

Designing digital behaviour change interventions to support older adults managing cardiac conditions.

David McQuaid
Netwell Casala
Dundalk Institute of Technology
Dublin Road, Dundalk, Co. Louth, Ireland
david.mcquaid@dkit.ie

Julie Doyle
Netwell Casala
Dundalk Institute of Technology
Dublin Road, Dundalk, Co. Louth, Ireland
julie.doyle@dkit.ie

As the number of older adults in our society increases, a greater demand is put on our healthcare systems. This increasing demand on healthcare and especially on the front-line care-givers and professionals has led to a greater need for individual patients to actively engage in personal behaviour change to manage their conditions and improve their quality of life. The Human Computer Interaction Community has a growing body of research pertaining to the many and varied ways that Behavioural Change Techniques have been integrated into digital applications and intervention systems. However, it has been noted that the limitations as to how these interventions have been evaluated has led to the existing research having little impact. This study will explore the design strategies and theories that currently exist regarding implementing digital BCTs and will concentrate on *why do these types of interventions work, if they work at all?*

HCI, Behavioural Change, Digital applications, Intervention systems, Older adults, Design strategies

1. INTRODUCTION

As the number of older adults in our society increases, a greater demand is put on our healthcare systems (Eurostat, 2018). This increasing demand on healthcare and especially on the front line caregivers has led to a greater need for individual patients to actively engage in personal behavior change in order to manage their conditions and improve their quality of life.

A great deal of cross domain research has been carried out, with regard to how can we encourage positive behavior change and limit negative behavior (Sutherland, 2013, Nilsen *et al.*, 2012, Davis *et al.*, 2015). This in itself is a worthy goal, with obvious benefits to mental and physical health, addiction, professional competency and a myriad of other diverse fields, however it is unclear as to why these interventions work. This study will explore the design strategies and theories that currently exist in regards to implementing digital Behavioural Change Techniques (BCTs), concentrating on older people with heart conditions and related co-morbidities. The possible impact and effectiveness of these BCTs shall be discussed and the most

promising of them, will then be put forward for evaluation in a longitudinal study. This would include the design and implementation of a digital intervention system.

2. CONTEXT AND BACKGROUND

The Human Computer Interaction (HCI) Community has recognised the opportunities that now exist to affect behaviour through interaction with User Interfaces (UI) and has compiled an impressive body of research regarding the implementation of digital BCTs (Kumar *et al.*, 2013, Riley and Rivera, 2014, Riley *et al.*, 2011). However, there is evidence, highlighted by (Klasnja, Consolvo and Pratt, 2011; Klasnja *et al.*, 2017) that this research has had little impact due to the limitations on how these interventions are evaluated.

2.1. BEHAVIOURAL CHANGE (BC)

Cases where Behavioural Change in an individual subject has been reported, (Michie, van Stralen and West, 2011) have tried to elucidate the exact reasons as to why such a change has occurred, however it has proven very difficult to evaluate, as the efficiency of the individual components that drive the intervention become clouded within the whole.

For example, individuals using a digital system to manage a cardiac complaint may have a perceived improved outcome. This may be because they were assisted in setting certain goals whilst using the application or it may be that they were deliberately reporting positive results. For any intervention to have an impact, it is necessary to understand which pieces of the process work best for who and in what context.

Klasnja *et al.*, (2017) has made a deliberate distinction between *distal* and *proximal* outcomes in evaluating BCTs. *Distal outcomes* are the broad aims of BCTs, such as longer life expectancy or improving quality of life. These distal outcomes need to be evaluated slowly and usually require a Randomised Controlled Trial (RCT), conducted longitudinally, to demonstrate any effect.

Klasnja *et al.*, (2017) argues that researchers designing digital interventions should therefore concentrate on an evaluation strategy that focuses on the assessment of proximal outcomes directly related to individual intervention components.

Proximal outcomes are the most direct changes that an intervention component is intended to create, changes which, over time, should create the more global changes in behaviour and health as defined by distal outcomes. As such, proximal outcomes are key to understanding if an intervention is working as intended because they allow researchers to test individual branches of the causal pathway through which the intervention is hypothesized to change behaviour and distal health outcomes. (Klasnja *et al.*, 2017)

There are several theories that attempt to explain why behaviour changes. These theories tend to group into two distinct categories, *models of behaviour* and *theories of change*

Models of behaviour are primarily diagnostic and help in understanding specific behaviours by detailing the factors that influence them, such as *The Health Belief Model* (Green and Murphy, 2014) and *The Social Cognitive Theory of Self-regulation* (Bandura, 1991).

Theories of change, such as *The Transtheoretical Model* (Prochaska and Velicer, 1997), are more pragmatic or process orientated and are aimed at supporting the adoption of new behaviours or the change of existing behaviours (Darnton, 2008)

For this study, *BC interventions* can be defined as coordinated sets of activities designed to

change specified behaviour patterns (Michie, van Stralen and West, 2011).

(Michie, van Stralen and West, 2011) argue that, to identify an effective intervention technique it is important to first investigate the full range of options that are available and then use a rational system to select the most promising from among them. However, it is also noted that,

It appears that most intervention designers do not use existing frameworks as a basis for developing new interventions or for analysing why some interventions have failed while others have succeeded. (Michie, van Stralen and West, 2011).

Michie, van Stralen and West, (2011) has proposed a composite framework to deal with understanding behaviour change, called the COM-B model (Fig. 1).

In this behaviour system, capability, opportunity, and motivation interact to generate behaviour that in turn influences these components. (Michie, van Stralen and West, 2011).

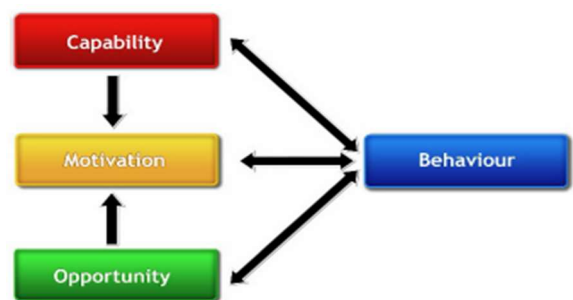


Figure 1: Com-B system (Michie, van Stralen and West, 2011)

Michie's work regarding understanding and codifying behaviour change and its causes will be the focus of this research's theoretical framework.

For this research, Congestive Heart Failure (CHF) will be the cardiac condition that is focused on. Over fifteen million people in Europe have CHF (Eurostat, 2018), and this number is increasing. Considering this, it is estimated that heart failure accounts for 1-2% of total healthcare expenditure in Europe and is the most common cause of hospital admissions in people over the age of 65 (Ponikowski *et al.*, 2016). Older adults are particularly affected, with close to 80% of people with CHF over the age of 65 (Lloyd-Jones, 2002). This is a drain on healthcare resources and due to the nature of the disease,

... a clinical syndrome having characteristic signs and symptoms (Alsafwah et al., 2007).

is an ideal population to examine the use of a digital intervention to affect Behavioural Change.

3. RESEARCH OBJECTIVES AND QUESTIONS

As Klasnja *et al.*, (2017) and Michie, van Stralen and West, (2011) have argued, there is a real need to effectively evaluate digital interventions due to the lack of existing data regarding which pieces of the process work best for who and in what context.

To adequately assess a digital intervention, it is necessary to identify the,

... causation, common cause, and theoretical explanation (Hanzel, 2012).

In the context of this research, this can be broken down as follows:

- What was the cause and effect of the digital intervention?
- Can the results of the intervention be reproduced generally?
- How can the results be explained using a theoretical framework?

These three elements can be further refined and encapsulated in the question at the heart of this research, *why do digital BCT's work, if they work at all?*

The objective of this research is to categorize a causal pathway between a digital application, designed with a clear intervention as its focus and assessing if there has been a clear change in an older person's behaviour using grounded theory.

4. METHODOLOGY

The objectives of this research will be achieved by splitting the study into 3 phases: (Fig. 2).

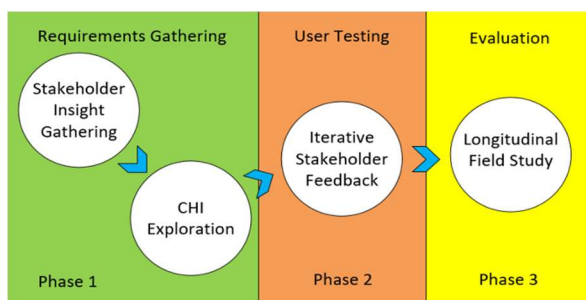


Figure 2: Study Structure.

Prior to the commencement of any of the studies, detailed ethical approval will be sought from Dundalk Institute of Technology Research Ethics Committee and The Health Service Executive (HSE) Research Ethics Committee.

4.1. Phase 1

Requirements Gathering (RG) is defined for this research as,

... (the) capture (of) Information through the use of multidisciplinary views. Such views express what is to be built (Lane, O'Raghallaigh and Sammon, 2016).

RG is a critical point in any system design, be that a digital application, manufacturing process or research project. Indeed, Hickey and Davis, (2004) argued that the success or failure of a system development effort depends heavily on the quality of the requirements. This is particularly true in this instance, with several key questions to be raised and evaluated.

The RG for this research align broadly to two main themes, *Stakeholder Insight Gathering* and *HCI Exploration* and as such need to be explored individually.

Stakeholder Insight Gathering will involve an in-depth analysis of what the stakeholders believe to be the most important behaviours that people with CHF need to change. The Stakeholders will include, the older adults who are managing CHF, family members, clinicians, front line health professionals and care givers.

Recruitment of these stakeholders will be accomplished through advertisement in local papers/social media, meeting with local community groups, direct meetings with clinicians/GP's, meetings facilitated through the local heart failure clinic and participating in a public meeting/support group contact facilitated by the Irish Heart Foundation.

Whilst evidence suggests that recording weight gain, blood pressure analysis and the monitoring of oedema (swelling caused by excess fluid trapped in your body's tissues) are all practices that help in the managing of CHF, it is necessary to formalize this view and to factor in the challenges that may already exist in managing and monitoring these variables. This will enable a close look at which of these practices is most favourable towards the practical design of a digital intervention.

Focus groups will be conducted with the specific aim to discuss the most important behaviours that need to be changed in older people with CHF. The Focus groups will consist of not less than six and not more than ten participants (fewer than six participants may limit the conversation and yield poor data while more than ten can be unwieldy) (Krueger and Casey, 2009). Two focus groups will be recruited, with a total number of stakeholders being not greater than twenty. These groups will be informed precisely as to the purpose of this research and their role within and then asked a series of five to ten questions that have been prepared prior to the discussion in order,

... to gather systematic information about a set of central topics, while also allowing some exploration when new issues or topics emerge. (Wilson, 2014)

The focus groups will be conducted in the Netwell Casala centre at Dundalk Institute of Technology and last between sixty and ninety minutes.

Qualitative analysis of the information gathered from these groups will allow for insight into the behaviour that will be targeted for change and form the basis of the intervention that will be carried out.

HCI Exploration will involve the same stakeholders in a study of their preferences regarding interaction with a digital application. This study will take place at a different date from the first, to allow for the participants to focus on each discussion independently and to ensure that the participants, especially the older adults, are not overly stressed or fatigued. Rosenbaum *et al.*, (2002) has recommended,

... that after an initial group discussion, we typically 'break out' into smaller clusters of two or three people who explore a product in a co-discovery manner (each cluster with a facilitator), then we reconvene the full focus group for discussion of the participants experiences. (Rosenbaum *et al.*, 2002)

Typically, digital applications have been "dashboard based" and have engendered the use of mobile and tablet devices. (Fig. 3).

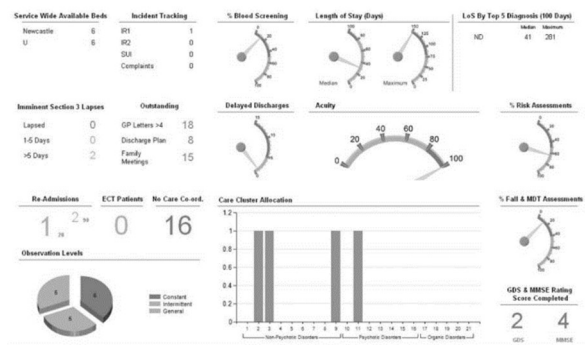


Figure 3: Clinical dashboard in older adult services (Daley *et al.*, 2013)

Qualitative analysis of the information gathered from these groups, with the inclusion of an exploratory stage, as recommended by Rosenbaum *et al.*, (2002) will allow for insight into the design of the digital application used to drive the intervention.

With the advances in Artificial Intelligence(AI) based applications such as "Alexa", "Cortana" and "Google Assistant", including aural (sound based) and haptic (vibration/touch based) interfaces as well, will enable the exploration of the full gamut of options available.

4.2. Phase 2

User testing. Having identified the preferred interaction paradigms for a multi-modal UI, it will become necessary to design and build a prototype application that will facilitate the BCT.

Taking the example of recording weight gain, this will involve the measurement of weight on a regular basis and then recording this data in a secure, centralized repository. A typical way of doing this may involve the use of digital scales and a mobile application that allows for the recording of the measurement and then the storing of the data in a database. This data can then be used to inform the older adult as to the status of their weight and advise appropriate action (as recommended by the cardiologist/GP) if required. The data can also be shared with the cardiologist/GP and allow for addition action if needed.

The example above, details a simple application that takes a lot for granted. It presumes that the older adult is comfortable and acclimatized to the use of mobile technology. It also presumes that the advice "pushed" by the application is appropriate and that the advice is followed.

Regardless to the form of the application or the intervention that is being tested, it is vital that the "users", in this case older adults with CHF, be consulted throughout the design process to ensure that the application design is appropriate and easy to interact with. This is reinforced by Gelperin, (2008), who's work, whilst criticizing some of the Agile Manifesto's core principles, still espouses the virtues of "customer collaboration" (Manifesto, 2001).

A cyclical series of application builds will be attempted and at the conclusion of each iteration the original stakeholders will be invited to interact with the build in order to gauge if the core requirements of the application have been met and if the interactive space that the participant is working in is appropriate and conducive to the digital intervention that is being attempted.

It is at this stage that Klasnja *et al.*, (2017)'s "Proximal outcomes" will begin to come into play. Each of the functional aspects of the application that are designed to facilitate BC, will be isolated from an analytical viewpoint. This could mean, for example, that the frequency of a screen-based button being tapped may be recorded, or the time difference between an audible alert and interaction with the interface may be measured, in order to,

...test individual branches of the causal pathway through which the intervention is hypothesized (Klasnja *et al.*, 2017)

This stage will also *refine* the requirements that will be identified in Phase 1.

4.3. Phase 3

Evaluation. The purpose of this stage is to observe and assess the efficacy of the digital intervention identified in Phase 1 of the research. A new group of participants will be recruited, who are over the age of 65, have previously not been exposed to the study and all have a need to manage CHF. This group will then be randomly assigned one of the three digital interfaces and observed over a period of two months as they interact with the application. After the two months, the digital interfaces will be rotated between the participants and again after a further two months, ensuring that at the end of a six month study all participants will have interacted with all the interfaces. At the end of the study, all the stakeholders will be interviewed as to:

- Which interface did they find most intuitive?
- Has the specific behaviour changed?
- Has the digital application been a factor in any Behaviour Change?
- Has the application assisted in managing their CHF?
- Have the participants health outcomes changed?
- Why do they think that the application has helped (if at all)?

At this point, using the data collected, it will be possible to begin mapping casual pathways between the digital intervention and the outcomes recorded. This will form the basis for a more detailed argument in the form of a thesis.

5. CONCLUSION

This research focuses on a complex and interesting problem: What proximal aspect of a digital intervention causes behaviour change?

Behaviour is a complex subject and behaviour change is more so. Our ability to influence behaviour through digital applications and the use of specific devices has been well documented however the individual or *Proximal* components that enable these changes, have been poorly evaluated (if at all).

By identifying components that directly influence behaviour it is envisaged that new insights into the design and application of digital interventions will become apparent.

This Project is supported by the European Unions INTERREG VA program, managed by the Special EU Programs Body (SEUPB).

6. REFERENCES

- Bandura, A. (1991) 'Social cognitive theory of self-regulation', *Organizational Behavior and Human Decision Processes*. Academic Press, 50(2), pp. 248–287. doi: 10.1016/0749-5978(91)90022-L.
- Daley, K. *et al.* (2013) 'Clinical dashboard: use in older adult mental health wards', *The Psychiatrist*. Cambridge University Press, 37(3), pp. 85–88. doi: 10.1192/pb.bp.111.035899.
- Darnton, A. (2008) *GSR Behaviour Change Knowledge Review - Reference Report: An Overview of behaviour change models and their uses*, *Government Social Research*. doi: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/498065/Behaviour_change_reference_report_tcm6-9697.pdf.

- Davis, R. *et al.* (2015) 'Theories of behaviour and behaviour change across the social and behavioural sciences: a scoping review', *Health Psychology Review*. Routledge, 9(3), pp. 323–344. doi: 10.1080/17437199.2014.941722.
- Eurostat (2018) *Population structure and ageing - Statistics Explained*. Available at: http://ec.europa.eu/eurostat/statistics-explained/index.php/Population_structure_and_ageing (Accessed: 20 March 2018).
- Gelperin, D. (2008) 'Exploring agile', in *Proceedings of the 2008 international workshop on Scrutinizing agile practices or shoot-out at the agile corral - APOS '08*. New York, New York, USA: ACM Press, pp. 1–3. doi: 10.1145/1370143.1370144.
- Green, E. C. and Murphy, E. (2014) 'Health Belief Model', in *The Wiley Blackwell Encyclopedia of Health, Illness, Behavior, and Society*. Chichester, UK: John Wiley & Sons, Ltd, pp. 766–769. doi: 10.1002/9781118410868.wbehibs410.
- Hanzel, I. (2012) 'Causation, Principle of Common Cause and Theoretical Explanation: Wesley C. Salmon and G. W. F. Hegel', *Journal for General Philosophy of Science*. Springer Netherlands, 43(1), pp. 29–44. doi: 10.1007/s10838-012-9176-2.
- Hickey, A. M. and Davis, A. M. (2004) 'A unified model of requirements elicitation', *Journal of Management Information Systems*. doi: 10.1016/j.jiforecast.2003.11.003.
- Klasnja, P. *et al.* (2017) 'Toward Usable Evidence', in *Proceedings of the 2017 CHI Conference on Human Factors in Computing Systems - CHI '17*. New York, New York, USA: ACM Press, pp. 3071–3082. doi: 10.1145/3025453.3026013.
- Klasnja, P., Consolvo, S. and Pratt, W. (2011) 'How to evaluate technologies for health behavior change in HCI research', in *Proceedings of the 2011 annual conference on Human factors in computing systems - CHI '11*. New York, New York, USA: ACM Press, p. 3063. doi: 10.1145/1978942.1979396.
- Krueger, R. A. and Casey, M. A. (Mary A. W. . (2009) *Focus groups: a practical guide for applied research, Focus Groups: A Practical Guide for Applied Research*. SAGE. Available at: https://www.mendeley.com/research-papers/participants-focus-group/?utm_source=desktop&utm_medium=1.17.13&utm_campaign=open_catalog&userDocumentId=%7B9834176a-4ead-4afa-96dd-0fcdf7c32554%7D (Accessed: 9 May 2018).
- Kumar, S. *et al.* (2013) 'Mobile Health Technology Evaluation', *American Journal of Preventive Medicine*. Elsevier, 45(2), pp. 228–236. doi: 10.1016/j.amepre.2013.03.017.
- Lane, S., O'Raghallaigh, P. and Sammon, D. (2016) 'Requirements gathering: the journey', *Journal of Decision Systems*. Taylor & Francis, 25(sup1), pp. 302–312. doi: 10.1080/12460125.2016.1187390.
- Lloyd-Jones, D. M. (2002) 'Lifetime Risk for Developing Congestive Heart Failure: The Framingham Heart Study', *Circulation*. American Heart Association, Inc., 106(24), pp. 3068–3072. doi: 10.1161/01.CIR.0000039105.49749.6F.
- Manifesto, T. A. (2001) 'Manifesto for Agile Software Development', *The Agile Manifesto*. Available at: https://www.mendeley.com/research-papers/manifesto-agile-software-development-312/?utm_source=desktop&utm_medium=1.17.13&utm_campaign=open_catalog&userDocumentId=%7B39758a97-ff2a-4aaa-a225-d6169e2715ba%7D (Accessed: 9 May 2018).
- Michie, S., van Stralen, M. M. and West, R. (2011) 'The behaviour change wheel: A new method for characterising and designing behaviour change interventions', *Implementation Science*, 6(1), p. 42. doi: 10.1186/1748-5908-6-42.
- Nilsen, P. *et al.* (2012) 'Creatures of habit: accounting for the role of habit in implementation research on clinical behaviour change', *Implementation Science*. BioMed Central, 7(1), p. 53. doi: 10.1186/1748-5908-7-53.
- Ponikowski, P. *et al.* (2016) '2016 ESC Guidelines for the diagnosis and treatment of acute and chronic heart failure', *European Journal of Heart Failure*. Wiley-Blackwell, 18(8), pp. 891–975. doi: 10.1002/ejhf.592.
- Prochaska, J. O. and Velicer, W. F. (1997) 'The transtheoretical model of health behavior change', *American Journal of Health Promotion*, 12(1), pp. 38–48. doi: 10.4278/0890-1171-12.1.38.
- Riley, W. T. *et al.* (2011) 'Health behavior models in the age of mobile interventions: are our theories up to the task?', *Translational Behavioral Medicine*. Oxford University Press, 1(1), pp. 53–71. doi: 10.1007/s13142-011-0021-7.
- Riley, W. T. and Rivera, D. E. (2014) 'Methodologies for optimizing behavioral interventions: introduction to special section', *Translational Behavioral Medicine*. Oxford University Press, 4(3), pp. 234–237. doi: 10.1007/s13142-014-0281-0.
- Rosenbaum, S. *et al.* (2002) 'Focus groups in HCI', in *CHI '02 extended abstracts on Human factors in computing systems - CHI '02*. New York, New York, USA: ACM Press, p. 702. doi: 10.1145/506443.506554.
- Sutherland, K. (2013) 'Applying Lewin's Change Management Theory to the Implementation of Bar-Coded Medication Administration', *Canadian Journal of Nursing Informatics*.
- Wilson, C. (2014) 'Semi-Structured Interviews', in *Interview Techniques for UX Practitioners*, pp. 23–

41. doi: 10.1016/B978-0-12-410393-1.00002-8.