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The Investigation of Mobile Health Stickiness: The Role of Social Support in a Sustainable Health Approach

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Abstract: In recent years, there has been a phenomenal proliferation of multifunctional fitness apps (MFAs), many of which are deeply ingrained into modern daily life as an aid to trace, manage, and improve users' health and fitness. With technological advancement, these emerging information technology (IT) artifacts have the potential to facilitate the sustainable development of society and the environment. However, MFAs are facing a critical predicament: how to ensure user stickiness and continuous use. Drawing on the social support theory, this study aims to investigate stickiness as a multi-dimensional construct and to explore the antecedents of continuance usage and continuance purchase intentions in MFAs. The research model is empirically tested with data collected from 328 users of mobile fitness apps. A structural equation modeling analysis reveals both instrumental stickiness and social stickiness exert statistically significant influences on continuance usage intentions and in-app purchase intentions. Appraisal support, information support, and network support are significant antecedents for instrumental stickiness. While emotion support, esteem support, network support, and tangible support are significant antecedents for social stickiness. In addition, two facets of user sustainability—instrumental stickiness and social stickiness—exert different levels of influence on continuance usage and continuance app purchase intensions, respectively. The findings of this study will provide valuable insights for practitioners and policymakers involved in designing sustainable health products and engendering e-health systems.

Keywords: user sustainability; continuance usage intention; purchase intention; mobile health apps; social support theory; user stickiness

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Citation: Yin, M.; Tayyab, S.M.U.; Xu, X.-Y.; Jia, S.-W.; Wu, C.-L. The Investigation of Mobile Health Stickiness: The Role of Social Support in a Sustainable Health Approach. *Sustainability* **2021**, *13*, 1693. https://doi.org/10.3390/su13041693

Academic Editor: Mihajlo (Michael) Jakovljevic
Received: 25 December 2020
Accepted: 1 February 2021
Published: 4 February 2021

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1. Introduction

The rise of mobile devices has taken the world by storm. The ongoing spread of these wondrous devices is expanding at an exponential rate, making connections much easier than any other communication sources ever seen in human history. There have been new opportunities for non-traditional services to thrive and establish themselves, such as eHealth services. On the one hand, health-seeking behavior is on the rise [1], on the other hand, mobile users have surpassed the landmark of 5 billion [2], transforming multifunctional fitness apps (MFAs), a gigantic market [3] engendering millions of subscriptions and a high profit margin. The development of MFAs is highly related to sustainability in terms of social development and the environment. It is closely related to social sustainability, as MFAs help users to establish favorable relationships with other users with similar fitness and health interests, facilitating harmony and cooperativeness [4,5]. MFAs also provide user-oriented/personalized services, offer intelligent management of fitness-related issues

(to reduce the user's energy consumption), and promote sustainable development of the environment [6].

In 2018, the global mobile health application market reached USD $12.4 billion, which will expand at a growth rate of 44.7% in the period 2019–2026 [7]. Health and fitness apps have been ranked as the top 10 most popular apps in Google Play and the Apple App Store [1]. According to the *mHealth Apps Market Size, Share, Trends Report (2019–2026)*, mHealth apps can be broadly classified into several categories, including fitness, lifestyle management, nutrition and diet, disease management, female health, medication adherence, and healthcare providers/payers [7]. These different types of MFAs primarily have a similar business model. There are five classical elements of the business model [8,9]: (1) in terms of value proposition, the key value of different types of MFAs is to improve user health situations. (2) In terms of "target users", MFAs opt for individuals who are more conscious about health-related issues. (3) In terms of the key products and services, MFAs provide different functions in satisfying users' specific needs. Hence, different MFAs offer specialized functions, such as fitness related knowledge, health records, health assessments, and weight loss programs. Healthy lifestyle management functions provide healthy lifestyle methods to users; nutrition and diet functionalities offer healthy diet strategies. (4) MFAs revenue models suggests three aspects, including advertising fees, value-added service fees, and transaction fees of health-related products. Hence, different MFAs are similar in their revenue model although specific products provided by them may vary, such as private customized fitness program services, diet planning, health-related foods, supplies etc. (5) In terms of sustainable competitive advantages, different MFAs also share similar business designs (concerning sustainable profitability and sustainable development). In other words, all of these apps endeavor to provide superior functions and services to facilitate user engagement and purchase intentions. To conclude, MFAs mainly adopt similar business models, although they differ in specialized services and products.

Due to the burgeoning size of the MFAs market and the growing trend of mobile users seeking health information from MFAs [10], it has become exceedingly convenient for app users to switch between apps and services. Specifically, 74% of health app users stopped using an app within ten times of using it, and 26% of health apps were used only once after being downloaded [11]. With this in mind, one of the biggest challenges for fitness app providers is to foster a sticky user base [12]. The more users who stick to a particular app or website, the better the chances of these users becoming customers (which can lead to profits). Thus, there is a correlation between user stickiness and the success of enterprises competing in the rapidly evolving apps markets. Sticky users linger longer, buy more goods and services, view more advertisements, or participate in other platform activities; thus, from the perspective of service providers and practitioners, developing user sticky behavior is important for profitability and market share [10,13]. This is essential in the fiercely competitive market of MFAs, and could further pave the way for sustainable e-health development. Lee [14] pointed out that, to enhance our understanding of modern user behavior in mobile healthcare applications, "app stickiness" should be studied.

Due to the important role that user stickiness plays in determining the sustainable development and success of the emerging business model and information technology (IT) artifacts [15], stickiness is drawing great attention from both researchers and practitioners. The notion of stickiness has been widely investigated in information systems literature [16,17]. Lien [18] investigated the effect of stickiness on usage intentions of mobile services. Guo, Zhang, and Wang [19] explored the effects of customer psychological characteristics on stickiness. Lin [20] expounded on the role of online stickiness as it leads to e-commerce success by influencing the purchase intentions of the users. Other researchers have also illustrated how stickiness entails an increase in in-app purchases [21], fostering user–website relationships [22], customer loyalty, and satisfaction [23], which, in turn, directly relates to social and environmental sustainability [5,6].

However, several major gaps remain to be filled:

- First: prior literature has explored the notion of stickiness as a single dimension construct [16,24,25], considering the stickiness of a user to a particular website or app as a whole. While modern platforms and apps include embedded multiple functionalities, giving rise to the idea of multiple facets of stickiness corresponding to these various functionalities in the same user applications. Nowadays, multiple functions, such as instrumental functions (e.g., health information and fitness appraisals), social functions (e.g., online fitness communities), and consumption services (e.g., in-app stores), etc., are incorporated in MFAs to assist users in obtaining support in order to pursue their health and fitness goals [14,26]. These multi-functional apps give rise to multiple dimensions of stickiness, which cover the diversity of users' needs—the fulfillment of these needs leads to user behavior [11,27]. Therefore, treating stickiness as a single-dimensional construct entails the risk of oversimplifying the construct of stickiness in deriving a theoretical framework. Due to this oversimplification, it is difficult to fully illustrate the correct rendition of stickiness originating from various supporting functions of apps. Since different functionalities in apps may generate diverse intensities of stickiness—in the same app—it is critical to explore an improved conceptualization of the construct of stickiness for the sustainable growth of new and evolving information and communication technology (ICT) applications, in the novel (and fiercely competitive) context of e-healthcare.
- Second: continuance usage intention is a critical factor in determining the success of an app and growth of the enterprise [6,18]. This is because continuance usage intention signifies a customer's indulgence in the service or functionality of the app, and, consequently, offers a better chance at producing a sustainable social and healthy environment [5,6]. Due to the credible and relevant recommendations offered to users in MFAs (e.g., customized solutions, services, products), and the convenience of in-app purchases, it has become the natural and spontaneous behavior for users to purchase from MFAs. Whereas, other revenue streams, such as the profitability from advertising fees, cannot become the major monetizing channel, unless the MFAs have obtained a large number of users. Hence, in the specific context of MFAs, specialized products and services have become the main sources of monetization [12]. Thus, in-app purchases are considered as essential sources of monetization for MFAs [12,20]. The more consistent this revenue stream is, the better chance an MFA has for growth and success in this fiercely competitive niche [28]. Consequently, MFA user stickiness appears to be one of the most important antecedents for continuance usage and continuance app-store consumption. Various studies have confirmed this notion—that stickiness has a significant influence on a user's continuance intentions [18,29] and in-app purchase behaviors [20,21]. Nonetheless, prior studies have not extensively studied the correlation between "stickiness" and "continuance usage intentions" as well as the correlation between "stickiness" and "continuance purchase intentions" in the context of MFAs and e-healthcare. Moreover, there exists little empirical evidence regarding which type of stickiness may exert more influence on continuance usage and continuance purchase intentions. In other words, how the different dimensions of stickiness are derived, and how they affect these two crucial user behaviors, concerning the continuous growth of businesses, is still unknown. There might be considerable variation in degrees of influence exerted by each kind of stickiness in engendering continuance behavioral outcomes. Thus, this naturally strengthens our case of expounding stickiness from multiple dimensions and gauging how it influence the user intentions.
- Third: Prior studies have utilized the social support theory to understand health-related behaviors [30–32]; however, this theory has rarely been used to illustrate the interaction between users and IT applications from the vantage point of stickiness [33], even though social support finds its significance in e-health related issues [34]. The literature related to the theoretical paradigm of social support—to study e-health business enterprise—is still in its nascency. In fact, to our knowledge, this study is one of

the first studies to employ the social support theory in the domain of health and fitness to investigate user–app interactions, explicitly from the perspective of user stickiness. Therefore, this study strives to shed light on the distinct behavioral outcomes of stickiness in MFAs, which are essential for a sustainable e-health environment [35].

In light of the aforementioned research gaps, this study strives to answer the following research questions (RQs):

- RQ1: what are the different types of social support that determine user stickiness in MFAs?
- RQ2: what are the antecedents influencing continuance usage and continuance purchase intention in MFAs?
- RQ3: do different types of stickiness exert statistically different impacts on continuance usage and continuance purchase intentions in MFAs?

In order to answer these research questions, this study attempts to empirically determine the antecedents and outcomes of varied types of stickiness under the context of user–app interactions in the domain of health and fitness. To achieve the research goals, this study seeks to propose and examine a research model that incorporates multiple dimensions of stickiness based on the theoretical underpinnings of the social support theory. Using a structural equation model (SEM), this study assesses the proposed model from empirical data collected from 328 users, and contributes to the literature of user behavior in the field of health and fitness.

The rest of the paper is organized as follows: In this section, we illustrate how social support theory could be applied in this study. The next section provides a literature review on stickiness and social support theory. Section 3 presents the research model and hypotheses. A detailed description of the research methodology and the data analyses results are presented in Sections 4 and 5, respectively. Then, in the last section, we discussed the implications of our research findings, the theoretical contributions, and the limitations of the study, as well as future research prospects.

2. Literature Review

2.1. User Stickiness in Mobile Fitness Apps

Continuance usage of mobile fitness apps is the key to mobile fitness app development [1]. Since stickiness exerts conspicuous influence on user behavior for app providers, creating and maintaining a sticky user base is of paramount importance. Prior studies found that sticky users not only use apps repeatedly and frequently, as embedded routines [22], as well as spend more time exploring and digging deeper into the various functionalities of apps than other users [16], but they also spend more money, and, with higher frequency, purchase the services and products offered by apps [21].

Usage of MFAs generally involve help-seeking behavior [34], e.g., to facilitate healthier lifestyles for users so they can improve their fitness levels. Continuance usage of MFAs is helpful toward improving the user's health (and promote MFA development). In order to retain a user's continuance usage of MFAs, MFA providers aim to make users sticky through variable functions and services, such as providing support derived from various MFA functions, in order to facilitate the process regarding the user's fitness regime. In prior studies, the relationship between stickiness and various app functions has been illustrated as well [18,36]. By definition, there are different kinds of functions and services in MFAs [11]. Some functions are designed for meeting users' instrumental needs, which can be called instrumental functions, and others are designed for meeting users' social needs, which can be called social functions. Instrumental functions mainly include fitness solutions, management of fitness records, analyses, health status estimates, etc. Through instrumental functions, users can discern their health conditions, obtain health information, and monitor their fitness goals. Social functions mainly include online fitness groups, offline fitness activities, and other social forms. Through these functions, individuals can find users who have similar interests and share similar fitness problems, emotions, and fitness results (e.g., pictures, videos, and health statistics), as well as obtain companionship and

encouragement during their fitness routines [34]. Since the instrumental functions and social functions of MFAs are designed for satisfying different needs, it follows that the stickiness these two types of functions generate must be quite distinct in nature as well. In other words, using MFAs as part of a routine to manage fitness-related issues [1], users may generate instrumental stickiness, mainly through the instrumental functions of MFAs, and they may generate social stickiness through social functions of MFAs. According to Hsu and Liao [16], we define instrumental stickiness as the instrumental ability (e.g., instrumental functions) of MFAs to attract and retain users, and prolong the duration of each stay (concerning instrumental functions). Furthermore, we define social stickiness as the ability (e.g., social functions) of MFAs to attract and retain users and prolong the duration of each stay (concerning social functions). Even though existing studies primarily treat stickiness as a single dimensional concept [16,24,25], this study propounds to identify user stickiness as two dimensions (i.e., instrumental stickiness and social stickiness). In addition, this paper explores the determinants of these distinct kinds of stickiness based on the facilitation process for the fitness regimen, especially the effects multiple types of support provide by instrumental functions and social functions. Hence, this paper diverges from prior studies by proposing to examine instrumental stickiness and social stickiness as two distinct constructs, rather than merging them into a single construct for the purpose of analysis.

Researchers have provided evidence that stickiness can affect user behaviors, such as continuance usage [18], in-app purchases [12], and word of mouth [23]. In the context of MFAs, sticky users may engage in continuance usage to further explore the instrumental functions and use the app as an embedded routine. Furthermore, users who generate social stickiness may engage in social activities in the app, as well as continuance purchase products and services from the app store.

2.2. Social Support Theory

Social support, considered a cardinal notion in the domain of health and wellbeing, has been defined as "an exchange of resources between at least two individuals perceived by the provider or recipient to be intended to enhance the wellbeing of the recipient" [37]. Likewise, Oh et al. [38] referred to social support as an exchange of aid or resources among community members. Existing literature is rich in evidence on the positive association between social support and various health and fitness-related scenarios. Social support has been elaborated in some studies as a process of promoting health and wellbeing [34]. Health researchers [39,40] have suggested that social support acts as a buffer for mental health conditions. Other studies [41] have concluded that social support influences physical health outcomes in a positive manner, as a psychological factor. Moreover, social support has also been studied for its influence on health-related communication between and among patients with various health concerns [42–44], sufferers of traumatic experiences [45,46], and those suffering from stress or anxiety [31,47,48].

In addition, mounting evidence has shown the significance of social support in online health-related outcomes. For instance, social support is found positively correlated with self-efficacy and willingness to offer support to others in the online health community [32]. Oh et al. [38] suggest that social support is positively related to health information-seeking behavior and health self-efficacy on Facebook. Hence, similar to traditional face-to-face communication, computer-mediated applications (i.e., digital apps) have facilitated social support provided to internet users [49–52]. Social support has been regarded as an interactive supporting mode that not only provides to those who suffer from disease or illness, but also to ordinary healthy people [53]. In the era of online interactive communities, people expect to have quick access to solutions to their problems, by using search engines or other related online applications and/or by sharing experiences and feelings with other online community users who have similar interests or experiences.

Social support has been studied as a multi-dimensional concept in prior studies. Healthcare professionals, researchers, and app providers—through understanding derived

by this categorization approach—may "facilitate health behavior modification" [54]. Thus, social support categories can be used as a foundation or framework, as is the case within this study, to assess how social support is enacted in the context of MFAs, when it comes to potentially improving understanding of the supportive process and the outcome of social support [55]. Cutrona and Russel [56] identified five major dimensions of social support: (1) esteem support refers to expressions of regard for one's skills, abilities, and intrinsic value. (2) Emotion support refers to expressions of caring, concern, empathy, and sympathy. (3) Network support is the presence of companions with whom to engage in shared social activities. (4) Tangible support includes offers to provide needed goods and services. (5) Information support is the provision of advice, factual input, and feedback on actions. Meanwhile, other researchers have used other terms to reflect similar stickiness dimensions. For example, network support is analogous to Cohen and Wills' [40] concept of social companionship, while tangible support can be mapped to Cohen and Wills' [40] instrumental support. Hence, applying these five dimensions, Lin investigated the effects of social support in the online health community [32]. In addition, appraisal support suggested by both House [57] and Reber [58] is a critical dimension of social support provided in the computer-mediated context. Hence, it has been studied as one important dimension of social support in health-related social network sites [38]. To conclude, six dimensions have constituted a complete set of social support in this study. In other words, appraisal support, tangible support, information support, network support, emotion support, and esteem support are investigated in this study.

Social support theory is employed to study user stickiness in this study because it offers a relational perspective to investigate the user–app relationship. Existing studies have called for more attention to investigate user stickiness and provide additional empirical evidence of this phenomenon from the relational perspective [22]. The relational view emphasizes the building and maintenance of the relationship between users and the website through personalized social and psychological exchanges [22,59,60]. Social support theory has been shown to provide sound theoretical grounds to explain the user–app interaction in the context of information support [33]. X. Lin et al. [61] argue that social support is an antecedent of stickiness during user interactions with online social networking sites (SNS). Recent studies on human–computer interaction have found that users may regard computer systems as social entities [22,62]. There exists a relationship between users and systems, which systems provide different kinds of support. For example, while interacting with an MFA, users may treat it as a social entity providing fitness information as an "expert", such as exercises and diet information, in other words, information support. Chien Lung Hsu and Liao [16] illustrated that perceived quality and accessibility of information, advice, or feedback from a digital platform is closely linked with developing a strong user–app relational and interactional bond. In addition, in the process of providing input and receiving output from the app, users can follow programmed interactive dialogs and interfaces to interact with the app, such as providing feedback and comments to other users, participating in in-app forums, and engaging in other user-driven interaction. During the process, users can receive emotion support from MFAs and other users, such as encouragement and appreciation for maintaining exercise routines and healthy diets. Users draw this kind of information and appraisal social support mainly from the instrumental and social functions of MFAs. Thus, we consider social support theory to be an appropriate foundation for exploring the antecedents and outcomes of instrumental stickiness.

3. Research Model and Hypotheses

3.1. The Effects of Social Support

3.1.1. The Effects of Social Support on Instrumental Stickiness

Drawing upon previous literature [32,56,58,63,64], this study disintegrated social support into six elements to cover all of the dimensions of social support: appraisal support, information support, tangible support, emotion support, network support, and esteem support. The proposed research model is depicted in Figure 1. Lien [18] theorized that,

when users are satisfied with the content, functions, and services of an electronic platform (e.g., an app or website), they develop a positive attachment to the platform, referred to as stickiness. Due to the positive outcome of the interaction with MFAs, such as tracking fitness progress or enabling users to follow particular fitness routines, users may define the services and functions of MFAs as being valuable and beneficial. Then, strong commitments to the instrumental functions of MFAs [21] are developed, which is referred as instrumental stickiness in this study.

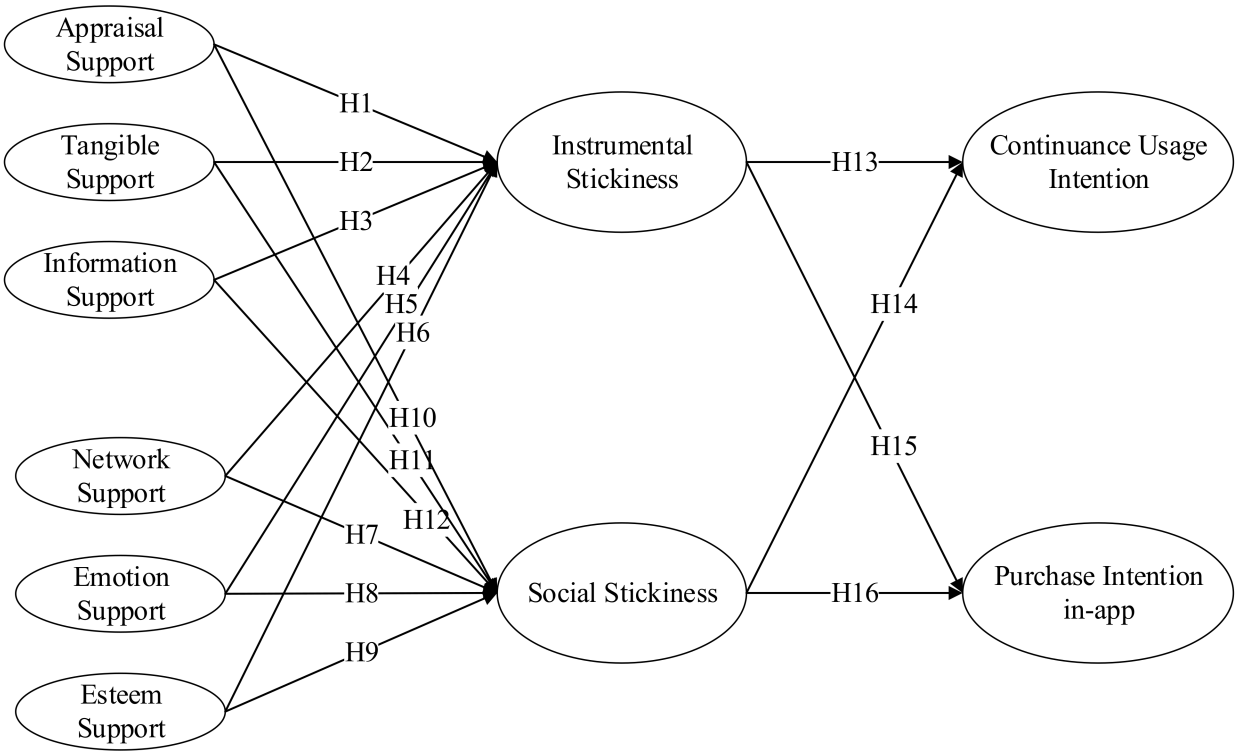


Figure 1. The research model.

Tangible support is generated from the instrumental functions, which facilitate an individual directly in his/her fitness regime [38,65], such as fitness-related products (e.g., track shoes and dried egg whites) provided in MFAs. Tangible support has been found to bear a high correlation with adherence to regimens [66,67]. The direct effect of tangible support derived from the instrumental functions of MFAs, in following the fitness routines, accounts for the instrumental aspects of stickiness to MFAs and their functionality. Further, information support derived from instrumental functions includes the provision of practical resources, such as objective information, suggestions, and advice, which help receivers regarding the overall process of fitness (e.g., diet and fitness program, updated fitness information) [32,68]. Information support (e.g., valuable knowledge, advice of experts, and experiences of fellow members of the community) are helpful for users to better plan and follow fitness regimes, to reap the fruits of the regimes. Ko et al. [69] empirically demonstrated that users who satisfy their information needs would spend more time on online sources. Consequently, this information support entails user stickiness to the instrumental functions of MFAs. Similarly, appraisal support is defined as the appraisal of the user's fitness level based on the instrumental functions in MFAs, in order to reduce fitness risks and improve the level of fitness [38,70]. There is ample evidence indicating that appraisal support has a positive association with various user behaviors, such as self-efficacy [32] and information-seeking [38], making online applications valuable in a user's perception, which would eventually lead towards strong attachment with an electronic platform, causing user stickiness [16]. Since appraisal support, through instrumental functions of MFAs,

provide a valuable feedback loop and clear fitness measuring tools for the users, it makes instrumental functions of MFAs valuable concerning user perception. Therefore, this would entail stickiness to the instrumental functions of MFAs. Hence, these three dimensions of social support have positive effects on a user's instrumental stickiness and behavior. Thus, we propose the following hypotheses:

Hypothesis 1 (**H1**). Appraisal support is positively associated with the user's instrumental stickiness of MFAs.

Hypothesis 2 (**H2**). Tangible support is positively associated with the user's instrumental stickiness of MFAs.

Hypothesis 3 (**H3**). Information support is positively associated with the user's instrumental stickiness of MFAs.

Since network support emerges from connecting people of similar interests [49], instrumental functions of MFAs invite and facilitate users to participate in the usage of the app, along with providing useful health information and fitness tracking functions. The shared experience aspects of online social support concerning fitness in MFAs is akin to the concept of network support [49]. Users can develop social relationships with one another, resulting in a dynamically interactive health community to enhance their interaction, communication, and sharing, regarding health interests and fitness goals. This would lead to close ties with the MFA network and dependency on the instrumental functions of the MFA, connecting users with this network. Since dependency or usefulness would lead to stickiness [32], this dependency on the instrumental functions would lead to stickiness of the instrumental functions of MFAs.

Similarly, emotion support refers to an amalgamation of feelings of empathy, sympathy, understanding, encouragement, and compassion [38,61]. Emotion support is a central form of social support [61], enabling motivation (i.e., to follow a fitness regimen) and contributing toward the user's sustained well-being. The instrumental functions of MFAs can assist users to create communities and networks [21], allowing users to exchange information and emotional connections through MFA blogs or forms. Therefore, these emotional and social interactions play significant roles as determinants of user stickiness [32] to MFAs. We can safely assume that emotion support originated as a result of instrumental functions of MFAs; consequently, having a positive association with instrumental stickiness.

Finally, esteem support refers to expressions regarding one's intrinsic value, and it includes reassuring an individual of his/her intrinsic worth and competence [32,63]. Instrumental functions of MFAs can enhance the self-esteem of users by recording and depicting fitness progress users have made over time towards their goals, providing a mechanism of fitness comparison among users, such as a scoreboard, acknowledging users' efforts towards their goals, or towards the community, in the form of badges or ribbons. Moreover, encouraging the self-esteem of a user, by others, can lead to continuance behavior [66]. In short, network support, emotion support, and esteem support affect a user's continuance behavior, and may exert positive effects on a user's instrumental stickiness. The following hypotheses are proposed:

Hypothesis 4 (**H4**). Network support is positively associated with the user's instrumental stickiness of MFAs.

Hypothesis 5 (**H5**). Emotion support is positively associated with the user's instrumental stickiness of MFAs.

Hypothesis 6 (**H6**). Esteem support is positively associated with the user's instrumental stickiness of MFAs.

3.1.2. The Effects of Social Support on Social Stickiness

When user–app interaction in the case of MFAs leads to positive results, the perceived value of social functions of the app are enhanced (such as forums for diet and health discussions or running groups to motivate people to pursue healthy lifestyles). Therefore, it would develop a strong committal relation between users and apps directed towards the social functions of MFAs [21], referred to as social stickiness in the paper. The social functions of a particular MFA tend to generate a community revolving around that MFA due to similar interests and common goals. Social interaction enhances the sense of community of the members and this enhanced sense of community makes the functions of MFAs much more beneficial for the users [16]. In this context, the exchange of emotional support occurs very frequently in virtual health communities [71]. Some researchers have reflected that users may enjoy the emotionally satisfying relationship with other members who have similar interests, values, and objectives [72]. The social support perspective suggests that people will develop an affective attachment to the entity (e.g., a person, a community, or an information system) with which they exchange emotion support [32,73]. This attachment can likely lead to extensive and prolonged social interactions. In other words, the emotion support received will facilitate the user to generate social stickiness to the MFAs. They would like to engage in these activities enabled by the social functions of MFAs, generating social stickiness to MFAs.

Concerning the online community perspective, network support is the presence of companions, where users engage in shared social activities [32]. In this study, MFAs enables the users to meet other users with similar health interests and fitness goals. These shared interests and goals generate a sense of community among MFA users, to develop a social network with other community members to engage in the shared health-related social activities. Once the social network is established, these networks often employ social functions of MFAs to organize a variety of shared activities to enable the users to enjoy the network support, such as cycling, running, or rowing (i.e., "together" activities). This is referred to as network support—users can easily perceive the presence of companions who participate in fitness activities with them [74] through MFA social functions. Studies reflect that these collective activities encourage and assist users to perform better in the domain of health and fitness, enhancing the value of social support users derived from these activities [75]. This enhanced value of social functions then leads to users to develop stickiness to the social functions of MFAs.

Esteem support includes messages that help recipients restore their self-concept or self-validation [32,38]. In the context of MFAs, users can receive recognition and respect from other community members through MFA social platforms. Previous studies have illustrated that social support leads first to increased self-esteem and then to better adherence, directly or indirectly [66]. Thus, esteem support supplied by others during the use of MFAs enable the users to enhance their self-esteem by following their fitness regimes or through overcoming fitness challenges. Consequently, this would entail stickiness to the social functions of MFAs. To conclude, emotion support, network support, and esteem support exchanged between members in the MFA virtual communities may be viewed as indirect support to facilitate a user to emotionally (and indirectly) follow the fitness regime. It is also possible that users may feel emotionally bound to their MFA communities [76] and develop social stickiness to MFAs. Hence, the following hypotheses are developed:

Hypothesis 7 (**H7**). Network support is positively associated with the user's social stickiness of MFAs.

Hypothesis 8 (**H8**). Emotion support is positively associated with the user's social stickiness of MFAs.

Hypothesis 9 (**H9**). Esteem support is positively associated with the user's social stickiness of MFAs.

Lastly, the social functions of MFAs give rise to information support through knowledge sharing between community members. If information support arises from the social function of an app, this creates a strong adhesive relationship between the user and the app [69], as this information would facilitate users to better manage their diet and fitness regimes, resulting in user stickiness to the social functions of MFAs. Further, tangible support, when arising as a result of social functions of MFAs, e.g., a community member directly and tangibly assisting another member to continue the fitness regime, entails user adherence [66] to the social functions of MFAs, generating social stickiness. Similarly, health and fitness information-seeking behavior originates appraisal support [38]. In other words, social functions of MFAs create a community that provides valuable feedback to users and assists users with gauging their progress against the fitness of other community members through social interaction, such as forums or microblogs [16]. Since valuable feedback and information acquired through app functions engender sticky user behavior [18], this leads to user stickiness to the social functions of MFAs. Thus, we propose that the three above-stated social support methods exert positive effects on user social stickiness. The following hypotheses are put forth:

Hypothesis 10 (**H10**). Appraisal support is positively associated with the user's social stickiness of MFAs.

Hypothesis 11 (**H11**). Tangible support is positively associated with the user's social stickiness of MFAs.

Hypothesis 12 (**H12**). Information support is positively associated with the user's social stickiness of MFAs.

3.2. Continuance Usage Intention

Many studies have investigated the determinants of users' continuance usage intentions in information systems [77–80]. The relationship between stickiness as a determinant of users' continuance usage intentions has also been explored. For example, Lien et al. [18] empirically found that user stickiness to WeChat had a positive influence on continuance intentions of using WeChat services. Kim et al. [29] concluded that the stickiness of an app influences the continued usage of the app. Accordingly, we adopt a similar assumption, postulating that both types of stickiness (instrumental and social) should exert a positive effect on continuance usage intentions. Therefore, we propose the following hypotheses:

Hypothesis 13 (**H13**). *Instrumental stickiness will positively affect users' continuance intention to use MFAs.*

Hypothesis 14 (**H14**). *Social stickiness will positively affect users' continuance intention to use MFAs.*

3.3. Continuance In-App Purchase

Intention to make continuance in-app purchases is the degree to which a user would like to purchase products and/or services sustainably within a given app [21]. In order to assist the user in achieving their fitness goals more efficiently and in maintaining a healthier lifestyle, most MFAs come with fitness-related products in-app store. The store recommends fitness-related products to their users, such as sportswear (e.g., basketball boots), fitness diet products (e.g., albumen powder), exercise equipment (e.g., dumbbell), and fitness services (e.g., online and offline fitness coaches, supervisors, and exercise programs). Both stickiness and in-app purchase intentions reflect important dimensions of customer values, and are expected to be positively associated with the app's market value [21], since in-app purchases are one of the most significant profit generating channels for app developers [81]. Naturally, investigating the effects of stickiness is very important for researchers and practitioners. Prior studies have confirmed that a user's willingness to

stick with a given website/app is a strong predictor of his/her intention to transact [20]. Chin-Lung Hsu and Lin [21] indicated that increased stickiness leads users to more likely make in-app purchases. Moreover, McCloskey empirically confirmed that, as a web user spends more time on the internet (user stickiness), he or she would be more likely to purchase online [82]. In addition, practitioners have observed the importance of stickiness in influencing the in-app purchase, suggesting that only sticky users are likely to make such purchases [83]. There is a dearth of research that investigates the varied effects of the two types of stickiness on continuance in-app purchases, making this study one of the pioneers in understanding and measuring the effects of multiple dimensions (i.e., instrumental and social) of stickiness. Various researchers have documented the effects of user stickiness (as a single dimension) on continuance in-app purchases, providing the basis for the following hypotheses:

Hypothesis 15 (**H15**). *Instrumental stickiness will positively affect users' continuance intention to make in-app purchases.*

Hypothesis 16 (**H16**). *Social stickiness will positively affect users' continuance intention to make in-app purchases.*

4. Research Methodology

4.1. Measurement Development

An online questionnaire was designed based on prior research. The questionnaire was divided into three main sections and was designed according to prior studies. The first section covered the description of the questionnaire, which presents the purpose and significance of the survey and introduces the definition of MFAs. The second section asked for demographic information of the participants, including gender, age, education, and experiences of MFA usage. The third and final section was the main section of the questionnaire, consisting of instrument measuring questions. We began the scale development process by surveying the extant literature for validated scales that could be used in our study. To ensure content validity, the measures for our constructs were adapted from the existing literature to suit the context of MFAs. All of the instruments measuring social support were adapted from Oh et al. [38] and Lin et al. [32]. Measures for instrumental stickiness and social stickiness were adapted from Lin [20], Yang and Lin [84], and Chiang and Hsiao [85]. Measures for continuance usage intention of MFAs were adapted from Bao [33]. Measures for continuance purchase intention in-app were adapted from Chin-Lung Hsu and Lin [21]. All of the items were measured on a five-point Likert scale ranging from "strongly disagree" to "strongly agree." As the survey was conducted in China, firstly, measures of latent variables were translated into Chinese and then translated back into English by two information system scholars, to eliminate potential language disparity issues and to ensure the translation validity. The operationalized scales of the research constructs/sub-constructs and the referred literature are summarized in Appendix A.

4.2. Data Collection

A pre-test was conducted to refine and validate the survey instruments. The pre-test was conducted with 80 graduate and undergraduate students from universities, from 8–15 August, 2019. Each respondent had a rich experience using MFAs (e.g., they use MFAs every day). After securitizing the pre-test data, two approaches were launched to optimize the final questionnaire. First, statistical tests were performed to explore the potential issues of the questionnaire, such as the factor analysis. The purpose was to conduct the preliminary test of the statistical validity of the questionnaire. The analysis process produced satisfactory results, which suggested the validity of the questionnaire. Second, an expert panel discussion was conducted to improve the content validity of the questionnaire. Four professors specialized in management information systems and two

managers of MFA companies participated in the discussion. Panel experts believed the questionnaire was clear and easy to understand. Minor revisions, such as wording and language, were slightly modified to further improve readability.

During the formal data collection process, we employed a professional online survey company to collect the empirical data via an online portal (https://www.wjx.cn/). First, the online survey was employed due to the characteristics of the research context. MFAs are applications installed on mobile phones and often require an internet connection during usage. Hence, MFA users are all internet users; an online survey seems the most proper channel to access the actual MFA users. Second, the survey company was employed due to its expertise and influence in the market. The company plays a leading role in its field, and it has helped 106 million users to collect 8.432 billion questionnaires. The survey company is the most influential survey company in China and is widely adopted by firms and researchers. The company distributed the questionnaire on their portal and identified valid respondents in its national database. In other words, the company is able to access national users with a variety of demographic information and MFAs. Each respondent was offered 25 RMB (around 4 U.S. dollars), and a lottery was launched to further increase the response rate. Hence, with the facilitation of a professional survey company, the monetary rewards, and the lottery, the response rate was significant (82%).

Eventually, empirical data were collected from 22–30 August, 2019. Attention check questions were included in the survey questionnaire to examine if the participants paid attention to the survey questions, to ensure the quality of the data. Repeat questions and reverse questions were adopted as the attention check tools. For instance, in the case of repeat questions, the respondents who provided conflicting answers to the same question were excluded from the final examination. After a strict screening and examining procedure, 72 participants who did not pass the attention check question, or who gave incomplete answers were excluded. A total of 328 valid questionnaires were left for further analysis (valid rate of questionnaire = 82%). Among the respondents, 48.4% were male, 51.2% were female, 82.7% were between the ages of 25 and 45, 95.7% had education higher than the high school level, more than 90% had used management functions of MFAs, more than half of the users had used social functions, and 41.2% had used in-app purchase functions. Table 1 summarizes the demographics of the respondents. The demographics profile shows that users were relatively young and generally well educated.

Table 1. Demographic Characteristics (N = 328).

Variable	Classification	Freq.	%
Gender	Male	160	48.8
	Female	168	51.2
Education	Middle school and below	3	0.9
	High school	11	3.4
	Junior college student	52	15.8
	Undergraduate	240	73.2
	Graduate and above	22	6.7
Use or not	Yes	310	94.5
	No	18	5.5
Age	≤18 year	0	0
	19–24	28	8.5
	25–35	195	59.5
	36–45	76	23.2
	46–60	27	8.2
	61 and above	2	0.6
Which function you have used	Instrumental function	302	92.1
	Social function	209	63.7
	Shopping function	135	41.2

5. Results and Data Analysis

5.1. Validity and Reliability

The data analysis utilized a two-step approach, as recommended by Anderson and Gerbing [86]. The first step analyzed the measurement model, while the second tested the structural relationships among the latent constructs. The aim of the two-step approach is to establish the reliability and validity of the measures before assessing the structural relationships of the model. SPSS and Smart Partial Least Squares (PLS) 2.0.M were employed as the primary tools to analyze the model and test the proposed hypotheses. Smart PLS 2.0.M3 [87] was used because it allows latent constructs to be modeled as formative or reflective indicators. Partial least squares (PLS) places minimal restrictions on the measurement scales, sample size, and residual distribution [88].

The measurement qualities of all of the scales were assessed based on their reliability, convergent validity, and discriminant validity. In particular, Cronbach's α was calculated, the value is 0.930, which indicates a high reliability of the questionnaire, and the Kaiser-Meyer-Olkin (KMO) value is 0.922, tested by SPSS, and indicates that it is suitable for factor analysis. All items loaded significantly on their corresponding latent constructs, with loading values well above the minimum threshold, as shown in Table 2, indicating sound convergent validity of the measurement model. Reliability was assessed using composite reliability (CR), and average variance extracted (AVE). As shown in Table 2, the CR values of all of the latent variables are greater than 0.7, indicating that the composite reliability of each latent variable is high and has good internal consistency. In particular, to measure the internal consistency of the constructs, Cronbach's α was calculated; the value is 0.930, which indicates a high reliability of the questionnaire. The KMO value is 0.922, tested by SPSS, which indicates the suitability for factor analysis.

Table 2. Reliability, variance, and confirmatory factor analyses.

Construct	Item	Loading	Mean	Standard Deviation	CR	AVE
Appraisal Support	APS1	0.903	3.884	0.607	0.74	0.596
	APS2	0.614	3.59	0.872		
Tangible Support	TAS1	0.7	3.79	0.783	0.757	0.511
	TAS2	0.764	3.91	0.705		
	TAS3	0.677	3.674	0.907		
Information Support	INS1	0.748	3.965	0.693	0.758	0.512
	INS2	0.76	3.813	0.744		
	INS3	0.633	3.89	0.764		
Network Support	NES1	0.767	3.926	0.787	0.786	0.551
	NES2	0.749	3.732	0.752		
	NES3	0.71	3.677	0.824		
Emotion Support	EMS1	0.739	3.765	0.812	0.845	0.577
	EMS2	0.765	3.697	0.775		
	EMS3	0.759	3.661	0.791		
	EMS4	0.776	3.59	0.83		
Esteem Support	ESS1	0.81	3.674	0.813	0.792	0.56
	ESS2	0.723	3.813	0.695		
	ESS3	0.708	3.926	0.727		
Instrumental Stickiness	INST1	0.743	4.035	0.806	0.819	0.603
	INST2	0.848	4.023	0.761		
	INST3	0.734	4.023	0.735		
Social Stickiness	SOST1	0.836	3.49	0.899	0.882	0.713
	SOST2	0.873	3.552	0.918		
	SOST3	0.823	3.535	0.987		

Table 2. *Cont.*

Construct	Item	Loading	Mean	Standard Deviation	CR	AVE
Continuance usage Intention	SUIN1	0.723	4.223	0.737	0.796	0.566
	SUIN2	0.764	3.971	0.703		
	SUIN3	0.768	3.974	0.771		
Continuance Purchase Intention in-app	SPIN1	0.861	3.532	0.905	0.882	0.714
	SPIN2	0.859	3.571	0.847		
	SPIN3	0.814	3.474	0.974		

Convergent validity and discriminant validity are tested through AVE. As shown in Table 2, the AVE value of each variable is above 0.5, indicating the data have good convergent validity. As shown in Table 3, the square root of each AVE value is on the diagonal and the rest are the correlation coefficients, the square roots of each AVE value are greater than correlation coefficients, which indicates the sample has good discriminant validity.

Table 3. Discriminant validity.

Variables	APS	TAS	INS	NES	EMS	ESS	INST	SOST	SUIN	SPIN
APS	0.772									
TAS	0.531	0.715								
INS	0.511	0.545	0.716							
NES	0.438	0.550	0.600	0.742						
EMS	0.389	0.472	0.600	0.648	0.760					
ESS	0.436	0.513	0.538	0.563	0.604	0.748				
INST	0.486	0.434	0.540	0.521	0.435	0.427	0.776			
SOST	0.374	0.472	0.457	0.534	0.557	0.513	0.343	0.844		
SUIN	0.484	0.538	0.574	0.561	0.503	0.568	0.664	0.529	0.752	
SPIN	0.378	0.533	0.440	0.481	0.489	0.491	0.325	0.602	0.349	0.845

5.2. Common Method Variance

As the measure of independent and dependent variables use the same survey over the same set of subjects, common method variance (CMV) may be a source of bias, influencing the results of our study. Podsakoff et al. [89] suggested that CMV should be tested for all self-reported data. In order to test the CMV, Harman's single-factor test was performed, firstly, in which all of the measurements of variables were loaded into a principal component factor analysis. The un-rotated factor solution consisted of seven factors, with the first factor accounting for 32.93% of the variance. Thus, there is no single factor that could explain the majority of the variances, indicating that the data sets do not have a substantial amount of CMV. Second, following Liang et al. [90], we included in the PLS model a common method factor whose indicators included all of the principal construct indicators and calculated each indicator's variances, substantively explained by the principal construct and by the method. The results demonstrate that the average substantively explained variance of the indicators is 0.591, while the average method-based variance is 0.001. The ratio of substantive variance to method variance is about 59:1, and most method factor loadings are not significant [90], the results are summarized in Appendix B, Therefore, CMV should not be a significant issue in this study

5.3. Hypothesis Testing

Smart PLS 2.3 was applied to construct the structural equation model; PLS algorithm was run to test the path coefficients between latent variables, Bootstrapping was used for calculating the significance level. When the t-value is greater than 1.96, it is significant. R^2 values mainly reflect the explanation power of the research model. The path analysis results of the model, significance level, and R^2 are depicted in Figure 2. Figure 2 also outlined the results of the hypotheses proposed. The model could explain 38.8% of the

variance in instrumental stickiness, 40.7% of the variance in social stickiness, 54.4% of the variance in continuance usage intention, and 37.8% of the variance in continuance purchase intentions in-app. Therefore, the research model has good explanatory power and can be accepted.

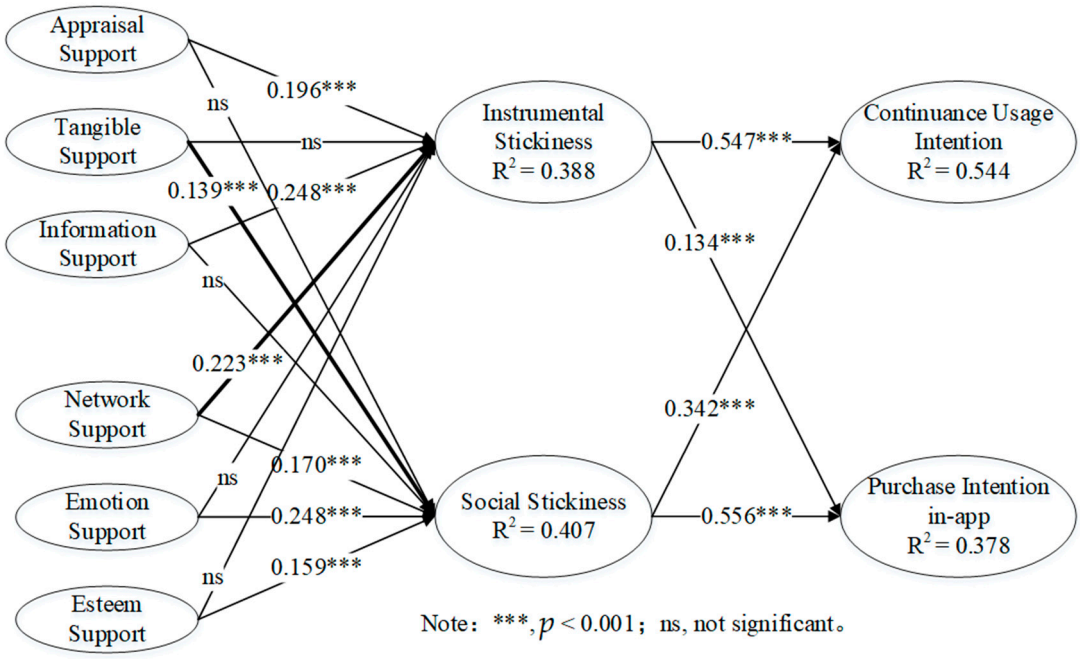


Figure 2. The research results.

As shown in Figure 2, appraisal support, information support, and network support all have a significant influence on users' instrumental stickiness; hypotheses (H1, H3, and H4) are supported. However, H2, H5, and H6 are not supported.

As shown in Figure 2, tangible support, network support, emotion support, and esteem support all have a significant influence on user stickiness, but the influence of appraisal support and information support on social stickiness is not significant. Hypotheses (H8, H10, H11, and H12) are supported, but H7 and H9 are not supported. This indicates that fitness-related products and services suggested by the app and other users, social interaction between users, user and MFA, and encouragement from other users, are important for users, and will generate social stickiness.

As shown in Figure 2, instrumental stickiness and social stickiness all have a significant influence on users' continuance usage intentions and continuance in-app purchase intentions. Hypotheses (H13, H14, H15, and H16) are all supported, and the effect of instrumental stickiness on continuance usage intentions ($\beta = 0.547$, $p < 0.001$) is much larger than social stickiness, and the effect of social stickiness on continuance purchase intentions in-app ($\beta = 0.556$, $p < 0.001$) is larger than instrumental stickiness.

6. Discussion

Lee [14] suggested that the correlation between user behavior outcomes and mobile healthcare applications should be studied from the perspective of "app stickiness" to enhance our understanding of modern consumption behaviors and user–app interactions. With this in mind, the purpose of this study is to investigate the relationships between different types of social support, different dimensions of stickiness, and to understand their impacts on continuance behavioral intentions. In the context of MFAs, this study developed a theoretical model and empirically tested continuance correlation between various types of social support and the two types of stickiness. We also examined how these two dimensions of stickiness influenced continuance in-app purchase intentions

and continuance usage intentions, respectively. This study provided empirical evidence confirming stickiness to be a multifaceted construct as the results largely supported the proposed model and hypotheses.

Elucidation and explanation of the prominent results of the model are discussed in the coming lines. Firstly, appraisal support and information support exerted significant influence on instrumental stickiness, whereas the effect of tangible support on instrumental stickiness was not statistically significant. Previous studies on online social support have indicated that information support is the most frequently received social support in a variety of online contexts regarding health [38,68]. In addition, tangible support exerts limited influence in the context of social network sites for health issues [32,38]. Specifically, while using the instrumental functions in MFAs, the primary appeal for users is to obtain professional fitness information and the convenient appraisal of their fitness progress. These action-facilitating supports can be delivered to users promptly via their mobile phones, which can be utilized as a resource to directly and efficiently gauge and improve their fitness levels. With the successful fulfillment of user needs through the instrumental functions, users generate instrumental stickiness to the MFAs. However, informational and appraisal support have not been able to exert any statistically significant effects on social stickiness. It reflects that the effects of informational and appraisal support are linked to the instrumental functions of apps rather than the social functions. We can conclude that the informational and appraisal supports have a much more powerful influence when engendered directly from the in-built functionality of apps and websites. This explanation of direct influence corresponds with existing studies [38,63]. Regarding the insignificant effect of tangible support on stickiness, one possible explanation could be that users mostly receive tangible support, such as fitness products, after the purchase, instead of the other way around, thus weakening the effect of tangible goods on the stickiness. In addition, tangible support could easily be obtained from other channels, such as e-commerce websites. Hence, users would not see tangible support as the crucial determinant leading to the instrumental stickiness on MFAs. Though tangible support has not engendered instrumental stickiness, the effect of tangible support on social stickiness has empirically proven to be significant. It suggests that, whereas users get little tangible support from the instrumental functions of MFAs, they do receive considerable tangible support from social functions, considerable enough to generate a statistically significant effect. We can infer that, by employing the social functions of MFAs, users can get much more meaningful and timely tangible support from the respective fitness community as compared to simply using instrumental functions. The inference that tangible support is a more dominant factor in online social settings has also been corroborated by previous studies [65].

Secondly, emotion support, esteem support, and network support exerted significant influence on social stickiness to MFAs. Esteem support and network support exerted nearly equal effects on social stickiness (ß = 0.159, ß = 0.170). Whereas, emotion support exerted a considerably stronger (ß = 0.248) impact on social stickiness than the other two supports. The stronger influence of emotion support is not surprising, given the wealth of studies that documented the significant role of emotion support in engendering user stickiness and enhancing user–app interactions regarding online health issues [32,68]. The significant effect of the three above-stated elements of social support on social stickiness implies that MFA users draw upon social functions to acquire indirect and psychological support, generated through the feeling of being part of an online community. This type of peer-based social support enhances the value of social functions in the eyes of users and engenders stickiness to the social functions of MFAs. In addition, contrary to our initial hypotheses the effects of emotion support and esteem support on instrumental stickiness are not statistically significant. This empirical result could be explained by digging deeper into the nature of emotional and esteem support. These types of support—having a psychological root—are associated with social interactions among users, rather than the instrumental functionality of the app. A number of studies have found that emotional and esteem

support draw their strength and value from online social interactions. Since users primarily obtain emotion and esteem support through interacting with one another, using social functions of MFAs instead of instrumental functions, these types of support engender statistically insignificant instrumental stickiness. Whereas, empirical results reflected that network support not only produced a significant effect on social stickiness, but also engendered a significant effect on instrumental stickiness. Network support generated through online networks—as reflected by results of other researches—has proven to be more effective than local and offline networks related to health and fitness, as it offers the unique aspects of convenience, anonymity, and non-judgmental interactions [49,70]. The instrumental functions of MFAs are very influential in building online networks or communities, giving rise to network support [75]. As corroborated by a number of studies [18,32,75,91], this sense of community would lead to stickiness. In our results, the users have perceived the instrumental functions as a cardinal source of building network support, resulting in a significant effect of network support on instrumental stickiness.

One of the most novel features of the study at hand is the varied impact of different dimensions of stickiness on continuance behavior outcomes. Since prior research has not distinguished among different types of user stickiness, the respective antecedents and respective outcomes linked to each dimension of stickiness have barely been discussed separately in the literature. As both instrumental stickiness and social stickiness exert statistically significant effects on continuance in-app purchase intentions, our research findings bolster existing stickiness literature by confirming a positive correlation between stickiness and in-app purchase intentions [21]. Moreover, one of the key findings of this study is that social stickiness (ß = 0.556) has a much stronger impact on continuance in-app purchase intentions than instrumental stickiness (ß = 0.347). One possible explanation is that the users who generate social stickiness to MFAs usually interact with other users, frequently, to receive emotional and psychological support (i.e., emotion support, esteem support, network support). During interaction, electronic word of mouth (e-WOM) from other users, concerning certain products and services provided in the in-app stores, are promoted in the online community [92]. Kim [28], in his study, illustrated the positive correlation between e-WOM and increased consumption. MFAs have developed environments to facilitate the effects of e-WOM on in-app purchase intentions. For example, the information obtained in MFA social forums is usually perceived as highly relevant to user concerns, since the potential consumers believe that the sources of the e-WOM are the actual MFA users who share similar fitness interests and health concerns; thus, e-WOM may often provide reliable use experience, advice, and outcomes. In other words, as a specific field, rather than the general e-commerce platform, such as Taobao and Amazon, e-WOM in MFAs are often perceived by users as being more reliable, credible, relevant, and specific in promoting shopping behavior. Hence, e-WOM plays a significant role in determining purchase intentions in MFAs. In addition, e-WOM in MFAs may also have negative side effects, especially in evoking impulsive buying and enhancing biased opinions. For example, the key opinion leaders in MFA forums may have biased opinions or personal preferences of certain products, which may exert influence on other users' objective perceptions. Consequently, other users' purchase decisions may be misled.

Hence, the stronger user sticks to the social functions of MFAs; the more information they received, the stronger the influence of e-WOM, which consequently may lead to continuance in-app purchase intentions. This result suggests that social stickiness is a crucial factor motivating users to make in-app purchases, as supported by Hsu and Lin (2016). Secondly, the other facet of the above-stated key finding is that, even though both instrumental stickiness and social stickiness exert statistically significant effects on continuance usage intentions, as highlighted in the existing literature (Lien et al., 2017), instrumental stickiness (ß = 0.547) has a much stronger impact on continuance usage intentions than social stickiness (ß = 0.342). The results may be due to three possible reasons. First, the key function and value of MFAs is to offer MFA users utilitarian values, facilitation, and convenience to gratify their health management needs. Hence, MFA users are highly

likely to continuously use MFAs and enjoy the functions provided, to directly facilitate their fitness activities. Second, MFA users may be locked-in to certain MFAs, especially when they stick to MFAs. It is mainly because personal data and preferences have been recorded in these MFAs. Consequently, users may lose historical data and have high switching costs, and sunk costs, if they switched to an alternative. Third, user data empower MFA platforms to synthesize and analyze personal data; thus, providing superior personalized services and products to facilitate the users' fitness activities. Hence, these personalized services may be very attractive for users to continuously use MFAs.

7. Implications and Future Research

In the following sections, the first paragraph outlines some of the theoretical implications of the present study. The second paragraph describes its managerial and practical implications, while some limitations and future research directions are discussed in the Conclusions. The findings of the present study expand our understanding of the role of stickiness in engendering user–app interactions, and provides theoretical support for the designing of sustainable health products [35], which, in turn, would espouse social sustainability [5,6]. Social sustainability comprises of a harmonious and cooperative relationship between groups of people [3]. MFAs play a crucial role in advancing this social sustainability by developing groups of people based on mutual interests, engendering in them cooperative and amicable spirits. Thus, understanding people's interactions in MFAs can go a long way in sowing the seeds for social sustainability. In terms of the contribution, this study can help achieve social sustainability.

The following are some of the core findings of the study. First, this study provides a robust understanding concerning the constructs of stickiness, antecedents, and mechanisms that determine stickiness and the outcomes of stickiness. Prior studies usually treated stickiness as a single-dimensional concept, which limits our knowledge in the prevalent multi-functional apps trend. By treating stickiness as a unidimensional construct in the context of multifunctional apps, it is impossible to illustrate how different kinds of stickiness arise from different functionalities, which mechanisms determine these different types of stickiness, and which stickiness contributes to different behavioral outcomes to the extent of sustainability. This study identifies user stickiness as a multi-dimensional concept, decomposed as instrumental stickiness and social stickiness. Thus, this paper is the first of its kind to classify different types of stickiness and expound on the underlying mechanisms of the creation of stickiness as a multiple facet construct. In the context of MFAs, research results suggest that instrumental functions would lead to instrumental stickiness and social functions would lead to social stickiness, respectively. In this sense, this study contributes to the stickiness literature by theoretically highlighting the paramount role of varied functionalities, in explaining the multi-dimensional nature of stickiness in multi-functional apps, while empirically demonstrating the effects of each determinant. In addition, the different impacts of each dimension of stickiness on user behavior were particularly notable findings, enhancing our understanding of "stickiness" as a theoretical construct. Specifically, both social stickiness and instrumental stickiness have statistically significant influences on continuance in-app purchase intentions and continuance usage intentions. However, social stickiness exerts a stronger influence on in-app purchase intentions, while instrumental stickiness has larger impacts on continuance usage intentions. Further, these findings demonstrate that, to better explain the antecedent role of different types of stickiness on the continuance behavior outcomes of app users, both types of stickiness should be taken into account separately. Hence, by empirically demonstrating that different types of stickiness exert different effects on behavioral outcomes, this study also adds valuable insights to the online user behavior literature as well as sustainable health literature.

This study also carries significant practical and managerial implications to MFA providers. By investigating MFA usage, this study contributes to attaining sustainable development for the environment. Through personalized services and management tools, MFAs cater, for users, fitness-related products; thus, by directing user actions in an efficient

manner, MFAs help to reduce user energy consumption, which would entail the sustainable development of the environment. However, more importantly, following the footsteps of Br et al. [35], our findings could prove insight for industry specialists and public authorities in designing sustainable health products. Firstly, according to the results of structural equation modeling, information support, appraisal support, and network support exert significant impacts on instrumental stickiness, which in turn has more critical effects on continuance usage intentions. The findings suggest that well-developed instrumental functions of MFAs engender instrumental stickiness in users, which encourage continuance usage intention. In other words, information support, appraisal support, and network support are crucial factors in improving the capabilities of MFAs to motivate the users towards interaction with MFAs. Thus, practitioners could use this simple underlying mechanism to promote the user's likelihood of using a particular app/service. For example, the appraisal results and interpretations could be presented to users, i.e., regarding a user's health situation, exercise performance, and updated fitness plans. Similarly, other functions could be developed to provide regular updated information and networking to MFA users. In this way, MFA users would be encouraged to stick to the instrumental functions, and this would further develop the wiliness to continue using the MFAs. Secondly, in-app purchase is an important channel to increase the profits of MFAs [12,20], and profitability is imperative for the success of MFAs [21,81], which could further lead to sustainable economic development. The results of the present study appear to have implications for app providers seeking to promote their in-app products and services. The results depicted that social functions of MFAs have a significant influence on users' continuance in-app consumption, by engendering users' social stickiness. The results illustrated that the emotion support, network support, and esteem support all have statistically significant effects on social stickiness, which has strong influential effects on continuance in-app purchase intentions. Accordingly, app providers should place more emphasis on developing social functions in MFAs; this could include a feasible and convenient digital communications platform or forum to encourage users to interact with one another, essentially developing a sense of community as users share their fitness experiences and expertise. Similarly, app providers could embed in MFAs features for users to share their fitness achievements with others and receive accolades as encouragement in return. These appreciations could come directly from the MFAs in the form of digital badges, fitness ribbons, etc., or in the form of compliments from other users. To further enhance the experience of networking and community, MFAs could also offer a feature for sharing digital, as well as tangible, fitness products among users. These functions would enhance a MFA's ability to engender strong communal feelings among the members, increase feedback from other users, prolong a user's stay/involvement in the MFA community, and boost the tendency of users to explore recommended products and services in the MFA's store. As a result, the social sticky behavior would spur users' in-app purchase intentions, which would lead to a sustainable profit model and growth for the MFA. While focusing on the stickiness perspective, the developers can create better health products, as this would contribute to more sustainable e-health systems [35].

8. Conclusions

Although this research provides meaningful insights about the correlation between different facets of stickiness and user behavior intentions, the following points need further expounding. First, the empirical study used for evaluating our theoretical model was conducted strictly on mobile fitness applications. Due to the unique characteristics of MFAs, caution is required when applying the results to other research contexts because different types of health apps are associated with different behavioral patterns [14]. Therefore, it is worthwhile to further investigate how behavior intentions would relate to stickiness in the context of other specific health issues and apps. Second, this research model is examined using cross-sectional survey data and although we have followed the standard research process to ensure that the survey was conducted in a rigorous way, the actual behavior may not be fully represented by behavioral intention. Thus, follow-up research of this

present study can collect and analyze longitudinal data as well. In fact, for a more thorough analysis, it is recommended, for future research, to conduct a panel study by collecting data from a particular group of MFA users at multiple temporal points. Third, in the actual usage of MFAs, different user groups have different perceptions of the use of MFAs, and characteristics of different user groups may affect user stickiness and continuance of use. It will be interesting to do a comparative study between subgroups, such as Google Play users and Apple App Store users, considering different demographics and personality characteristics. In particular, a latent profile analysis of android MFA users and Apple MFA users can lead to some very insightful results for app developers.

Author Contributions: Conceptualization, M.Y. and X.-Y.X.; methodology, M.Y. and X.-Y.X.; software, M.Y., S.-W.J. and C.-L.W.; validation, M.Y., X.-Y.X.; formal analysis, M.Y.; data curation, M.Y.; writing—original draft preparation, S.M.U.T., M.Y., X.-Y.X.; writing—review and editing, S.M.U.T., M.Y., X.-Y.X.; supervision, X.-Y.X.; funding acquisition X.-Y.X. All authors have read and agreed to the published version of the manuscript.

Funding: This research was funded by the China Postdoctoral Science Foundation, grant number 2016M602838, PhD early development program of Henan University of Animal Husbandry and Economy, grant number 2019HNUAHEDF003, and the school-level scientific research and innovation fund project from the Henan University of Animal Husbandry and Economy, grant number XKYCXJJ2020008.

Institutional Review Board Statement: Not applicable.

Informed Consent Statement: Not applicable.

Data Availability Statement: The dataset set used and/or analyzed in the current study are available from the corresponding author on reasonable request.

Conflicts of Interest: The authors declare no conflict of interest.

Appendix A. Survey Instrument

Construct	Item	Survey Item (1 = Strongly Disagree to 5 = Strongly Agree)	References
Appraisal support	APS1	Give objective feedback to me about how I'm handling my health problem.	Oh et al. (2013)
	APS2	Make me feel comfortable discussing sensitive health issues in the mobile health application.	
Tangible support	TAS1	Mobile health application provides health expert to solve health problem for me.	Oh et al. (2013), Lin et al. (2015)
	TAS2	Mobile health application provides health project to solve health problem for me.	
	TAS3	Mobile health applications provide health equipment that I need, such as running shoes, sports clothing and etc.	
Information support	INS1	Mobile health application and its users offer me suggestions and advice when I meet health problem.	Oh et al. (2013), Lin et al. (2015)
	INS2	Mobile health application and its users provide health information to solve my health problem when I meet health problem.	
	INS3	Users of mobile health application answer me when I give my health question.	
Network support	NES1	There are some members in the mobile health application with whom I share common values or interests.	Lin et al. (2015)
	NES2	There are some members whom I trust to help solve my problems.	
	NES3	There are some members in the online support group with whom I can share joys and sorrows.	

Construct	Item	Survey Item (1 = Strongly Disagree to 5 = Strongly Agree)	References
Emotion support	EMS1	Members in the mobile health application make me feel that they care about me.	Lin et al. (2015)
	EMS2	Members in the mobile health application listen to me talk about my private feelings and emotions.	
	EMS3	Members in the mobile health application express concern about my wellbeing.	
	EMS4	Members in the mobile health application care about my feelings and my health condition.	
Esteem support	ESS1	Show confidence in my ability to deal with my health concern.	Oh et al. (2013)
	ESS2	Make me feel as though I am capable of handling my health problem.	
	ESS3	Make me feel that I am good at making healthy decisions.	
Instrumental stickiness	INST1	Health management function of mobile health application has the ability to make me stay a longer time than other function.	Lin (2007), Yang et al. (2014), Chiang et al. (2015)
	INST2	Health management function of mobile health application has the ability to make me use the health management function as often as I can.	
	INST3	Health management function of mobile health application has the ability to make me visit the health management function every time I am open the application.	
Social stickiness	SOST1	Social function of mobile health application has the ability to make me stay a longer time than other functions.	
	SOST2	Social function of mobile health application has the ability to make me use the social function as often as I can.	
	SOST3	Social function of mobile health application has the ability to make me visit the social function every time I am open the application.	
Continuance usage intention	COIN1	I intend to continue using mobile health application.	Bao et al. (2016)
	COIN2	I intend to use the mobile health application as much as possible.	
	COIN3	I will recommend my friends to use the mobile health application.	
Continuance purchase intention in-app	PUIN1	I intend to continue purchasing health-related products and services in mobile health application.	Hsu et al. (2016)
	PUIN2	I will continue purchasing health related products and services in mobile health application.	
	PUIN3	Mobile health application is the main way for me to purchase health related products and services.	

Appendix B. Common Method Bias Analysis

Construct	Item	Substantive Factor Loading (R1)	$R1^2$	Method Factor Loading (R2)	$R2^2$
Appraisal support	APS1	0.813 ***	0.661	0.004	0.000
	APS2	0.744 ***	0.554	−0.005	0.000
Tangible support	TAS1	0.725 ***	0.525	−0.026	0.000
	TAS2	0.741 ***	0.550	−0.002	0.000
	TAS3	0.677 ***	0.459	0.030	0.000
Information support	INS1	0.740 ***	0.547	0.006	0.000
	INS2	0.766 ***	0.586	0.000	0.000
	INS3	0.636 ***	0.404	−0.007	0.000
Network support	NES1	0.756 ***	0.572	−0.066	0.002
	NES2	0.747 ***	0.558	0.098	0.003
	NES3	0.724 ***	0.524	−0.032	0.000

Construct	Item	Substantive Factor Loading (R1)	$R1^2$	Method Factor Loading (R2)	$R2^2$
Emotion support	EMS1	0.710 ***	0.504	0.1465 ***	0.008
	EMS2	0.756 ***	0.571	−0.070	0.002
	EMS3	0.775 ***	0.600	−0.065	0.002
	EMS4	0.800 ***	0.640	−0.003	0.000
Esteem support	ESS1	0.770 ***	0.593	0.089	0.003
	ESS2	0.743 ***	0.552	−0.024	0.000
	ESS3	0.735 ***	0.541	−0.071	0.002
Instrumental stickiness	INST1	0.861 ***	0.741	−0.014	0.000
	INST2	0.856 ***	0.733	0.0812 ***	0.003
	INST3	0.817 ***	0.667	−0.071	0.003
Social stickiness	SOST1	0.765 ***	0.586	0.1174 ***	0.006
	SOST2	0.754 ***	0.569	−0.038	0.001
	SOST3	0.737 ***	0.543	−0.084	0.003
Continuance usage intention	COIN1	0.820 ***	0.672	0.024	0.000
	COIN2	0.873 ***	0.761	−0.011	0.000
	COIN3	0.840 ***	0.705	−0.012	0.000
Purchase intention in-app	PUIN1	0.717 ***	0.514	0.025	0.000
	PUIN2	0.843 ***	0.711	0.046	0.001
	PUIN3	0.766 ***	0.586	−0.078	0.003
Average		0.767	0.591	−0.013	0.001

Note: ***: $p < 0.001$.

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