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Mobile Apps for Mental Health: Overview and a Social Gaming Framework

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ABSTRACT:- This paper reviews current research on the role of Smartphones and similar technology play in mental health and mental health maintenance, promotion, and assessment. The first section overviews the current state of the art concerning the role Smartphones may play as tools for mental health in general. The second part reviews one of the more promising Smartphone application areas related to social gaming and gambling addiction and related mental health issues. This is followed by a section that presents a prototype Smartphone app for data collection related to social gaming behaviours and their potential relevance to gaming and gambling addictions. The prototype app is outlined in order to delineate the major components required for collecting player data as a means of inferring behaviour. The final section overviews the inclusion of technology such as Virtual Reality or Augmented Reality in apps being developed and directed toward mental health.

Keywords:- Mobile apps, Mental Health, Social Gaming/Gambling, Data collection for behavioural inference..

I. INTRODUCTION

There is little doubt that Smartphones and Smartphone apps are impacting people's lives in many ways. This work is not about the proliferation of Smartphones, their omnipresence, nor a person's expanded electronic social network. This work is also not to debate the relative value of Smartphones and their various uses; it takes for granted that Smartphones are nearly ubiquitous and serve as a platform for a myriad of personal and professional applications. This work explores the role Smartphones may play within the niche of apps concerning mental health maintenance, assessment and promotion. For discussion purposes, mental health apps would fall under a much larger space of mobile health related apps (mHealth apps), which relate to the practice of medicine and public health mediated by mobile devices, including the delivery of health services and information. Diabetes monitoring is a common example of anmHealth app, and examples in the area of self-monitoring include fitness and nutrition apps. In this work, the initial focus is on the state of the art in mobile health apps specific to mental health assessment. This is followed by a discussion of Smartphone apps and related technologies focused on opportunities within a subclass of mental health disorders associated with gaming and gambling addictions.

In order to provide an implementation perspective and technological requirements in designing and building an app for mental health assessment, a prototype app framework is presented. To constrain the scope, the app is contextualized within mobile and social gaming and gambling. This is motivated by the fact that a Smartphone app for mental health assessment, specifically related to understanding gaming and gambling addictive behaviours, will by necessity require greater player data collection related to behavior than a typical Smartphone app. In addition, the role analytics plays in assessing mental health is considerably greater than that required in, for example, recommending a movie or a book.

Finally, the work overviews the role of emerging technology such as Virtual and/or Augmented Reality relative to mental health and mental health assessment.

II. THE ROLE OF SMARTPHONE APPS IN MENTAL HEALTH SELF-CARE

Within general health and lifestyle apps, the area of collecting mental health data from Smartphones is very promising [1][2]. These apps typically address self-monitoring and self-management of mental health concerns such as depression, anxiety, stress, and their associated manifestations. Apps such as emoods [http://emoodtracker.com/] and similar claim to "track daily depressed and elevated moods, symptoms, sleep, and medications and email a doctor a chart at the end of each month." Others purport that that Smartphones offer advantages over other means of mental health self-reporting relative to concomitant biases such as retrospective recall [3].

However, there is typically little empirical clinical data supporting the efficacy of mental health Smartphone apps, and "a striking difference between the volume of commercial apps compared to the small number of tested evidence based apps" [4]. While the science is still considered to be in its infancy [5] and the

landscape points to the need for further evidence-based research into the role that mental health apps can play, their safety and efficacy, their relationship to public education, their place within industry regulation [4][6], a body of evidence for their role in mental health is building [7]. In general, Smartphones are thought to have the potential to be effective in reducing depression, anxiety, stress, and potentially substance abuse, as well as the potential to increase accessibility to treatment. [4]. Dagöö et al. (2014)[8] that concluded "CBT (Cognitive Behavior Therapy) for SAD (Social Anxiety Disorder) can be delivered using modern information technology", using Smartphones, tablets and traditional computers. Their trial included 52 participants. Another study with 35 participants concluded "these results provide evidence to indicate that delivering a CBT program using a mobile application can result in clinically significant improvements in outcomes for patients with depression" [9]. In another study, a pilot was undertaken with participants diagnosed with psychiatric conditions. "To simplify their initial evaluation, we focused on one typical health intervention—walking as physical exercise—with the assumption that if measures of this simple health activity are valid and meaningful, and app usability rates are high, it will be worthwhile to design, test, and deliver a wide variety of other physical and mental health interventions via Smartphone apps" [10]. Although these claims may be a bit ambitious, nonetheless, these pilot studies are becoming more rigorous as the prevalence of Smartphones and mental health apps continues.

Between 2013 and 2015, the number of mobile-health trials registered on ClinicalTrials.gov more than doubled, from 135 to 300, and the number of trials specifically focused on mental and behavioural health increased by 32% [5].

Despite this rise in attention from the research community, app and app development for mental health clearly outpace medical or clinical studies [6]. Although only approximately 6% of mobile health apps are related to mental health, some of those are achieving a moderate number of downloads and positive reviews (http://www.psychiatryadvisor.com/top-10-mental-health-apps/slideshow/2608/; http://liveclinic.com/blog/digital-health/11-mental-health-apps-doctors-recommend-patients/).These are summarized in Table I. Of note is that these apps are primarily intended for self-care or self-monitoring of individuals of their own mental health (i.e. self-management). Clinician-side mobile apps for mental health monitoring also exist but not addressed here (e.g. http://www.mobiletherapy.com/).

Table I: Popular Mental Health Apps

App Name	Purpose	Availability	Downloads	Reviews/Status
emoods	track common mood disorders like Bipolar/Manic Depressive illness.	Free (In-app offers)	>100K	>1300 Positive Ratings (Android)
Code Blue	Depression and Bullying: Support Group Alert	Being Crowdsourced		Not Launched
Breath2Relax	Stress Management	Free	>100K	>785 Positive Ratings (Android)
Intellicare	Suite of apps for depression	Free	1000-5000	Not enough reviews collected
Lantern	Cognitive Behavior Therapy	Subscription-based service		
PTSD Coach	Post-traumatic stress disorder.	Not available in Canada		
Optimism	Strategies for managing depression, bipolar or other mental health conditions	Free		700 Mostly Positive Ratings
Previdence	Assessment for depression, anxiety, drug and alcohol and suicidal issues	Free		Not enough reviews collected
SAM	Self-help for Anxiety Management	Free	>100K	2700 Mostly Positive ratings
Talkspace	Therapy and Counselling for Anxiety and Depression	Subscription-based service		900 Moderately Positive Ratings
T2 Mood Tracker	Monitor moods on six pre-loaded scales (anxiety, stress, depression, brain injury, post-traumatic stress, general well-being)	Free		200 Mostly Positive Ratings
Big White Wall (UK)	Anonymous support 24/7 to anyone struggling with a range of common	Subscription-based service		Not enough reviews collected. Not

App Name	Purpose	Availability	Downloads	Reviews/Status
	behavioral health issues			found on Google Play
Equanimity	Meditation timer that also features graphical tracking and a journal feature	$4.99		140 Mostly Positive Ratings
MindShift	App to help teens and young adults cope with anxiety	Free		

Although Table I is not exhaustive, there are a relatively small number of apps available for download, and with a few exceptions, the number of downloads and reviews were generally low. There are several that require a subscription and in some cases are still in development (being positioned for crowdsourced funding). However, like the rise of apps in other areas of professional and personal application, the pace of development of mobile apps for mental health applications is only expected to increase.

III. THE OPPORTUNITY FOR SMARTPHONE APPS IN SOCIAL GAMING AND GAMBLING

Within mental health mobile app development there is an opportunity for mobile apps related to social gaming and gambling addictions and their related mental health issues. The estimated prevalence of problematic online gaming is between 1.7 to 10 percent, depending upon research nomenclature and methodology [11]. It is estimated there are 1.78 billion gamers globally and that this number is likely to grow alongside the increasing adoption of mobile phones [12]. Existing research has identified numerous factors associated with problematic online gaming [13][14][15][16][17][18]. While there is not yet scientific consensus regarding its status as an official psychiatric diagnosis [19], in 2013, the American Psychiatric Association introduced "Internet Gaming Disorder" in the DSM-5 as a condition requiring further study [20][21][22][23][24]. At the same time, mobile phone applications have been suggested as a promising intervention medium for addiction recovery [25]. A more nascent body of research specifically concerning problematic aspects of mobile social gaming has also emerged [26][27][28].

While social gaming and gambling are conceptually and empirically distinct phenomena, there is emerging research that suggests the intersectionality of these behaviours [29][30][12][31][32][33]. Research has identified a number of structural and experiential similarities between video/online games and gambling [11][34]. Increasingly, many online/video games have gambling-like, games-of-chance features and scenarios built in to lure players into continued or intensified play, wager-like options that promise quick easy rewards in the form of credits and/or means to speed advancement in the game. Although the rewards in these games may not be real currency, the intermittent-reinforcement schedules parallel those of real gambling (whether land- or internet-based). As online games continue to converge stylistically, structurally and experientially with gambling games, the question of whether this poses a new and growing addiction risk has become increasingly important.

However, the intersection of mobile social gaming and problematic online gambling is not yet well understood and there remains a paucity of information regarding possible causal pathways between social gaming and online gambling [35][36][32][37]. Understanding the conceptual and empirical interrelationships among these phenomena is a pressing concern for behavioural addictions research and policy. Population health promotion campaigns are increasingly directed at educating people as to the chance-determined nature of winning and the negative long term return associated with prolonged gambling [32]. "However, if gambling comes to be increasingly immersed in video game contexts it may be harder for players to discriminate between situations where the application of skill is, or is not, possible. In effect, it might be hypothesized that an involvement in video gaming may lead people to be more primed to the expectation that the probability of success improves via sustained practice" [32]. This is a warrant for the data collection heuristic such as the one prototyped and discussed in the next section, for the online exploration of the intersection of mobile social gaming and problem gambling behaviours.

One of the more relevant references is the technical report commissioned by the Gambling Commission of Great Britain [38]. The technical report's intent is to provide a "source of what is currently known about "social gambling" and widen the discussion of potential implications for risk, harm and responsible play in relation to gaming behavior." The report is inclusive of many forms of gaming classification but of particular interest is app-based Freemium games. The Freemium model is where users of the service (game) play for free but are encouraged to pay for extended game play, to compete or enter tournaments, or customize or acquire game assets, more complex and engaging game environments, and/or clues to overcome game obstacles. The most relevant discussion concerns research recommendations for obtaining and using objective data about player profiles and social gaming behaviors.

There are compelling arguments for in-app or player account data collection. These include the limitations of self-reports as an alternative, the potential to use player account data to advance conceptual models, identify behavioural risk factors for problem gambling, and evaluate and guide effective policy for responsible gambling. Although there are also unique limitations associated with research using player account data, the potential to make significant contributions also exists.

The research heuristic presented in the following section represents an innovative data collection platform that is characterized by a unique methodological combination of real time player behavioural and retrospective self-report measures. Innovatively, from a mixed methods standpoint, this type of heuristic will also allow advancement this area of study by assessing differences between real time, behavioural data collection compared to retrospective data gathered from a scale developed by Pontes et al. (2014)[39]. Development of such a data collection heuristic is a significant first step to reflexively understand the intersection of mobile social gaming and problematic online gambling, as a prerequisite to the development of evidence based policy and practice based interventions.

The exponential growth in mobile social gaming made possible by the development of online communication technologies has also been attended by a marked increase in the number of empirical studies which have addressed problematic online gaming as a complex, multi-dimensional phenomenon. Reviewing this body of research, Griffiths [40] notes that, among the generalizations that can be made of online gamers and problematic gamers are that "adolescent males and young male adults appear to be at greater risk of experiencing problematic online gaming" and concludes that "the course and severity of these problems are not well known." Young adults are particularly immersed in internet and social media technologies, with constant easy access to highly captivating and interactive services such as chatting, social networking, and game-playing. A recent Pew research study found that 93% of teens and young adults currently go online and 81% of 18-29 year olds access the internet using wireless technologies such as cell phones or laptops [41]. Another Pew national study showed that 97% of American teenagers report playing video games on a console, handheld device, or computer and over half said they played "yesterday" [42]. Given these high levels of engagement, youth and young adults may be particularly vulnerable to increasing exposure to online gaming and its convergence with online gambling [34]. Existing research has established that online gaming can be addictive and problematic, particularly for a younger male segment of the population, but it is not yet clear how the burgeoning popularity of mobile phones and social gaming may exacerbate this issue. Nor is there research consensus concerning potential relationships between mobile social gaming and online gambling.

Griffiths, King, and Demetrovics (2014)[37] note that within the field of online addictions research there is debate concerning the extent to which technologically mediated addiction such as Internet Gaming Disorder is conceptually and empirically distinct from other potentially addictive activities, such as gambling, video gaming, sex, and shopping, which can be involved online. These authors also note that this debate is attended by controversy in the psychiatric and addictions research communities concerning the possible inclusion of Internet Gaming Disorder in the American Psychiatric Association's Diagnostic and Statistical Manual of Mental Disorders. Petry et al. (2013)[24] describe how the Substance Use Disorder Working Group ultimately recommended the inclusion of the disorder in the "Emerging Measures and Models" section of the DSM-5 as requiring further research. This has stimulated a number of studies and the development of numerous psychometric assessment tools working towards achieving a consensus definition of pathological video-gaming [15]. While social gaming and gambling are conceptually and empirically distinct phenomena there is emerging research that points towards the intersectionality of these behaviours [29][30][12][31][32][33].

"The observation that there are similarities between gambling and video game playing has been noted many times in the psychological literature dating back to the early 1990s up until the present day" [32]. While there is a paucity of research on mobile gaming, emerging literature suggests that for some gamers, at least, there may be relationships between social gaming and online gambling. For instance, a study by Phillips and Blaszczynski (2010) [33]which compared non-problem gamblers, low-risk gamblers, moderate risk gamblers, and problem gamblers, as classified by the Canadian Problem Gambling Index, found that problem gamblers: spent more time playing mobile games; were significantly more likely to use their mobile phones to make commercial purchases; were more likely to use SMS on their mobile phone to enter cash prize competitions; and, were significantly more likely to be contacted by companies asking them to participate in prize competitions. In another study that used an online survey of adults who played social casino games online to examine the convergence between gaming and gambling, Gainsbury and colleagues found that while only a minority of social game players migrate to gambling directly, "these games may act as a gateway to gambling within specific activities for a subset of users" [31]. These researchers explain that, "The notion of migration is complex and could involve transfers from social casino gaming to gambling activities while still remaining with the same operator, or it could refer to transfers to other available gambling activities. This may include users who have not previously gambled, as well as existing gamblers for whom the games triggered engagement in discrete or ongoing gambling sessions" [31].

Further evidence of the intersection of social gaming and problematic gambling comes from studies of the neurobiological correlates of behavioural addictions. For instance, Chamberlain and colleagues (2016)[29] point out that research has identified a confluence of pathological brain changes in individuals with Internet Gaming Disorder and other behavioural additions, such as Gambling Disorder. In a study which compared Internet Gaming Disorder, Gambling Disorder, and Alcohol Use Disorder in terms of impulsivity and compulsivity, Choi and colleagues (2014)[30] found that those with Internet Gaming Disorder show levels of impulsivity similar to those with Alcohol Use Disorder. A recent review of studies of the neurobiological correlates of Internet Gaming Disorder concluded that "there is considerable overlap in the neurobiological underpinnings of Internet Gaming Disorder and problematic gambling, as indicated by alterations in brain function and behavior. Patients with Internet Gaming Disorder and problematic gambling both exhibit decreased loss sensitivity; enhanced reactivity to gaming and gambling cues, respectively; enhanced impulsive choice behavior; aberrant reward-based learning; and no changes in cognitive flexibility" [12].

From their analysis of the technological convergence of gambling and video gaming practices, Griffiths, King, and Delfabbro conclude[32], "Given the huge popularity of video gaming, it is not hard to see why the gambling industry wants to (i) infiltrate its player base, (ii) blur the boundaries between gambling and video gaming, and (iii) monetize video gaming activities". Overall, the research literature appears highly suggestive of intersections between social gaming and online gambling.

The question which arises out of this body of research is the extent to which there may be causal pathways between mobile social gaming and problematic online gambling? In order to explore theoretically possible intersectional pathways between mobile social gaming and problematic online gambling it would be useful to have real time player behavioural and retrospective self-report measures gathered from a heterogeneous population of mobile gamers. The development of such a data collection tool in the form of a mobile social gaming data collection heuristic is discussed in the next section. Future iterations of this social gaming software may be adapted to take on more gambling-like features, including actual wagering, and allow for the provision of personalized feedback (e.g. pop-ups, nudges) to players to help encourage self-monitoring and responsible gambling.

The prototype social gaming/gambling app addresses the partial development a mobile app that closely resembles a social casino like game, and therefore features gameplay that is gambling-like. Unlike other player feedback tools in existence, the tool is being positioned to be integrated with the following features that are unique in combination: (1) User-engaging gambling-like game mechanics for longitudinal study; (2) Built-in questionnaire/survey functionality; and (3) Gameplay instrumentation / analysis capability.

Pontes and colleagues [39]note that "Despite the proliferation of research on gaming behaviour over the last few years, the field has been hindered by the use of inconsistent and non-standardised criteria to assess and identify problematic and/or addictive video game use". They elaborate that inconsistent terminology used by researchers in the field have exacerbated conceptual and empirical inconsistencies in this emerging area of study. One potential and methodologically innovative means to address these conceptual and methodological ambiguities and thereby advance the study of gaming behaviour is to employ Internet-mediated technologies in mixed methods praxis, which blends the collection of retrospective reports with real time, behavioural data [43]. The Internet Gaming Disorder IGD-20 Test, is a scale developed and tested by Pontes, Kiraly, Demetrovics, and Griffiths (2014)[39] that is intended to assess the nine criteria that comprise a diagnosis of Internet Gaming Disorder proposed by American Psychiatric Association (2013). Notably, the scale derived from the nine Internet Gaming Disorder criteria from the DSM-5 empirically corresponds with the six criteria of Griffiths' (2005) [44]components model of addiction (i.e., salience, mood modification, tolerance, withdrawal symptoms, conflict and relapse) [39]. The IGD-20 Test has thus far demonstrated psychometric properties of reliability and validity [39][45]. Other potential validated instruments available to researchers include: the Problem Gambling Severity Index (PGSI) as well as several items from Canadian Problem Gambling Index [46] assessing types of gambling activity engaged in; the Gambling Motives Questionnaire (GMQ) [47], a 15-item self-report measure of gambling motives developed based on the widely-accepted three-factor model of drinking motives; the Problem video game playing test (PVGT), a 21-item instrument that has demonstrated good internal reliability as a continuous measure of problem video game playing (α=.93) in previous studies [48]; the Motives for Online Gaming Questionnaire (MOGQ), a 27-item questionnaire that assesses 7 motivational factors for online gaming and has shown satisfactory psychometric properties with factor reliabilities ranging between .79 and .90 [49] and a number of questions measuring types of online gaming, frequency and duration of play and money spent.

IV. A WORKING PROTOTYPE OF A FREEMIUM MODEL SOCIAL GAME WITH PLAYER TRACKING

Building on the research-based arguments for the value of in-app or player behavioural data collection, and with the objectively to advancing the understanding of the intersection of mobile social gaming and problematic online gambling, initial development of an online gaming framework was undertaken in 2015. The framework takes the form of an online game and combines real time player behavioural and retrospective self-report measures. The prototype online two player mobile game is called MOBRO WAR and incorporates a small degree of social networking features. MOBRO WAR represents a prototypical game that is mobile, concurrent, and competitive. In its present state, each game consists of five rounds of the card game WAR, each game played is measured in seconds, and feedback is near instantaneous. Presently, three levels of a minimum of 100 games each have been implemented in the prototype, and the human player plays against a bot. The bot maintains a strategy for 100 games, and only after a player has demonstrated that they have beaten the bot by a non-chance margin can the player 'level up'. The basic gaming framework has also been further developed during the summer of 2016 to include gaming and gambling survey questions as an in-app feature which the player completes in order to proceed. Figure 1 shows a screenshot of the proof of concept, which is currently rudimentary but functional.

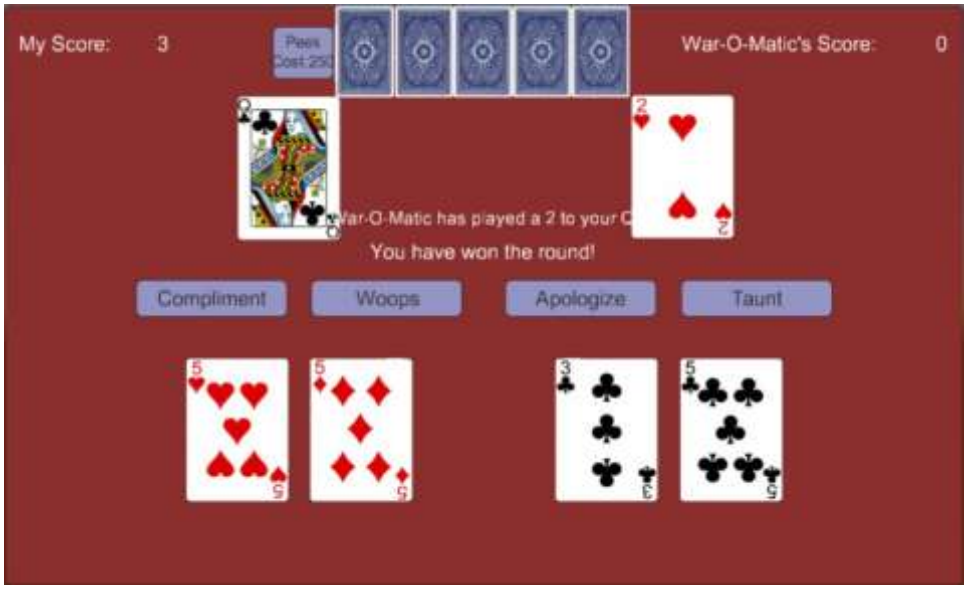

Fig. 1: Example play of MOBRO WAR

Short duration social games represent a relatively new genre of social networking games, specifically, the competitive concurrent casual game. The main distinguishing characteristics of these games are that they are competitive and concurrent as opposed to being turn based, they are played in real time over a network, and they are of short duration. Over the summer 2016, the game has begun to acquire the look and feel of a social casino look and feel. For example, during play, the user is provided immediate feedback as to having won or lost the game (Figure 2).

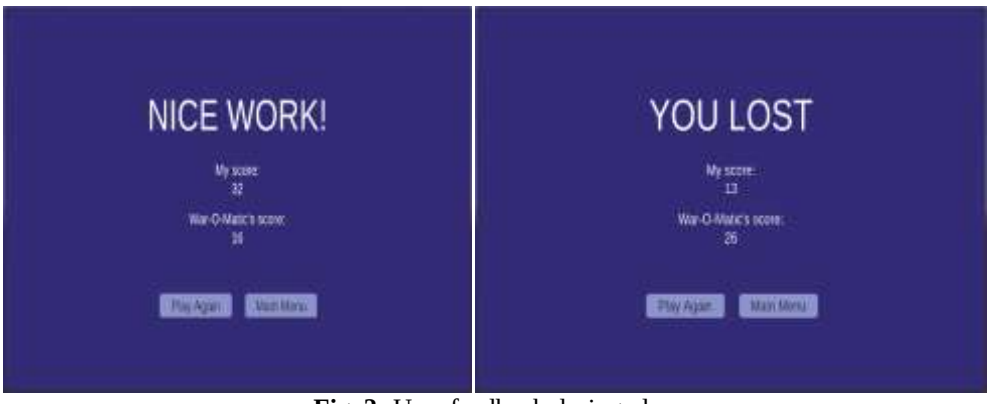

Fig. 2: User feedback during play

The research is built upon the Freemium model, in which users of the service (game) play for free but are encouraged to pay for extended game play, to compete or enter tournaments, or customize or acquire game assets. In the MOBRO WAR prototype, short (2-3 question) in-app surveys are inserted which the user has to complete in order to extend their playing time.

The research element will continue to focus on the elements required to develop an engaging mobile competitive Freemium game with the objective to collect in-app survey and player account data. This work is a pre-requisite for downstream research to use the data to understand player behavior from the perspectives of gaming disorders, examine the intersection of problem gaming and gambling, and contribute to policy and harm reduction.

Currently, the framework is sufficiently developed to present the basic requirements of any mobile app that is oriented to collecting player behaviour information. The remainder of this section outlines the framework refactoring, redeveloping and testing to date.

At present, a functional prototype of MOBRO WAR exists for the Android client platform with the software architecture based on a game engine (Unity). From the traditional software point of view, Unity is middleware facilitating compiling the game to various platforms, greatly facilitating development.

As this is a competitive mobile game, it needs to communicate with back-end servers using services via WiFi or cellular radio. The need for testing the connectivity between the mobile game and back-end services is very important and is a large component of project development. Unlike many games, ones that are oriented to collecting extensive player behaviour data have a heavy server load as it is in constant communication with the clients (players). In this prototype, two types of player data were of interest: player data such as time of play, duration of play, and patterns of play; and in-app survey completion data including survey completion rates and survey responses. All player interactions are logged in a MySQL backend server.

The mobile game has a server-client interaction requiring a login, uploading of data (e.g. game results/progress/answers) and downloading of data (results/progress/survey questions). In these situations, one needs to ensure that code changes to either server side or client side do not break the functionality of the service.

As the mobile game is developed, the system is constantly tested on end-user devices. A small device inventory representative of the most common Android devices are used for these purposes. As with any app, user experience is very important [50]. Throughout development, it is important to be able to undertake build verification testing, which is a type of testing that comprises of a non-exhaustive set of tests that aim at ensuring that the most important functions work. The results of this testing are used to decide if a build is stable enough to proceed. When the mobile game is in the state that is testable in the context of 1) game itself, 2) platform-compiled and 3) connects with back-end services (platform APIs), a more complete specification reference test will be undertaken that can give results and provide an understanding of how well the game performs.

As part of testing,the MOBRO WAR prototype engages a real player against a bot to play 100 hands or games within a subset of the game framework. This prototype test app allows one to better understand network latency and its impact on the real mobile game. Typically, bugs or crashes that occur will be those associated with asynchronous protocols for accessing the server and database and are notoriously difficult to locate and fix without widespread testing. As of September 2016, the MOBRO WAR prototype experienced communication faults every 10-20 hands played. This bug has of the time of writing not been fully eliminated. When collecting extensive player data, the server side and network performance are integral to the overall app performance. The majority of game apps are considerably more client side oriented than a social competitive game with detailed player data collection. As here, this represents a challenge for similar real-time player data collection app development efforts.

From the overall system perspective, focus is on load testing which is directly related to performance. When certain load is exposed to the game and infrastructure, one can get an understanding of where bottlenecks are and what parts of game/infrastructure need optimization. Load testing varies from basic server upload/download function to database connection and queries.

Although the basic framework is not completely stable, survey questions were integrated into the game as a currency to continue play in the Freemium mode. The survey questions came from validated instruments including the IGD-20 Test and the MOGQ. In addition to being able to integrate in-game survey questions and collect responses (player survey data), software was be developed to log user interactions with the backend server (player data).

At present, there is very little research on real-time data collection with social games other than for internal corporate or marketing insights. There are closed systems (e.g. PlayScan http://playscan.com/, Mentor http://www.neccton.com/en/about-mentor-en.html, Bet Buddy http://bet-buddy.com/) that provide analytic services that work on behalf of large gambling establishments or operators. These are typically software that provide solutions to gambling companies to help them better understand and manage at-risk play behaviour. These are operator tools and not social gaming/gambling mobile apps. The MOBRO WAR prototype represents one of the first efforts to capture player behavior patterns with emphasis on better understanding risks associated

with mobile social casino gaming and risk trajectories (and can later be adapted to games with more gambling and wagering features).

Ongoing work is related to a preliminary user trials of up to 100 volunteers to play the mobile game, inclusive of the Freemium model. Feedback will be related to the overall performance, look and feel, as well as testing users' willingness to answer in-app surveys as a means to extend play. This will help validate the game in the real world on real devices over a variety of networks and help assess players' engagement with the game and the elements of the Freemium model.

What follows are some theorized examples of how data that the MOBRO WAR prototype is able to collect may be used to better understand the analytic potential, as derived from existing literature [38][51]. Understanding demography: Collected data can be used to explore the demographic profile of participants in the game/s. We anticipate that analysis by age, sex, region (direct GPS location data or potentially taken by proxy measures of IP addresses) could be performed. However, there are ethical and data confidentiality issues to be addressed and it is uncertain whether this could be achieved in practice.

Understanding different types and patterns of play: We anticipate that sub-group analysis will be possible. Having complete control over the social game/gambling platform, it is possible to gain objective data about frequency of play, length of sessions and, where appropriate, expenditures. These would be informative in describing and contrasting different types of players. In addition, as part of our Freemium model, players would be completing survey questions that would also lend themselves providing social gaming addiction feedback similar to that of [52]. The major difference and unique aspect of the platform discussed, is that the addiction survey is integrated into the Freemium model of the mobile social casino-like game itself.

Understanding trajectories: If an on-going relationship can be established with a group of players, one can explore the behavior and the play of select groups longitudinally. This would allow empirical classification of different groups of players. For example, this might include those who play consistently at certain levels, those who increase their social involvement with these games, those who display variable patterns of play and those who stop play. Once these trajectories are identified, their profile may be explored. Importantly, patterns of play preceding monetization could be traced. This information can provide insights into patterns that are related to broader gambling behavior and more specifically, risk or harm. This can lead in subsequent iterations of the software to the implementation of pop-ups and personalized feedback to encourage player self-monitoring and responsible gaming/gambling [53]. For instrument development iterations, Smartphone installations are controlled by hosting the game app ourselves on a secure server and inviting volunteers and the research team to "side load" the game. This allows considerable control over the game during development and debugging.

Limitations: There are both technological and practical limitations to the proposed research. Building a mobile game with player appeal is both a matter of luck, timing, and appropriate technology. The graphical user interface and near real time response play a large role in social casino-like games and one of the objectives of the current work would be to substantively enhance the game's appearance as well as feel and performance. We recognize the concern about similarities between social gaming and online gambling, and that social gaming may be a gateway to online gambling and attendant problems. With better tools we can help reduce problem gambling risk and promote responsible gambling and related mental health issues.

Availability: Currently, the MOBRO WAR prototype is only available on the Android platform and requires side-loading from https://home.cc.umanitoba.ca/~mcleod/ (filename: ADD Emergent Strategy) with attendant device permissions to install.

This version of the prototype has been played well over 1000 times as illustrated in the following table.

Table II: Player records (prototype test volunteers)

User	Level 1		Level 2		Level 3		Level 4	
	win	oss	win	loss	win	loss		loss
Bob	142	53	220	74	292	101		
Ken	70	30						
Kevin	85	12	160	34	219	50		
Mehrdad	80	16					317	72
Sridhar	69	28	208	87				
Farnaz	80	19	162	35	256	51		
Rahul	75	26						
Fernando	76	23	149	50	213	83		
Monjurul*	80	71						

* Did not level up

Complete source code is also available in a zip file.

V. THE FUTURE ROLE OF PERSONAL HEALTH DEVICES AND OTHER TECHNOLOGIES IN INTEGRATING THE LATEST TECHNOLOGICAL ADVANCEMENTS

In this context, we define health devices as being devices that are auxiliary to the Smartphone itself. The most common would include commercial devices such as fitbit (Fitbithttps://www.fitbit.com/ca) and similar which provide some level of fitness tracking. These devices arguably may motivate physical activity and discourage sedentary behaviour, but even these relatively simple data collection devices face issues of accuracy and precision [54][55]. Other health related auxiliary devices are discussed elsewhere [56][57], and only two were found related to mental health concerns. These included a Mobile Therapy Watch reportedly capable of helping in the treatment of one of the most difficult mental disorders, schizophrenia. In a considerably more invasive proposal, [58], a device called a "LifeShirt" -- a computerized vest that continuously monitors the patient's movements - shows that patterns of movements differ between patients with schizophrenia and bipolar disorder. The device monitors hyperactive and repetitive movements and collects data on respiration, heart rate and other physiological measures. While wearing the vest, subjects' movements were also recorded by a camera. This work dates to 2007 and was considered speculative at the time.

Equally speculative is a summary of work at MIT circa 2005 related to wearables that monitor biometrics as a means of inferring health and in some cases, mental health [59]. Research into this area has continued, Puiatti[60] presented the MONARCA wearable system, which is meant for recognizing early warning signs to predict manic or depressive episodes. The system is a Smartphone-centred and minimally invasive wearable sensor network that is being developing in the framework of the MONARCA European project (http://www.ife.ee.ethz.ch/research/groups/health/ MONARCA). More recently, a more complete overview and architecture of both mobile phones and to a lesser degree auxiliary devices to assist in assessment and treatment of mental health disorders can be found in [61].

MaghazilandYellowlees[56]also discusses the role of Virtual Reality in assessing and treating several mental health disorders, and García-Betanceset et al. [62] provide a review and appraisal of recent and current Virtual Reality technology for Alzheimer's disease applications. In this article, Smartphones are not mentioned but it should be noted that Smartphones are being integrated onto head mount display such as Samsung Gear VR, which will expand the role Virtual Reality may play as a technology for assessment and treatment of some types of mental health disorders. Others have considered the role Virtual Reality may play in more general mental health technology [63][64]. The role of Smartphones are also not included in these discussion at present, as they are more typically associated with gaming headsets like the Oculus Rift.

A recent blog discusses Digital health – health and fitness wearables, apps and platforms – and its implications for assessing health and longevity interventions (http://www.anti-agingfirewalls.com/2015/01/11/). Although these are not necessarily associated with mental health, the blog provides an effective overview of Smartphone augmented with wearables. In a report by the IMS Institute for Healthcare Informatics: Patient Adoption of mHealth, lists the "innovative data collection features linked sensors and wearables drive use" and development (http://www.imshealth.com/en/thought-leadership/quintilesims-institute/reports/patient-adoption-of-mhealth).

One would be remiss not to mention the opportunities for integrating machine learning (ML) into mental health Smartphone apps. For example, [65] discusses the use of N-gram concept features and Support Vector Machines (SVMs) for predicting the following Speech and Language Disorder assessment items automatically from speech samples: the Thought, Language and Communication (TLC) […] and the Clinical Language Disorder Rating Scale (CLANG) rating items. TLC has 18 items for evaluating schizophrenia speech, such as Poverty of Speech and Loss of Goal. CLANG has 17 items, such as Excess Phonetic Association and Abnormal Syntax. The sum of the prediction value of each of the items was then used to predict the underlying mental health condition. Although not necessarily related to the use of a Smartphone in mental health assessment, there are clearly opportunities related to speech capture on a Smartphone that would be amenable to ML classification.

Similarly there are Smartphone opportunities for mental health assessment through ML and face image classification as discussed in [66]. These may also be scraped from social media sites which are largely the domain of the Smartphone.

The application and framework we have presented here may also be redeployed for pre-symptomatic screening for memory slips which are often associated with early signs of various dementias. There are also considerable Smartphone opportunities in eye tracking as a means of assessing cognitive abilities associated with viewing novel and familiar images [67]. A technical difficulty at this time is with camera quality and the APIs associated with the front facing cameras on Smartphones. One would need to display familiar images and attempt to extract eye tracking from a single front facing camera.

VI. CONCLUSIONS

It is apparent that there is considerable effort in developing Smartphone apps for general health assessment and management, including mental health. Yet, there is a lack of empirical research on their efficacy and the challenges in this area are considerably greater than for recreational or more general purpose health apps.

Tracking one's data in isolation is relatively easy as the reporting is extensively back to the user. Developing apps for mental health assessment imply that behavioral data is to be collected and an assessment made by someone other than the user. As such, data need to be collected and sent to a service for processing and analysis. App development toward an understanding of gaming and gambling behaviors, including potential addiction, appears to be an avenue where data collection and analysis frameworks may first emerge within more general apps for mental health assessment, albeit in a somewhat constrained area of focus. This is likely possible as developers can exploit development tools for games while placing increased emphasis on behavior data collection processes and analytics. This paper presented apps for mental health and mental health assessment and discussed a prototype Smartphone app and its development as a data collection platform of both player account data and in-game player survey data.

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