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Factors affecting user intention in continuous interaction: A structural model

[1]In-Chu Liao, [2]Yi-Shin Deng, [3]Hsiao-Chen You

[1,2]Institute of Creative Industries Design,
[1,2]National Cheng Kung University, Tainan, Taiwan
[3]Department of Multimedia Design
[3]National Taichung University of Science and Technology, Taichung, Taiwan

***Abstract*: The emergence of a variety of digital devices has changed the way people interact with digital services. Continuous interaction is considered to be one of the important interactions in multi-screen services. Therefore, this study aims to identify the factors affecting people's acceptance of multi-screen services in continuous interaction. A research model was constructed based on the Technology Acceptance Model (TAM) and the Theory of Planned Behavior (TPB) to conceptualize continuous interaction with user intention and to reveal significant relationships with behavioral constructs. Data collected from 203 multi-screen users were used to test the proposed research model. The result identified perceived synchronization and perceived seamless migration in continuous interaction as two important determinants in continuous interaction. Also, the model in this study demonstrated how continuous interaction affects user intention and the results indicated that among all factors, perceived seamless migration, perceived usefulness and user attitude are the strongest predictors that influence the decision to use multi-screen services. To conclude, this study is important in finding the gaps between continuous interaction and user intention, as well as in identifying areas for improvement when designing effective multi-screen services.**

***Keywords*: Continuous interaction, multi-screen service, synchronization, seamless migration, user intention, technology acceptance model, theory of planned behavior.**

I. Introduction

With the proliferation of cloud computing, the internet allows information to be reached across multiple devices. The increasing popularity of mobile devices and the increases in digital touchpoints have fully promoted the development of services like mobile applications, SaaS (software as a service) and streaming platforms, also known as the multi-screen service. People now can achieve their tasks on multiple devices anytime and anywhere resulting in smarter, more comprehensive and context-specific user experiences [1]. Compared with the ease of using a single device, the multi-screen services enable users to use multiple devices simultaneously and continuously. Users start to learn how to manage tasks on different devices and maintain data consistency between several of their devices. This can sometimes cause troubles for them, making it impossible to fully utilize the services. According to previous research, the quality of interaction should be evaluated from a more comprehensive perspective, that is, the individual's acceptance of multi-screen services and the effective use of the system are factors that determine the quality of the system [2], [3].

Since multi-device is changing the way we interact with digital content, new types of multi-screen interactions have emerged. Interaction refers to the way people relate to the task and how the use of different devices can help them to accomplish their goals [4]. Several prior studies have come up with different multi-screen interaction categories. Levin [4] introduced three general multi-screen interactions, which are the basis of all multi-screen services. They include consistent, continuous and complementary interactions. Sørensen et al., [5] proposed a 4C framework based on users, artifacts, sequential and simultaneous interaction to explain the interactions within the digital ecosystems, namely communality, continuity, collaboration and complementarity. Brudy et al., [6] synthesized earlier multi-screen research and presented six key dimensions: temporal, configuration, relationship, scale, dynamics and space to illustrate the different kinds of multi-screen interactions. Nagel [7] proposed seventeen interaction patterns to describe how device can be expanded, aggregated and complemented to conceptualize multi-screen services. In the multi-screen research by Google [8], the result showed that 90% of the people use multiple devices sequentially to complete tasks like planning a trip, shopping online and social networking. Previous studies also shown an increased attention in the research of continuous interaction concerning continuous motivation [9], content and task [5], usability in device switching [10], [11], [12], continuous design property [13] and design model [14]. Continuous interaction has received great attention in both academic research and in people's everyday lives, and it is a research subject worthy of in-depth discussion.

To summarize, multi-screen interactions are defined in different terms, some may be categorized into different groups or specific usage scenarios, while others use a broad term to encompass several scenarios. For instance, the continuous interaction introduced by Levin is similar to the concepts of device shifting and synchronization proposed in Nagel's definition. This indicate that the above classifications of multi-screen interactions are not mutually exclusive, they are only divided from different dimensions [15]. In addition, Previous research on continuous interaction has focused on specific activities or technical contexts. There is no research that used a holistic point of view to explore how continuous interaction affects individual's use of multi-screen services. Moreover, the important antecedents from continuous interaction have not received the attention they deserved. Thus, the purpose of this study is to answer the following research questions: (1) What are the determinants that affect user to perform continuous interaction? (2) How does continuous interaction affect user's intention toward using multi-screen service? It has been pointed out that it is important to understand the impact on the adoption of a multi-screen system and identify important factors that support this [3].

In order to bridge the gap between continuous interaction and user intention, this study will develop a research model to understand the factors affecting user intention in multi-screen services. By establishing this model, this study will make an academic contribution to the study of user intention in the multi-screen world. The model can be used for future multi-screen interaction research and can be extended to different multi-screen contexts. The results of this study will also provide practical design implications for multi-screen developers in designing continuous interaction to enhance users' intentions to use multi-screen services. The organization of the study is as follows: we first introduce literature reviews on continuous interactions and their antecedents, and then describe the theoretical development and research hypotheses which then followed by methodology, analysis and result. Finally, we discuss the relationships between continuous interaction and user intention with further design implications.

II. Literature Reviews

Nowadays, most multi-screen services are available to be used on smartphones, laptops, tablets or wearable devices. Each device has its own unique characteristics in terms of form size, display area, interaction logic, input method, device-specific functions or suitable place to be used. Continuous interaction in multi-screen ecosystem means that the interaction starts on one device, then continue on another device, and the entire process is likely to involve a sequential use with multiple devices [4]. Previous research pointed out that there were two criteria affecting continuous interaction: the availability of the function, and the operational procedure across multiple devices [13]. Thus, designing continuous interaction for multi-screen services must address the functional and operational differences between devices. Moreover, Denis and Karsenty [10] stated that having the same function is not enough to ensure good continuity. They put forward the idea that when designing continuity, the operation process should be considered, that is, whenever the user switches from one device to another, new operation process should be introduced on the current device to facilitate smoother user experience across devices. This shows that when switching device is concerned, users may encounter several challenges when interacting with multiple heterogeneous devices, therefore more sophisticated interaction design strategies are needed to better suit user needs.

Synchronization in continuous interaction

In continuous interaction, people tend to use a series of devices to accomplish a task, so there is an exchange of data between devices. Therefore, synchronization between devices becomes an essential criterion to maintain data consistency and promote continuity across multiple devices [1], [5]. Synchronization between devices means that data are always up-to-date, and the data status are constantly updated, so services located on different devices can be combined with each other to facilitate efficient information exchange and increase service richness. If data are well synchronized, then people can be independent of the device, time and place [7]; otherwise, if too much effort is required, it will affect people's motivation in switching devices [16]. It is also mentioned by Oulasvirta and Sumari [17] that a well-prepared synchronization strategy will balance the hazards in the forthcoming event and thus determine whether a user would adopt additional devices in his or her task. This echoes the goal of this study as we are interested in exploring the antecedents of synchronization that affects continuity between devices in terms of the functional aspect of the interaction.

Synchronization is an important part of the entire interaction with multiple devices. Numerous researchers have revealed the needs to incorporate more synchronization design in their system to promote the interaction between devices [16], [18], [19]. Compared with single-screen interaction, synchronization in multi-screen context focuses more on managing data across multiple heterogeneous devices. Previous research has stated the importance of content and actions in synchronization during migrating tasks across different devices [1], [10]. Others have pointed out the need to address how to transfer data across devices, and how data can be stored and shared across devices in data synchronization [16]. Transfer method is an important element in multi-screen synchronization [7], [17]. Santosa and Wigdor [16] stated the lack of data transfer mechanisms between devices is considered to be one of the main obstacles to synchronization, and is particularly prominent in multi-screen use, because the composition of a different set of systems / devices increases the need for more appropriate synchronization design.

When it comes to synchronization mechanism, another big issue is trust. How do designers demonstrate trust in file transmission? The problem is that users do not believe that synchronized data will be stored reliably, or that the correct version is saved. Studies have shown that the trust relationship between users and systems can be understood to help develop more reliable synchronization strategies, including improving system's visibility and control [16]. That is, users can access their browsing history, bookmarks, chat logs or to-do list items performed on specific tasks, even if these are through different devices. In addition, the lack of suitable strategies to demonstrate synchronization within the same multi-screen application on different devices can also cause users to feel mistrust. It is recommended that the system incorporate historical logs, such as providing the date and time of previous modifications on the application, which not only helps to improve the user's understanding of the synchronization process, but also helps to manage file versions. [16].

It is obvious that user demands more transparent background data transmission due to the lack of enough information about the synchronization process. According to the research by Majrashi and Hamilton [20], twelve important multi-screen usability factors in designing multi-screen system were listed, and designing transparency is one of them. Transparency can be achieved by displaying a pop-up notification on user's current devices to show when, where, and from what device files are being synchronized. A transparent synchronization process will help users build up accurate conceptual model in the entire use scenario, thus help users make full use of the multi-screen services [21].

Seamless migration in continuous interaction

People are pursuing seamless experiences in the interaction with multiple devices [17], [18]. A seamless experience in continuous interaction enables users to shift from one device to another with ease. An individual can video chat with his friend seamlessly by shifting from using his smartphone first and then move to using his laptop, and lastly to his tablet. A proper seamless interactive design should not make people change their workflow for task migration [22]. Meeting user requirements during the interaction process may be the basic rule for seamless interaction, however there are other design strategies to achieve a seamless experience. Antila and Lui [23] mentioned in their study that in order to support users to migrate task across devices, data and content synchronization is the key to achieve seamless experience, which demonstrate the casual relationship between synchronization and seamlessness. While others pointed that persuading users or offering guidance to help switch between devices can help achieve seamless experience [24]. The more seamless the process, the more positively the experience can be perceived [7]. It can be assumed that if the migration between device is perceived to be seamless, users will more likely want to conduct their tasks across various devices. According to Denis and Karsenty [10], seamless migration can be achieved from knowledge continuity and task continuity.

Knowledge continuity is defined as the knowledge accumulated through retrieval and adaptation of using numerous devices [10]. In Shneiderman's [25] usability measurement, they use the term memorability to refer to the extent to which the system support users in remembering how to use the essential features when switching between devices. The multi-screen system share user's memory of the data state, which is referred to as a shared memory between the user and the services [1]. For knowledge continuity to be reflected in the multi-screen system, there are three general criteria: access to the same data, access to the same function and access to the same presentation of the service [10], [13]. These three criteria are basically to keep the service as consistent as possible across devices on the premise of switching devices. However, in multi-screen services, consistent design shall only be considered when it is applied to help support seamless task migration [22]. Therefore, incorporating device-specific or task specific functions or presentations on top of the original service would better serve users in achieving seamless migration. In terms of task continuity, several studies have identified the problem of task retrieval that occurs when migrating between heterogeneous devices [26], [27], [28]. The problem that users usually do not remember where the task ends on the previous device after change to another device. Denis and Karsenty [10] pointed out the need for systems to facilitate users in retrieving the status of the data and the original context of the status. Chang and Li [28] also suggested the support of an appropriate tool and easier task transfer method to help users retrieve their task status more easily across devices. Aside from providing a more convenient way of task migration, incorporating the context of the current use after change of device is also important [22]. According to Trevisan et al. [12], inserting context of device according to the user's task facilitate continuous interaction. Adding contextual information to fulfill the current task requirements can facilitate a smoother transfer of task since it leads to better results towards fulfilling human needs [4], [29].

In this study, continuous interaction is defined as an interaction that facilitates users to perform tasks across multiple devices through synchronization and seamless migration across devices. When people want to use multiple devices to complete a task, system must allow the task to be executed on one device and continue to execute the task on other devices and keep the data consistent across multiple devices. Most previous studies emphasized the technical part of continuous interaction while this study attempts to explore continuous interaction from a user-centric perspective, aiming to identify factors that affect users' perception toward this emerging multi-screen interaction. Therefore, this study identified synchronization and seamless migration as two main components that represent continuous interaction through literature reviews and discussed how users perceived them as antecedents to affect their intention to use multi-screen services.

Technology acceptance model (TAM) & theory of planned behavior (TPB)

To understand how continuous interaction influences the intention to use multi-screen services and the factors that affect continuous interaction, the proposed research model and hypotheses relationships adopted both the technology acceptance model (TAM) and the theory of planned behavior (TPB) to provide a more rigorous theoretical analysis and statistical explanations. TAM is established by [30]. It is a theoretical extension of the theory of reasoned action (TRA) [31], which is meant to explain consciously intended behaviors in the field of social psychology. TAM uses TRA as a theoretical background and adds two more cognitive constructs: perceived usefulness and perceived ease of use to predict users' attitudes, intentions and how they accept and use technology systems [32]. TAM works by manipulating external factors to influence the user 's internal cognition and beliefs, to enhance their acceptance of the technical system or take specific actions. TAM is also a suitable model to examine the antecedents, mediators or moderators derived from the main constructs [33], [34]. Similar approaches have been discussed in prior research as to incorporate additional determinants to help understand the factors in increasing the experiences of using the system [35], [36]. This model has been used widely in information system research to explore the decisive factors for users to accept a variety of information systems in various scenarios, such as social media usage [37], [38], education platform [39], mobile application usage [40] and so on. Recently, some studies have used TAM to evaluate topics in multi-screen interactions. For example, Shin and Biocca [41] explain and predict the impact of user experience on the adoption of multi-screen technology by identifying determinants related to the quality of experience (reliability, accessibility, portability, usability). While Chen and Koufaris [42] explore the impact of task-technology fit on the intention to use multiple devices by integrating the concepts of task-technology fit and mental workload to the TAM framework.

One of the extensions approaches for TAM model is to introduce constructs from the related theories, such as the theory of planned behavior (TPB) [43]. TPB is considered to be an effective theory for examining psychological changes dealing with human social behavior [44]. In the TPB theoretical framework, three psychological factors are used to determine the behavior intention and the actual behavior: attitude, subjective norms and perceived behavioral control [45]. Attitudes toward the behavior are influenced by the anticipated utilitarian outcomes resulting from interaction with technology; subjective norms examine the normative beliefs about individual's motivation to use technology and perceived behavior control evaluates the resource and opportunity required to achieve the expected behavior [44]. In the research of information systems, TPB is used to evaluate whether the use of technology encourage or discourage people to engage in an intended behavior through the assessment of psychological factors and to gain insights on why people accept or reject certain technology [46].

According to prior research, TAM and TPB are the two prominent research models adopted in the study of intention and behavior of using the technology. The use of TAM or TPB alone can only partially explain and predict user behavior, it is suggested that both human and social factors have to be considered to provide a more comprehensive explanations as well as better exploratory power to the research [43], [47], [48]. Therefore, this study would like to integrate the TPB and TAM models together to construct a more complete theoretical model for continuous interaction and user intention.

III. Theoretical Development and Research Hypotheses

This study adopts TAM's constructs into the proposed model for the following reasons: firstly, TAM has been used extensively in IS research, and the development methods to incorporate other determinant constructs are mature enough to predict users' perception in using new technology. Numerous research have used modified TAM model to better reflect the core value of the specific context of research [9], [41]. Since this study aims to explore the impact of emerging trends in a multi-screen context and understand how the introduced constructs may affect overall service acceptance, the theoretical background is consistent with the structure of the TAM model. Secondly, TAM is high in validity in terms of model prediction and explanatory strength [49], which is in line with our research purpose as to provide designers with a holistic view that effectively predicts how continuous interaction affects user intention.

As a result, in order to understand the determinants of continuous interaction, this study extended TAM model to incorporate additional constructs to TAM's perceived usefulness and perceived ease of use. It is mentioned that incorporating antecedents into theory development can improve the applicability of the findings and increase the relevance for practices [49], [50]; therefore, this study followed the guidance proposed by [49] and conceptualized two constructs: perceived synchronization and perceived seamless migration. The framework of the research model also incorporates TPB constructs to understand user's affective responses. The perceived subjective norm was added to examine the effect of people's belief about their capabilities to perform continuous interaction. However, subjective norm is not applicable to this study because multi-screen scenarios involve the use of multiple devices, and the opinions of others are difficult to define, so we removed this construct accordingly. From the literature described above, an exploratory research model was developed in Fig. 1 to provide a better explanation of continuous interaction to user's acceptance of multi-screen services.

In the proposed model, perceived synchronization and perceived seamless migration were modeled as formative constructs. We indicated a set of heterogeneous indicators that form and represent perceived synchronization and perceived seamless migration following the principles from prior research [51], [52], [53], [54]. Formative indicators do not need to be correlated with each other, and they are assumed to jointly quantify the impact of multiple dimensions on latent variables (perceived synchronization, perceived seamless migration) [54], [55]. Changes in the indicators imply that they might positively or negatively affect the value of their predicted latent variable, and therefore influence subsequent user intention variables.

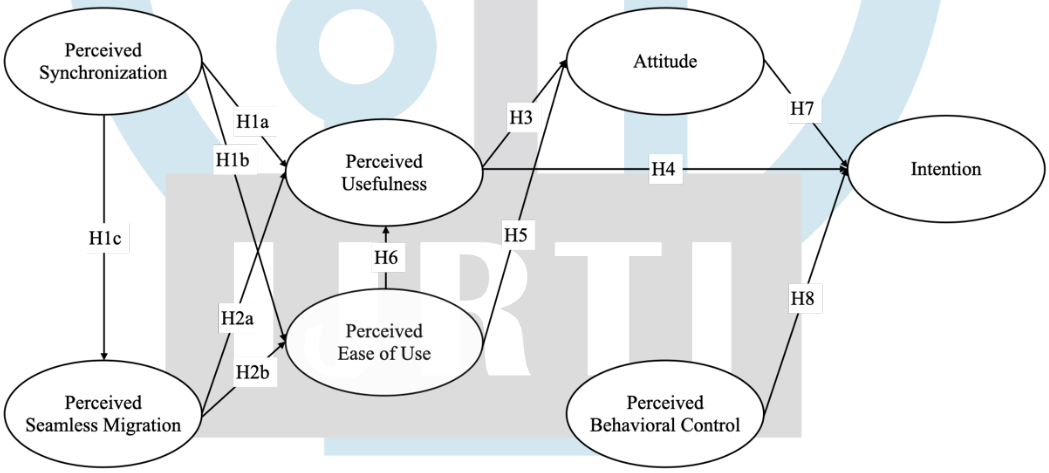

Figure 1 Proposed research model

Perceived Synchronization

Numerous studies have identified antecedents that affect synchronization. For example, different types of transfer methods may affect data synchronization and have the tendency to influence people's willingness to use such multi-screen services. Previous study also indicated that trust and task transparency were both important factors in designing synchronization mechanism. This study modeled perceived synchronization as a formative construct and theorizing indicators based on the data collected from previous studies associated with synchronization. We identified three theoretical dimensions that influence perceived synchronization: transfer method, trust and task transparency.

Transfer method

Transfer method is a solution that stems from the challenge in data synchronization. A well-designed transfer method must allow users to perform tasks on different devices without interruption, while also address on the problems caused by switching devices or changing locations. Overall, people want easy to use synchronization methods that allow them to freely switch between devices anytime and anywhere [17], [18]. Different transfer method also helps users in managing their data more effectively during data synchronization.

Trust

In continuous interaction, a trusted system allows users to perceive synchronization as a reliable mechanism to facilitate continuous interaction across multiple devices. Study by Dearman and Pierce [18] showed that lack of trust in automated systems may cause people to do more confirmation work, while also preventing them from using such systems.

Task transparency

Task transparency refers to the process by which the system allows users to fully grasp the transfer of information between devices, so users will not be confused about whether they are working on the latest version. It is recommended that when synchronization starts on the device, users should be provided with the current transfer progress to help them understand the actual synchronization situation [56].

The indirect impact between the determinant construct (perceived synchronization) and the core constructs (perceived usefulness and perceived ease of use) should be examined to ensure the relevancy to continuous interaction so that the impacts of the determinant constructs can be explained based on the theory of TAM and TPB [49]. Evidences from prior research confirmed that synchronization is associate with usefulness and ease of use. In the research by [57], applications that provide secure synchronization across multiple devices are considered useful. Proper synchronization between shared folders in cloud storage services could improve user's task completion rate and increase productivity [58], [59]. Better synchronization means easier to use when it requires less effort and less cognitive burden, resulting in better usability (e.g., easier to learn, easier to operate, and easier to remember). This study proposed that when people can transfer their task more easily between devices, it can also be regarded as achieving a more seamless experience. Based on the above, perceived synchronization in this study is hypothesized to have a direct impact on perceived usefulness, perceived ease of use and perceived seamless migration.

H1a. Perceived synchronization has a positive effect on perceived usefulness.
H1b. Perceived synchronization has a positive effect on perceived ease of use.
H1c. Perceived synchronization has a positive effect on perceived seamless migration.

Perceived Seamless Migration

A seamless interaction means that users expect the least learning. While shifting devices, users are expecting that their previous knowledge can be used to interact with the new device [7]. Similar concept has also been introduced by Denis and Karsenty [10]. They stated that seamless migration depends on knowledge continuity and task continuity. Both are committed to adapting the system to the user's cognitive characteristics and to help user interact with multiple devices to a greater extent. This study modeled perceived seamless migration as a formative construct and theorizing indicators based on the data collected from previous studies. We identified five theoretical dimensions that influence seamless migration, namely operation memory, knowledge of usage, status retrieval, easy transfer and contextual needs.

Operation memory

For a seamless migration to be seamless, it should help users reuse their knowledge previously acquired on other devices. The shared memory is comprised of the representation of the state of data based on user's memory of the recent operations performed, and users can utilize this shared memory to restore the desired data state on the other device [10].

Knowledge of usage

Having the knowledge of the devices or interaction can help users using the services more effectively on different devices. When users have more knowledge in the interaction with the multi-screen services, this adapted analogy will help them identify similar contexts more easily in future interactions with other devices [10]. Moreover, applying similar data, function and service representations on multiple devices may also facilitate users in building stronger knowledge of usage and making migration easier [10], [13].

Status retrieval

Status retrieval refers to how well the system can help users to resume their task after switching devices. To seamlessly switch between devices, one need to immediately resume the task and retrieve the last operation performed on another device [10]. It is also important for systems to pay attention to the safety issues that may occur during device switching to prevent any data damage or lost.

Easy transfer

A seamless migration also emphasizes how well the system supports task migration across multiple devices. Previous studies showed that the ability to switch tasks between devices easily means that tasks can be transferred without the user having to perform additional settings or excessive learning [1], [28]. Chang and Li [28] suggested the support of an appropriate tool and easier task transfer method would allow people to transfer their task more easily across their devices.

Contextual need

Contextual need refers to the contextual demand emerged from the current conditions of using the system. Context information include the most relevant information for the current usage situation. System adapts to those situations by changing its content, presentation and navigation to support users according to the current context of use [60].

To examine the indirect impact between perceived seamless migration and the core constructs (perceived ease of use and perceived usefulness), evidences from prior research have shown a causal relationship between them. The results showed that people think it makes them feel useful when content can be continued in different places without interruption [61]. Moreover, if people continue consuming content on different devices in a convenient way, they will feel the functions are easy to use, convenient and useful [61]. Based on the above, perceived seamless migration in this study is hypothesized to have a direct impact on perceived usefulness and perceived ease of use.

H2a. Perceived seamless migration has a positive effect on perceived usefulness.
H2b. Perceived seamless migration has a positive effect on perceived ease of use.

Perceived Usefulness

The definition of perceived usefulness is defined as the degree to which a person believes that using a particular system would enhance his or her performance [30]. Perceived usefulness is a strong utilitarian predictor to predict user's attitude and technology usage intention in TAM [30]. When people feel that performing a task continuously on multiple devices is useful and perhaps increase their task performance, they will develop a positive impression toward continuous interaction, and thus are more willing to use multi-screen services. From the above, perceived usefulness in this study is hypothesized to have a direct impact on attitude and intention.

H3. Perceived usefulness in continuous interaction has a positive effect on attitude.
H4. Perceived usefulness in continuous interaction has a positive effect on intention.

Perceived Ease of Use

In the context of multi-screen interaction, perceived ease of use is defined as users believing that utilizing multiple devices to perform a task is free of effort. According to TAM and related literature, perceived ease of use has positive effects on users' attitude [30]. If the design of continuous interaction has been carefully considered, users do not have to spend too much time figuring out how to transfer data between devices or remember the last used area. Hence, the more the system can meet the user's expectations and reduce the degree of effort, the more likely users will have a positive attitude towards continuous interaction. It was mentioned in TAM that perceived ease of use also affects perceived usefulness, which means that if users feel that continuous interaction is easy to use, the particular multi-screen service will be perceived to be useful as well. Therefore, we postulated that perceived ease of use in this study is hypothesized to have a direct impact on attitude and perceived usefulness.

H5. Perceived ease of use in continuous interaction has a positive effect on attitude.
H6. Perceived ease of use in continuous interaction has a positive effect on perceived usefulness.

Attitude

Attitude is an important concept that explains a person's evaluation of the desirability to perform a particular behavior, and it is also related to whether he or she intends to use the technology [30], [31]. Attitude has been identified in both TAM and TPB as a key determinant to trigger users' intention [44], [62]. This study defines attitude as one's preference to perform a task continuously across multiple devices. With positive attitude, people are more willing to adopt continuous interactive approach in the future when the task is requires. Based on the above, attitude in this study is hypothesized to have a direct impact on intention to use multi-screen service.

H7. Attitude in continuous interaction has a positive effect on intention.

Perceived Behavioral Control

In this study, perceived behavioral control is defined as the degree of user's belief that he or she has the ability to control the technology, and the total resources and opportunities he or she received. A strong sense of perceived behavior control enhances people's accomplishment, thus increase intention tendency to use multi-screen service [63]. Vice versa, if people do not perceive themselves as capable of performing a task continuously on multiple devices, this might be due to some uncontrollable conditions such as it is an unfamiliar situation for them, and the lack or previous experiences making them doubt their ability in performing a task continuously on multiple devices. Therefore, perceived behavioral control is hypothesized to have a direct impact on intentions to use multi-screen service.

H8. Perceived behavioral control in continuous interaction has a positive effect on intention.

Intention

Intention is defined as the strength of a person's willingness to perform an action based on the desirability and feasibility of a course of action [64]. According to numerous research [31], [65], intention is a key predictor for a person to perform subsequent behaviors and it is proven to be successful in explaining actual behavior across a variety of domain. People form intention toward certain behaviors that they believe will improve their performance. In this study, intention is defined as a user's intention to use a multi-screen application or website. According to Levin [4], a good multi-screen interaction may increase users' willingness to use multi-screen applications. Therefore, we hypothesized that a well synchronized and seamless continuous interaction between devices may enhance interaction quality. The results may lead to a greater and more frequent use behavior of multi-screen services.

IV. Methodology

Analytic strategies

The research model was analyzed using partial least squares (PLS) technique by utilizing the SmartPLS 3.3.0 software [66], which is a component-based modeling software to test structural equation model. There are other alternative causal-modeling approaches like the covariance based structural modeling (SEM) technique, however we think PLS is more applicable for this study for the following reasons: firstly, PLS is a more appropriate technique to be use when the research purpose is exploratory based or prediction-oriented [67]. Secondly, PLS is a suitable method to handle models that include formative constructs or both the formative and reflective constructs like we have in this study [68]. Therefore, this study followed the recommended procedure by Hair et al. [69] and Henseler et al. [70], we assessed the measurement model first by evaluating the constructs and the formative indicators that represent them and followed by assessed the structural model to evaluate the hypothesized relationship between the constructs.

Questionnaire

The study used an online questionnaire to collect people 's perception of continuous interaction and their intention to use multi-screen service. The questionnaire was divided into three sections: section A is the demographic information; section B is to examine the important factors regarding perceived synchronization and perceived seamless migration in continuous interaction with multiple devices; section C is to find out the impacts of continuous interaction on the intention to use multi-screen application. Questionnaire items used to measure perceived usefulness (PU) and perceived ease of use (PEoU) were mainly adapted from Davis's Technology Acceptance Model (TAM) [35], [71], [72]. Items used to measure attitude (ATT), perceived behavioral control (PBC) and intention (INT) were adapted from Ajzen's Theory of Planned Behavior (TPB) [43], [44]. Measures for the indicators in the proposed model were self-developed based on literature review. Synchronization measure is a 6-item multidimensional scale that measures transfer method, trust and task transparency. Seamless migration measure is a 5-item multidimensional scale that measures operation memory, knowledge of use, status retrieval, easy transfer and contextual needs. All constructs were measured using a seven-point Likert scale ranging from 1 (Strongly disagree) to 7 (Strongly agree).

Pre-test

To test the validity and reliability of the questionnaire items, a pre-test with 30 participants was conducted through online survey and reviewed by HCI experts for content validity. Based on the results of the pretest, some items in the questionnaire were revised to improve their clarity and the representativeness of research questions. For the measurement model, one item was merged with another item due to their semantic similarity, three items were removed due to their low significance, and the theoretical judgment based on [73].

Sample and procedure

In the final survey, only participants who have prior experiences in interacting with more than two devices were included in the research population to ensure that they all have a certain level of multi-screen experiences. Participants participated in the online study through the questionnaire link published on social network sites. Upon entering the survey, participants were first introduced to the purpose of the questionnaire and the instructions on how to fill-in the questionnaire. After that, they need to answer demographic information. Then they were asked to read a brief scenario about how a lady used a trip planning application to plan a family trip. This scenario mainly describes the process of continuing to perform a task (browsing, editing) across multiple devices, and explains the motivations and reasons on why she chose to use such specific device. Following the scenario are a series of questions asking participants to indicate their degree of agreement with each of the statement on a seven-point Likert scale. The second set of questions were about the intentions to use multi-screen application. We asked the participants to choose a multi-screen application that they are most familiar with within the list provided (For example, applications that contain a large portion of continuous interaction like trip planning app, blogging app, recipe app, etc.) and asked them to keep this application in mind while answering the questions that follows. The purpose of this is to let them keep an anchor application in mind when answering questions about usefulness, ease of use, attitude and the intention to use the application.

At the end of data collection, a total of 221 responses were received while 18 responses were eliminated for erroneous data records and 203 complete responses were approved for final analysis. Among all the participants, 54% is male and 46% is female. 64% of participants are in the age range of 25~34 years old. We also asked them to specify the types of devices they own, and most of them have an average of 2 to 4 devices, including smartphones, tablets, laptops, desktops, smart TVs and wearable devices.

V. Analysis and Results

Research model of this study contains both formative constructs (Perceived synchronization and perceived seamless migration) and reflective constructs (Perceived usefulness, perceived ease of use, attitude and intention). To test model validity and reliability, the procedure used to assess reflective constructs are different from the ones to access formative constructs [74], [75]. Therefore, we conducted the analysis in two different approaches for both formative and reflective measures. Lastly, we also conducted structural model assessment to determine the predictive power or our model.

Assessment of the reflective measures

Reflective measures are assessed through the evaluations of internal consistency, indicator reliability, convergent validity and discriminant validity as according to [69] and [75]. As shown in Table 1, composite reliability (CR) and value for Cronbach alpha (CA) were calculated in order to evaluate the reliability of the constructs. The result showed that all reflective measure concerning CR have exceeded the generally accepted threshold of 0.70 [76], the indicator reliability of this study ranging from 0.847 to 0.873, which is considered to have reached a satisfactory level in internal consistency [77]. The reflective measures concerning CA have also exceeded the recommended level of 0.70, suggesting that the model has advocate internal reliability [68].

Table 1 Reliability and Validity of Reflective Measurement

Constructs / Indicators	Factor Loadings	Cronbach Alpha	AVE	Composite Reliability
Attitude (ATT)		0.765	0.587	0.85
ATT1	0.744***			
ATT2	0.801***			
ATT3	0.723***			
ATT4	0.795***			
Intention (INT)		0.791	0.545	0.857
INT1	0.787***			
INT2	0.705***			
INT3	0.688***			
INT4	0.752***			
INT5	0.756***			
Perceived Behavioral Control (PBC)		0.776	0.692	0.87
PBC1	0.769***			
PBC2	0.905***			
PBC3	0.816***			
Perceived Ease of Use (PEOU)		0.826	0.535	0.873
PEOU1	0.787***			
PEOU2	0.769***			
PEOU3	0.713***			
PEOU4	0.707***			
PEOU5	0.715***			
PEOU6	0.693***			
Perceived Usefulness (PU)		0.759	0.58	0.847
PU1	0.717***			
PU2	0.791***			
PU3	0.774***			
PU4	0.763***			

Note: ***significant at $p< .001$

The convergent validity analysis was observed through the evaluation of average variance extracted (AVE) and factor loading. AVE for the reflective indicators were greater than the minimum value of 0.5 [78], ranging from 0.535 to 0.692, which indicates that more than 50 percent of the indicator variance can be explained by the construct, suggesting that the result support convergent validity. The factor loadings for most of the reflective indicators have exceed the threshold of 0.70 except for INT3 (β =0.688, p= 0.000) and PEOU6 (β= 0.693, p= 0.000). However, it was considered not to be removed because removing such indicator does not improve CR [69] and their value were slightly below 0.70 while still exceeded the minimum threshold of 0.60 as suggested by [75]. Discriminant validity was assessed through cross-loadings based on Chin [68] to confirm that the model's constructs are differ from one another. Table 2 shows that all loadings are higher in their designated constructs than any other constructs, that is each bold indicator represents the highest value in their corresponding columns and rows as compared with other indicator values. Therefore, the model in this study is confirmed to reach an adequate convergent validity and discriminant validity.

Table 2 Results of Discriminant Validity: Cross-Loadings

	ATT	INT	PBC	PEOU	PU
ATT1	**0.744**	0.613	0.387	0.505	0.532
ATT2	**0.801**	0.574	0.498	0.483	0.577
ATT3	**0.723**	0.54	0.311	0.406	0.487
ATT4	**0.795**	0.577	0.419	0.529	0.567
INT1	0.587	**0.787**	0.393	0.505	0.514
INT2	0.54	**0.705**	0.366	0.505	0.459

INT3	0.462	**0.688**	0.365	0.424	0.367
INT4	0.569	**0.752**	0.444	0.471	0.434
INT5	0.607	**0.756**	0.412	0.452	0.476
PBC1	0.452	0.387	**0.769**	0.576	0.573
PBC2	0.444	0.479	**0.905**	0.657	0.584
PBC3	0.433	0.469	**0.816**	0.551	0.518
PEOU1	0.486	0.477	0.593	**0.787**	0.606
PEOU2	0.521	0.505	0.484	**0.769**	0.601
PEOU3	0.451	0.446	0.533	**0.713**	0.488
PEOU4	0.515	0.512	0.517	**0.707**	0.601
PEOU5	0.401	0.428	0.552	**0.715**	0.559
PEOU6	0.363	0.419	0.453	**0.693**	0.466
PU1	0.454	0.411	0.484	0.554	**0.717**
PU2	0.581	0.507	0.56	0.679	**0.791**
PU3	0.584	0.46	0.55	0.582	**0.774**
PU4	0.525	0.483	0.435	0.498	**0.763**

Note: The bold numbers are the largest ones on their corresponding columns and rows.

Assessment of the formative measures

The formative constructs proposed in this model are perceived synchronization and perceived seamless migration. They are modeled as second-order formative constructs with first-order constructs which act as indicators to the construct. Indicators are causal variables that form and represent the formative constructs by definition [68].

Formative measures conduct multicollinear analysis to assess the correlation between formative indicators. It is not necessary for indicators to covary nor correlate with each other, and excessive multicollinearity in formative assessment may cause unstable model estimation [54], [79]. As a result, to make sure multicollinearity is not highly correlated among formative indicators of perceived synchronization and perceived seamless migration, variance inflation factor (VIF) was conducted. The general threshold for VIF in formative measurement is suggested to be lower than 3.3 [80] and the VIF values of the indicators in our study ranged from 1.095 to 2.264, which were all under 3.3 showing that multicollinearity is not present and sufficient indicator validity for the formative indicators was achieved.

Moreover, as shown in Table 3 second-order formative construct was examined through the significance of each of the first-order indicator's weight to see if they contribute to form and represent the formative construct [69], [81]. Each formative indicator contributes different impact to the constructs. In perceived synchronization, the largest impact is associated with transfer method related formative indicators; followed by task transparency and trust. In seamless migration, the largest impact is associated with easy transfer, status retrieval and operation memory related formative indicators, followed by knowledge of use and contextual needs as moderate influences.

Table 3 Weights of The Indicator for Formative Construct

Second-order Constructs	First-order Indicators	Outer Weights
Perceived Synchronization	SYNC1 (Transfer method)	0.241**
	SYNC2 (Transfer method)	0.426***
	SYNC3 (Trust)	0.178*
	SYNC4 (Trust)	0.218*
	SYNC5 (Transfer method)	0.316***
	SYNC6 (Task transparency)	0.159**
Perceived Seamless Migration	SM1 (Operation memory)	0.304***
	SM2 (Knowledge of use)	0.235**
	SM3 (Easy transfer)	0.389***
	SM4 (Status retrieval)	0.349***
	SM5 (Contextual needs)	0.211**

Structural model

Structural model (inner model) was assessed to determine if the proposed research model have reached a meaningful predictive power [81]. A meaningful model is validated by examining both the path coefficients and the R-square to test the hypothesized relationships among the constructs [82]. Path coefficients were assessed based on a bootstrap resampling procedure with 5,000 samples to evaluate the significance of the paths. The result showed all hypotheses were supported, except for hypotheses H1a, H4 and H8. As hypothesized, perceived synchronization was positively associated with perceived ease of use (β= 0.433, p< 0.001) and perceived seamless migration (β= 0.762, p< 0.001) (H1b and H1c), however it was not significantly related to perceived usefulness (H1a). Perceived seamless migration was found to positively influence perceived usefulness (β= 0.282, p< 0.001) and perceived ease of use (β= 0.302, p< 0.01) (H2a and H2b). Furthermore, perceived usefulness was found to positively influence attitude (β= 0.542, p< 0.001) (H3), but it was not significant to influence intention (H4), and perceived ease of use was positively related to attitude (β= 0.217, p< 0.05) and usefulness (β= 0.483, p< 0.001) (H5 and H6). Finally, intention was positively influenced by attitude (β= 0.620, p< 0.001) (H7) but not influenced by perceived behavioral control (H8). More explanations will be provided later in this study.

The coefficient of determination (R-square) was assessed to determine the quality of the structural (inner) model. The result in Fig. 2 demonstrates that perceived synchronization explains 58% of the variance in perceived seamless migration, while perceived synchronization and perceived seamless migration together explain 48% of the variance in perceived ease of use. Perceived synchronization, perceived seamless migration and perceived ease of use; the three variables together explain 67% of the variance in perceived usefulness. In addition, the effects of perceived synchronization on perceived usefulness is mediated by perceived seamless migration, and the effects of perceived synchronization and perceived seamless migration on perceived usefulness are mediated by perceived ease of use. Furthermore, perceived usefulness and perceived ease of use explain 52% of the variance in attitude and the effects of perceived ease of use on attitude is mediated by perceived usefulness. Attitude, perceived usefulness but not perceived behavioral control together explain 60% of the variance in intention, while the effects of perceived usefulness to intention is mediated by attitude. In conclusion, the R-square value in the proposed model ranges from 0.48~0.67 indicating the proposed model has medium to high explanatory power and is capable to explain the antecedents constructs and the endogenous constructs in the structural model.

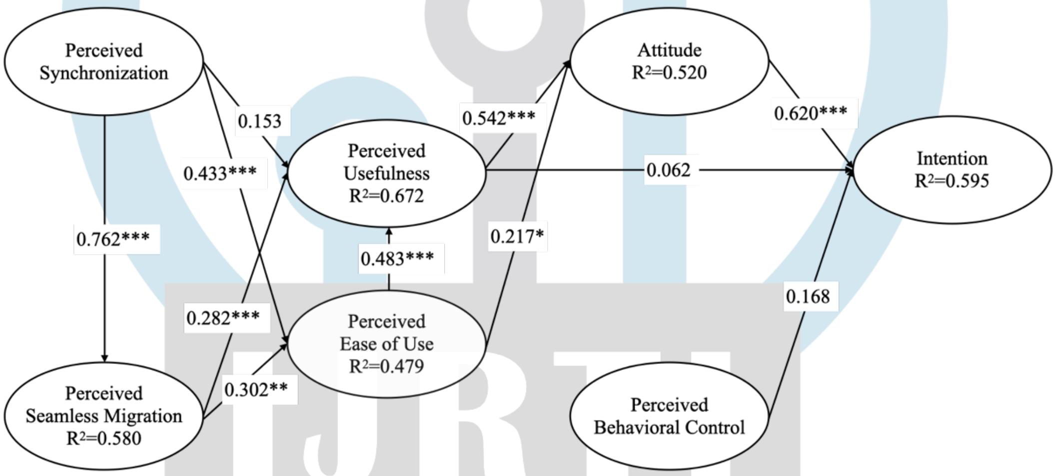

Figure 2 Structural Model for Continuous Interaction
(Note: PLS algorithm: maximum iterations= 300; bootstrapping procedure: samples= 5000;
*significant at p< .05, **significant at p< .01, ***significant at p< .001

VI. Discussion

The purpose of this study is trying to bridge the gap between multi-screen interaction and user intention. Combining both technology acceptance model (TAM) and theory of planned behavior (TPB), this study explored the development of user intention in multi-screen services. The empirical result expands our understanding of this prosperous multi-screen trend by constructing a research model to understand users' cognitive and affective processes toward the intention to use multi-screen services. This study makes two contributions to the understanding of continuous interaction and user intention:

First, this study identified perceived synchronization and perceived seamless migration as two key determinants for user to perform continuous interaction in multi-screen devices. These two determinants are a worthy extension of TAM and TPB because they have been found to predict user's attitude and intention to adopt multi-screen services. It is believed that incorporating additional constructs into model development improve the applicability of the research results and increase its relevance to practice [49], [50]. In our proposed model, synchronization in continuous interaction is considered to relate to ease of use, which echoes the findings of [58], [59] that better synchronization is considered easier to use. In order to make users feel that the synchronization between devices is easier to learn, easier to manage and demand less cognitive burden, designers should first provide appropriate data transfer methods between devices, then make the tasks transparent, and finally enable users to feel reliable as they continue to perform tasks across multiple devices. To our surprise, the relationship between synchronization and usefulness in this study was not statistically significant. The reason for explaining this phenomenon may be that the synchronization in multi-screen service is closely related to the system's work. Very often, synchronization is done in the system background (auto-sync), which makes it even difficult for users to regard it as useful. However, even though synchronization is not directly related to usefulness, it has an indirect effect to usefulness by influencing perceived seamless migration. Perceived seamless migration is a powerful mediator and it is suggested that designers should incorporate more seamless design decisions, such as reusing user's existing knowledge or determine the user's motivation for switching devices and incorporate those strategies into the synchronization design. As for perceived seamless migration, the result of this study indicated its strong effect on perceived usefulness and perceived ease of use, supporting the result by [61]. Seamless migration in this sense focuses on system facilitating users to make task transfer as seamless as possible without excessive learning and helps to increase task productivity. The results showed that easy transfer, status retrieval and operation memory are of the highest rating among indicators, meaning that users expect system to provide familiar operating context across devices, easy task transfer, and immediate task recovery and retrieval. In conclusion, this study identified two determinants that affect users' intentions to use multi-screen services, and their implications have helped to answer our first research question.

Second, this study proposed a research model to conceptualize continued interaction and reveal important relationships with other structures to answer our second research question. Findings demonstrate that perceived synchronization and perceived seamless migration as two critical factors of continuous interaction significantly affect perceived usefulness and perceived ease of use across multiple devices, which lead to explain 60% of the variance in the intention to use multi-screen services. The contribution supports the statements by [83] that model development is vital to provide useful abstractions for designing multi-screen system. The findings are consistent with previous behavior research theories [30] [44], including the relationships between attitude and intention, perceived usefulness to attitude, perceived ease of use to attitude and perceived ease of use to perceived usefulness. The results again prove that attitude is an important indicator of whether users want to use the service. It can be interpreted that user's positive attitude is important for them to decide whether to use the multi-screen services. It can be further explained that when users believe that continuous interaction is worthwhile, they will be more willing to use multi-screen services to help them handle tasks across multiple devices. Moreover, according to the analysis result, attitude is affected by the extent to which continuous interaction improves users' productivity and whether continuous interaction is easy to perform. Even though perceived usefulness does not affect users' intention to use multi-screen services directly as hypothesized, usefulness to intention can be mediated by attitude. That is, designing useful continuous interactions is not enough to affect user's intention. It is also necessary to consider the user's attitude towards continuous interactions to effectively improve their acceptance of the service. In this sense, it is recommended that developers can inform users of the benefits of continuous interaction in advance to establish a positive impression about the interaction. The results of the survey also showed that people tend to want to engage in continuous interaction when it is worth using, better in achieving goals or increase interaction experiences. Once users realize that continuous interaction can help them better achieve their goals, they are more likely to form an intention to use such services. In terms of perceived behavior control, the result implied that people do not think they are capable to perform a task across multiple devices. The possible explanation might be that perceived behavioral control result in better rating when users have adequate past experiences or knowledge with continuous interaction. Some users might want to be guided by the system instead of controlling the system themselves. Therefore, when users are not familiar with such operation, they tend to feel unable to control or perform continuous interaction in their tasks. Herrmann and Kim [84] provide similar explanation from the application perspective. They mentioned that the use of the application requires users to input information or operate according to the way the application is used, so it is more controlling of the user than the user controlling over the application. Moreover, we think there is a contradictory phenomenon in perceived behavior control and that is although users want to control the details of data synchronization, they also want the convenience of the system to automatically complete the synchronization for them, and the same view has also been mentioned in the study by Capra, Vardell and Brennan [85]. As a result, when continuous interaction emphasizes on the convenience of synchronization and seamless migration, there is no doubt that the degree of perceived control will be reduced. It is therefore suggesting that further experiments are necessary to find out possible underlying effects between perceived behavioral control and continuous interaction.

VII. CONCLUSION

The research model in this study can be interpreted from two approaches. From a micro perspective, this study suggests that designers should pay attention to perceived synchronization and perceived seamless migration when designing continuous interaction, because this will affect whether users want to use that multi-screen service. In addition, the formative indicators leading to synchronization and seamless migration can be used as design implications or directions when designing for continuous interaction in the future since these indicators are factors that determine the usefulness and ease of use in continuous interaction. Factors that affect people to perceive synchronization in continuous interaction are transfer method, task transparency and system trust. Factors that affect people to perceive seamless in task migration are easy transfer, status retrieval and operation memory, while knowledge of use and contextual needs are considered less important. From the macro point of view, the proposed model offers a clear view on the relationships between continuous interaction and user intention. The model informs design decisions that aid to identify and leverage constructs that are vital to increase user's intention to use multi-screen services. In the research model, perceived seamless migration is considered more important than perceived synchronization to affect perceived usefulness of continuous interaction that lead to attitude and intention. Perceived seamless migration is one of the prerequisites for perceived synchronization to affect user intention, establishing its importance in designing continuous interaction and as an important determinant to influence user intention. In addition, people's attitude is another important construct of this research model because it acts as mediator between perceived usefulness, perceived ease of use and user intention. The attitude of continuous interaction can be regarded as an important gateway to user's intention that designers should pay attention to.

This study attempts to understand the factors affecting the acceptance of multi-screen services and developed research model to help clarify the impact of continuous interaction on user intention. Considering the applicability of the research results, this study did not include domain attributes in the research model, which is the limitation of this study. This research provides multi-screen developers with a holistic understanding of continuous interaction with user intention; therefore, the model developed in this study can guide the design of continuous interaction and allow them to extend to different contexts. Future research on other multi-screen interactions, such as consistent interaction and complementary interaction in multi-screen services will be studied, and it is expected to provide a more complete multi-screen interaction model to explain the interplay between different interactions and the relationships between multi-screen interaction and user intention.

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