A Review of Empirical Studies on Persuasive Technology for Physical Activity: Common Practices and Current Trends

Muhe Yang*
McGill University

Karyn Moffatt†
McGill University

ABSTRACT

As the number of empirical studies on persuasive technology (PT) is increasing, prior reviews focused primarily on the application and effectiveness of PT systems, while paying scarce attention to how studies were conducted. We present a methodological review of empirical studies on persuasive technology for promoting physical activity. This review includes 37 papers published in peer-reviewed venues, grouping them into three categories based on their research objectives: to design PT systems, to evaluate PT systems, and to examine the elements involved in PT. Through the in-depth analyses and syntheses of methodologies, we identify the common practices for each category respectively, and highlight current trends and research opportunities, which could provide a practical guide for future research.

Keywords: Persuasive technology, behavior change technology, methodology, literature review.

Index Terms: Human-centered computing—Human computer interaction (HCI)—HCI design and evaluation methods; Applied computing—Life and medical sciences—Health care information systems

1 INTRODUCTION

Since its introduction in 1997 [1], the area of persuasive technology (PT) is seeing an increasing number of empirical studies. While some prior literature reviews focused on the application and effectiveness of PT systems or behaviour change strategies [2-4], there has not been a review specifically concentrating on how those empirical studies were conducted. Without clarifying and synthesizing the methodologies used, it becomes challenging to analyze prevalent practices, reflect on opportunities for improvement, and guide future studies. Therefore, this paper aims to review the methodologies used in empirical PT studies for promoting physical activity—the most frequently studied behavior in health PT [3]. The research question of this paper is: *For empirical studies on PT for promoting physical activity, how are they conducted in terms of different research objectives?* In this paper, we categorize those studies by their research objectives, synthesize their common practices respectively, and highlight some current trends, potential pitfalls, and research opportunities in this area.

*e-mail: muhe.yang@mail.mcgill.ca
†e-mail: karyn.moffatt@mcgill.ca

2 METHODS

We conducted the literature search primarily in the Association for Computing Machinery Digital Library, which was complemented by a search in an interdisciplinary database Elsevier Scopus, since the topic of health PT is at the intersect of several areas including human-computer interaction, health science, and psychology. We performed keyword searching on title, abstract, and keywords in the selected databases in May 2021. Key concepts were persuasive technology (e.g., "persuasive technology", "persuasive system", "persuasive design", and mHealth) and physical activity (e.g., "physical activity" and exercise), with the searched terms being combined by Boolean operators "AND" and "OR" to limit the results. In addition to searching in the databases, we also included the reference lists of prior reviews on PT or behavior change technology [2-4].

We reviewed the titles and abstracts of the records, and selected articles according to the following criteria: (1) focusing on PT or behavior change technology; (2) focusing on promoting physical activity; (3) presenting empirical studies; (4) published in peer-reviewed academic journals or conference proceedings; (5) published in English. After removing duplicates, screening titles and abstracts, and further reading and assessment, a total of 37 papers were included in this review (a complete list of the 37 papers can be found at http://act.mcgill.ca/BehavChangeTech/review-PTPA.html).

Through reviewing the included studies, we identified three major research objectives: to design PT systems, to evaluate PT systems, and to examine elements related to PT effectiveness (note that a study may have multiple objectives). We grouped the studies into these three categories, and then synthesized their methodologies respectively.

3 RESULTS

The 37 included papers, published from 2006 to 2021, are comprised of 13 (35%) journal articles and 24 (65%) papers published in conference proceedings. In terms of the published venues of those articles, 30 (81%) are from HCI or computer science, and 7 (19%) are from health or medicine. Based on their research objectives, 17 (46%) of the 37 reviewed studies aimed at PT design, 26 (70%) aimed at PT evaluation, and 10 (27%) aimed at elements examination. Their corresponding common practices are presented as follows.

3.1 PT Design

Given that the complete design process was often not reported in detail, we analyzed the methods and techniques used in primary design steps, as well as designed systems.

Although requirements gathering for exploring users' preferences and design requirements is an essential step for design, less than half (41%) of the design studies had or reported this step, and only three studies (18%) particularly specified their employment of user-centered design method. For this purpose,

survey and interview have been two frequently used techniques. In particular, building personas was used as a design technique to construct scenarios and identify user needs. Usability tests were included or reported in three studies (18%), with varying scales from in-lab tests to field tests.

As for their designed systems, walking was the most popular type of target behavior involved in most of the design studies (71%). They tended to target broadly at adults aged 18 and over (59%), with only two studies (12%) specifically focusing on teenagers and older adults respectively. These systems were often designed as mobile applications or websites, frequently employing behavior change strategies such as social supports and personal motivation.

3.2 PT Evaluation

Evaluating PT systems is a major and probably the most frequently studied topic in PT area. Though the specific topic varies across studies, there emerges a commonality in their methods used.

PT systems are usually evaluated in longitudinal deployment studies with experimental design. The number of participants involved in the evaluation studies varied greatly, ranging from 2 to 220, with the average being 32 and the median being 16. The overwhelming majority of these studies (92%) had less than 50 participants. These participants would use PT systems for four weeks in their daily lives, with one week being a baseline period. These studies often employed a combination of quantitative and qualitative measurements, including, measuring participants' physical activity by step counts (collected via system logs), assessing their changes in motivation by the stages of change [5] (via questionnaires or interviews), exploring user experience (via post-study interviews), sometimes also measuring system usage (via system logs). The collected data would be analyzed by descriptive statistics, inferential statistics, and thematic analysis. In most cases, the results of these studies were reported in two aspects: systems' effects on participants and participants' reactions to systems.

3.3 Elements Examination

The effectiveness and performance of PT systems are affected by a variety of elements, such as system features, persuasive strategies, and users' characteristics. Accordingly, another popular topic in PT research is investigating whether and how those elements influence the effectiveness of PT systems, as well as examining the relationships between those elements.

Overall, studies for this purpose mainly revolved around the effectiveness of PT, users' personal attributes, and behavior change strategies, which determines the measurements used in each study. Almost all of these studies (90%) used quantitative methodology, while one study (10%) was mixed-method. Survey was the primary research method employed by the majority of the studies (80%). Normally, these studies involved a large number (more than 200) of general public as participants. Particularly, survey with storyboards is a popular method for examining behavior change strategies. Furthermore, the data collected by questionnaires were often analyzed by inferential statistics or modeling techniques to examine the relationships between variables.

4 Identified Trends and Research Opportunities

First, the reviewed empirical PT studies exhibit a commonality in research topics as well as their corresponding methodologies. Whether the goal is to evaluate systems or to examine involved elements, these studies fundamentally revolve around the effectiveness of PT. That is, empirical PT studies are generally "effects-oriented." Moreover, studies with similar research objectives often employ similar methodologies, which is particularly apparent in studies for evaluation and elements examination.

Second, there is a trend of "technology-driven" approach in this area, in that most studies try to match existing persuasive strategies or system features to users, instead of starting from users' needs and designing corresponding solutions. The prevalence of such approach, to some extent, accounts for the aforementioned commonality in research topics and methods.

Third, the generalizability of the findings in those studies seems limited, despite the commonality in methodologies, because their variability outweighs their commonality in most cases. In evaluation studies, particularly, their system designs varied significantly, which is the biggest hurdle for comparing the results from different studies.

Fourth, there is an insufficient attention to design process. Since design process was often not reported in detail, the rationale of PT designs remains unclear so that design knowledge would be difficult to be transferred. Furthermore, target users were rarely involved in the design process, and even rarely when it comes to some less studied groups such as teenagers and older adults.

The reasons accounting for these trends and the relationships between these trends are complex, on which we are currently developing this review into a full paper to discuss further. In addition, based on the identified pitfalls, we are planning to explore the design space of PT for older adults by actively involving them in an user-centered design process.

5 Conclusion

Through synthesizing the methodologies used in empirical studies on PT for physical activity, this review presents how those studies were conducted to design PT systems, to evaluate PT systems, and to examine elements related to PT effectiveness. The synthesized common practices not only could provide a practical guide for researchers who intend to design and evaluate PT systems, but also could offer a perspective for establishing standardized approaches in PT research. Moreover, the identified current trends could shed light on potential pitfalls and research opportunities for future research.

References

[1] Fogg, B. *Captology: the study of computers as persuasive technologies*. in *Conference on Human Factors in Computing Systems, CHI EA 1997*. 1997. Atlanta, Georgia. DOI: 10.1145/1120212.1120301

[2] Kelders, S. M., Kok, R. N., Ossebaard, H. C. and Van Gemert-Pijnen, J. E. W. C. Persuasive system design does matter: A systematic review of adherence to web-based interventions. *Journal of Medical Internet Research*, 14, 6 (2012). DOI: 10.2196/jmir.2104

[3] Orji, R. and Moffatt, K. Persuasive technology for health and wellness: State-of-the-art and emerging trends. *Health Informatics Journal*, 24, 1 (2018), 66-91. DOI: 10.1177/1460458216650979

[4] Torning, K. and H. Oinas-Kukkonen. *Persuasive system design: State of the art and future directions*. in *4th International Conference on Persuasive Technology, Persuasive'09*. 2009. Claremont, CA, United States. DOI: 10.1145/1541948.1541989

[5] Prochaska, J. O. and Velicer, W. F. The transtheoretical model of health behavior change. *American journal of health promotion*, 12, 1 (1997), 38-48. DOI: 10.4278/0890-1171-12.1.38