by identifying popular disaster apps in New Zealand; after which we invited the app developers to promote the survey to their users. As part of an agreement with the app owners to promote the survey, the app names are withheld in confidence. Since the survey was distributed online, the respondents were not limited by New Zealand's geographical boundaries; although the majority of the respondents are from New Zealand (77.1%), but the survey also attracted respondents from the United States of America (9.2%), Canada (2.6%) and other countries (11.1%). 562 participants submitted responses. The initial qualifying questions moderated the respondents to ensure they were disaster app users; through asking the participants to name the disaster apps installed on their phones. Only 337 respondents qualified to be disaster app users. Of these 337, we assessed missing values, outliers, and normality to ensure the quality of the dataset. Sixty-six were omitted from the data set because of incomplete or disengaged responses; only responses that had a 90% completion rate were included. A final set of 271 entries were retained for further analysis being 80.42% of the qualified responses.

ANALYSIS AND RESULTS

The analysis follows the standard two-stage process of structural equational modelling (Hair et al. 2014). First, we conducted a measurement model assessment through factor analysis; to provide statistical support that the survey items adequately represent the theorised constructs. Second, we conducted a structural model assessment; evaluating the causal relationships of the usability factors to the dependent variable continued intention to use.

Measurement Model Assessment

"Factor analysis is a technique used to identify or confirm a smaller number of factors from a large number of observed items" (Worthington and Whittaker 2006). Exploratory factor analysis (EFA) is recommended to first ascertain the number of hypothetical factors (Fabrigar and Wegener 2012). Given that we were testing a model with an additional theorised factor, and in the specific context of disaster app use, we deemed it appropriate to conduct an initial EFA. We used the software SPSS to conduct the EFA with maximum likelihood extraction method and a Promax rotation method. Table 1 shows a resulting pattern matrix. The results indicate eight distinct groupings of variables with strong correlations; affirming the theorised number of factors (the seven usability factors and the variable continued intention to use) was adequately determined.

Table 1. EFA Pattern Matrix

	Factor							
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**
α	0.959	0.858	0.777	0.924	0.828	0.898	0.916	0.936
CONT2			0.406					
CONT3			0.880					
CONT4			0.747					
DSGN1		0.983						
DSGN2		0.432						
DSGN3		0.688						
DSGN4		0.799						
UTIL1								.837
UTIL2								.880
GRPH1	0.917							
GRPH2	0.913							
GRPH3	0.943							
DPND2						0.834		
DPND3						0.975		
INPT1				.840				
INPT2				.994				
OUTP1							.687	
OUTP2							.820	
OUTP3							.953	
STRU1					.732			
STRU2					.721			
STRU3					.816			

Hair et al. (2014), suggests significant factor loading for EFA based on a sample size of 250 is at 0.35; the sample size for this analysis is 271, and all factor loadings in the solution are above 0.40. Furthermore, the eight-factor model cumulatively explains 76.922% of variance reported in the EFA. Moreover, the pattern matrix shows evidence of convergent validity as the average loadings per factor is greater than 0.70; and initial evidence of discriminant validity as there is no cross loading between factors. Reliability was attained in this solution as the alpha for all constructs were higher than the recommended threshold of 0.70 (Fornell and Larcker 1981).

Having extracted an eight-factor structure through EFA, we then conducted a subsequent confirmatory factor analysis (CFA) in AMOS software; to confirm that the factor structure has a good model fit, and to further test convergent and discriminant validity. After reviewing the modification indices, we dropped one item STRU1 to achieve a good model fit (See Table 2), with thresholds based on Hu and Bentler's (1999) recommendation.

Table 2. Model Fit

Criteria	Reported Value	Recommended Threshold
CMIN/df	1.658	<3 and >1 excellent
CFI	0.979	>0.95 excellent
RMSEA	0.049	>0.06 excellent
PCLOSE	0.528	>0.05 excellent
SRMR	0.053	<0.08 excellent
GFI	0.913	
AGFI	0.876	

*From Hu and Bentler (1999)

Table 3 shows the construct correlation matrix resulting from the CFA. All factors have composite reliability (CR) of greater than 0.70; this indicates reliability based on Hair et al.'s (2014) suggested threshold. The average variance extracted (AVE) for all constructs were greater than the recommended 0.50 to establish convergent validity (Kline et al. 2012). Discriminant validity was satisfied for all factors; discriminant validity can be examined by finding whether the square root of AVE is greater than the absolute value of correlations between factors (Hair et al. 2014).

Table 3. Construct Correlation Matrix

	CR	AVE	CONT	DSGN	DPND	UTIL	GRPH	INPT	OUTP	STRU
CONT	0.815	0.602	**0.776**							
DSGN	0.876	0.645	0.487	**0.803**						
DPND	0.903	0.824	0.474	0.674	**0.908**					
UTIL	0.937	0.882	0.761	0.612	0.517	**0.939**				
GRPH	0.959	0.887	0.324	0.649	0.542	0.453	**0.942**			
INPT	0.926	0.862	0.193	0.593	0.522	0.381	0.439	**0.928**		
OUTP	0.916	0.785	0.468	0.778	0.681	0.537	0.727	0.665	**0.886**	
STRU	0.890	0.801	0.404	0.716	0.700	0.506	0.593	0.663	0.840	**0.895**

Note: Square root of AVE on diagonal

Structural Model Assessment

The structural model consists of the seven usability factors as independent variables and the dependent variable continued intention to use. Evaluating the causal model shows that the R^2 for continuance intention is at 0.64; indicating that the independent variables show sufficient explanation for the variance of the dependent variable. Figure 2 displays the results of the model estimation of the causal model, showing the standard regression weights of the independent variables to continued intention to use. Five out of the seven paths were statistically significant at either 5% or 0.1% level. The results confirm the three hypotheses (H2, H3, H6): continuance intention is positively influenced by app dependability (DPND), app utility (UTIL), and UI output (OUTP). However, results show counter evidence for two hypotheses (H4 and H7): UI graphics (GRPH) and UI input (INPT) have a significant negative influence on continuance intention. Finally, for two hypothesis (H1 and H5) there is no indicated significance: app design (DSGN) and UI structure (STRU) show no significance in predicting continued intention to use. The discussion section explains the results.

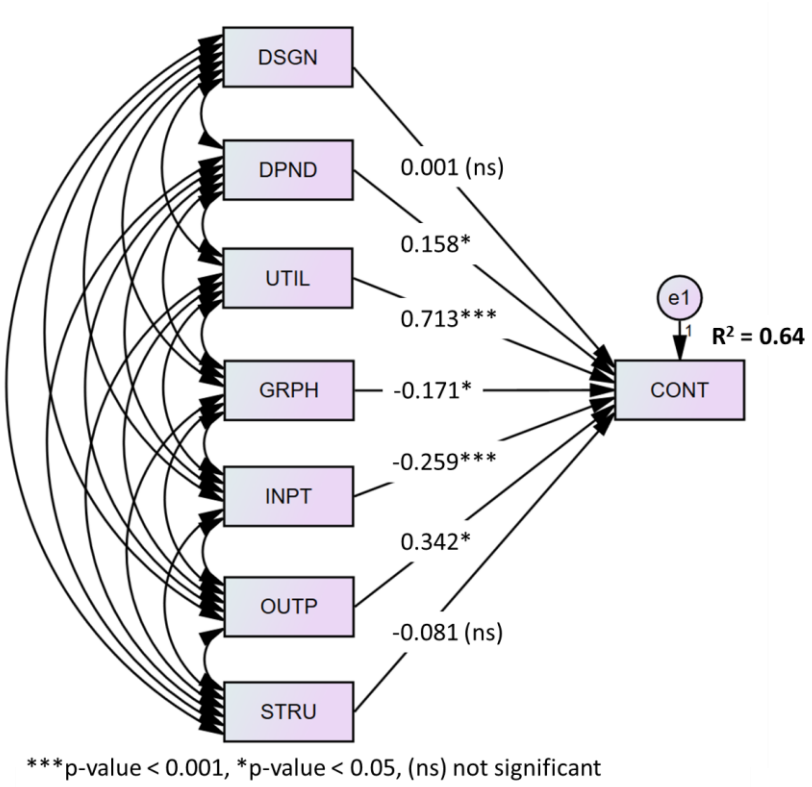

Figure 2. Results

DISCUSSION

Significant Positive Relationships

The results indicate that the usability factors (1) app utility, (2) app dependability, and (3) UI output positively influence the continued intention to use disaster apps. Thus, the key influencers as to whether users' intend to continue using a disaster app are their perceptions as to whether the app delivers its function, whether it does so dependably, and whether it provides information that can be easily understood by the users.

App utility has the most influence on continuance intention. The more users perceive that the app delivers its intended function, the more likely the users will continue using the app. Prior research has emphasised that apps should be designed to deliver what is most relevant to users (Venkatesh and Ramesh 2006; Hoehle and Venkatesh 2015). The result implies that in designing for disaster apps, the users must be able to recognise the purpose of the app and to perceive that the app does not deviate from its main function.

App dependability also has a significant positive influence on continuance intention. The more users perceive that an app can perform dependably the more likely the user will continue using the app. Perceived usability also involves avoiding negative experiences such as crashes and errors (Ding and Chai 2015). Customer frustration can lead to users uninstalling apps; however, the degree of frustration may be different between hedonic (e.g. games, entertainment) and utilitarian (e.g. utility, information seeking) apps (Hazarika et al. 2016). We highlight from our results that for disaster apps, which have a specific utilitarian purpose of providing information during disasters, the perception of dependability is critical to continuance intention. This behaviour is consistent with findings from existing literature where the perception of error-freeness affects the user's trust and reliance on mobile warning apps (Kotthaus, Ludwig, and Pipek 2016).

UI output also has a significant positive influence on continuance intention; implying that the users' perceptions of the effective delivery of information are important for disaster app users' continued intention to use. The easier it is for users to understand critical information, the more likely they will continue using the app. For a disaster app, effective output means to provide information in a manner that can be easily internalised by its users in critical situations. The literature of safety-critical systems has emphasised the importance of output interface (Prasanna, Yang, and King 2013). Moreover, output considerations for disaster technology must not be limited to visual aspects but also consider auditory and sensory outputs as a means to communicate information.

Westermann (2017) had affirmed that users are more receptive to sound notifications from apps that provide serious information about events (such as thunderstorm apps) and less so from apps that contain less critical information (such as gaming apps).

Significant Negative Relationships

The results also showed that UI input and UI graphics have a significant negative influence on users' continuance intention for disaster apps, contrary to our hypotheses that they would positively influence use.

UI input is the degree to which users perceive that the app allows input (Hoehle and Venkatesh 2015). The negative relationship between UI input and continuation of use may relate to the specific nature of disaster apps. Many apps, such as social media apps, rely on user-generated content; hence, intuitively, apps should be designed to allow users to put in information effortlessly. However, the majority of disaster apps are information dissemination tools from authorities to citizens (Tan, Prasanna, Hudson-Doyle, et al. 2017), often involving one-way communication that requires minimal input from users. Requesting user input may provide the negative perception that the app is not optimised to provide targeted information to users during disasters. Therefore, for disaster apps, results imply that to encourage continuance intention the focus should be on reducing the need for users to provide input in the first place.

UI graphics also has a significant negative relationship to continued intention to use. This is contrary to research that has found that the graphical aesthetics of apps provide benefits that attract use (Xu, Peak, and Prybutok 2015). The serious nature of disaster apps may also drive the results that UI graphics does not drive continuance intention. Users often abandon apps because of frustration with the complexities of design; thus products should have the bare minimum, delivering its intended purpose to the users as quickly as possible (Pranam 2018). Overcomplicating the interface design can confuse mobile app users (Morson 2014). Too much focus on graphics may cause users to doubt the seriousness of the app or distract them.

Insignificant Paths

The two insignificant paths estimated in the model were from app design and UI structure to continuance intention; indicating the two factors do not affect users' intent to continue using disaster apps. The reasons and implications for the insignificant paths will be further explored in future research.

CONCLUSION AND FUTURE RESEARCH

The initial results show that usability affects users' intention to continue using disaster apps; however, the factors' influences have different significance, weights and directions. Three usability factors (UTIL, DPND, OUTP) have a significant positive relationship with continuance intention. Two factors (GRPH, INPT) appear to have a significant negative relationship; and two factors (DSGN, STRU) do not have a significant relationship with continuance intention.

The results show which areas designer and developers should focus on to enhance continued intention to use for disaster apps. Knowing what usability factors can enhance continued intention to use can be helpful for developers to know which areas to prioritise. To improve continuance intention, the focus for disaster app usability should be on improving the perception of app utility, app dependability and UI output. Conversely, reducing the need for input and providing less focus on interface graphics may influence continuance intention positively.

In future work, we plan to explore the reasons and implications behind the insignificant paths, study whether the individual factors may have mediating effects on others, and investigate whether users' experience or technological comfort have moderating effects on the results.

Also, one of the limitations of the study is that it looks at the continuance of use of apps on the assumption that users remain constant in using a smartphone device; the study has not considered the technological lifespan of devices. The average lifespan of smartphones could be as short as 2.5 years (Statista 2018), future research on the continuance of use may also consider the likelihood that the users will re-install the app when they upgrade and transfer to a new smartphone.

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APPENDIX – A

Online survey items

Item ID	Statement
DSGN1	The app's overall design meets my expectations.
DSGN2	I think the app needs to significantly change its overall design.
DSGN3	Generally speaking, the app is well designed.
DSGN4	I am happy with the overall design of the app.
UTIL1	The app is of value to me.
UTIL2	I think the app is useful.
UTIL3	The app serves its purpose well.
UTIL4	To me, the app performs as intended.
DPND1	I am satisfied with the way the app operates from start to finish.
DPND2	The app works smoothly from start-up to exit.
DPND3	I can depend on the app to work from start to finish.
DPND4	I am happy with how the app operates from start to finish.
GRPH1	In general, the app is visually appealing.
GRPH2	I like the graphics displayed on the screen of the app.
GRPH3	Overall, the app uses pleasing visuals.
GRPH4	I am happy with the graphics of the app.
STRU1	I find it hard to find my way around the app.
STRU2	The layout of the app makes it easy for me to locate the content I need.
STRU3	I think the app has an organised structure.
STRU4	I am happy with the layout of the app.
INPT1	The app allows me to enter my preferences or information easily.
INPT2	I am satisfied with how the app allows me to enter information.
INPT3	To find it difficult to instruct to app to do what I want it to do.
INPT4	I am happy with how the app takes in my preferences or input.
OUTP1	The content of the app is presented in a format that suits me.
OUTP2	I find it easy to read the information in the app.
OUTP3	I like how the app presents information.
OUTP4	I am happy with how the app presents information.
CONT1	I intend to continue using the app.
CONT2	I would stop using the app if I find an alternative.
CONT3	I want to discontinue using the app.
CONT4	I have considered uninstalling the app.