Designing for agency and compassion: Critical reflections on technology to support physical activity in late life

A 'Get a Move on' thinkpiece

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Leveraging Technology to Enable Mobility and Transform Health

Designing for Agency and Compassion: Critical Reflections on Technology to Support Physical Activity in Late Life

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Abstract

Contemporary policy on ageing overwhelmingly focuses on active ageing and the increase of disability-free years. Consequently, the research community has adopted an agenda that broadly addresses the issue through technology interventions that focus on deficits of older persons, who are often viewed as a homogeneous group, and little consideration is given to the relationship between the ageing body and physical (in)activity, the impact of the life course, and implications of the acceptance of life stages. As a result, technology interventions are potentially effective on a functional level, but simultaneously fail to consider personal and emotional aspects, resulting in prescriptive, standardised interventions rather than empowering systems that emphasize agency.

In this paper, we give an overview of ongoing discourses in critical gerontology questioning common approaches to ageing as decline and active ageing to adopt a broader perspective on technology and activity across the life course. We present findings from a systematic review of systems presented at leading venues in Human-Computer Interaction (HCI) and analyse to which extent the model of active ageing pervades existing research. We leverage the lenses of critical gerontology and sports science to examine existing systems (including our own work on playful technologies), and discuss shortcomings along with strengths of present research to help guide discourse and future work in HCI. Moving beyond critical analysis, this paper outlines challenges that need to be addressed in order to create technology that offers room for the lived experiences of older adults, and empowers them to re-gain ownership of their embodied experiences of physical activity.

Introduction

There are over 10 million older people in the UK, a figure estimated to rise to over 16.4 million by 2033. Improvements in the lengthening of the life course has been supported by health gains achieved via better public health, improved access to health care and advances in socio-economic conditions, both across the life course and in older age. Despite these improvements, achievement of an increase in healthy life expectancy remains of significant concern to policy makers. A strong economic case accompanies the policy aspiration to achieve sustained improvement in physical activity (PA). Active ageing has become a key policy response to contemporary ageing and includes the goal of promoting physical, mental and social well-being in order to promote healthy life expectancy.

As a result, discourse on ageing and PA predominantly focuses on active ageing and health risks associated with sedentary lifestyles (McGowan et al., 2016), highlighting societal challenges such as an increase of older adults needing long-term care and financial pressures on healthcare systems (NICE, 2015). However, shortcomings in the interpretation of active aging are the

adoption of a normative deficit approach that regards older adults as problematic, fails to consider individuality, and neglects contextualising features such as social determinants of health (Popay et al., 2010; Gard et al., 2016).

Particularly when designing technology to motivate PA among older adults, this problem-centric perspective on ageing may result in systems that do not recognize needs and desires of the individual. As a result, there is a risk that technology interventions are effective on a functional level, but simultaneously fail to consider personal and emotional aspects, resulting in prescriptive, standardised interventions rather than empowering systems that emphasize agency (Evans & Crust, 2015; Tulle, 2008). More recently, human-computer interaction (HCI) – research that addresses the way humans interact with technology and the relationship they have with it – has entered dialogue around views on older adults and general technology design (Cozza et al., 2017; Vines et al., 2015), outlining the need for a positive narrative to drive research and technology design in this area. However, to fully address concerns regarding the way technology is designed to support physical activity among older adults, a more detailed understanding of how policy affects research processes and system design and development within the HCI community is needed to outline avenues for future work.

In this paper, we reflect upon ongoing discourses in critical gerontology by questioning common approaches to ageing as decline and active ageing to adopt a broader perspective on technology and activity across the life course. We present findings from a systematic review of systems presented at leading international venues in HCI and analyse to which extent the model of active ageing pervades existing research. We leverage the lenses of critical gerontology and sports science to examine existing systems (including our own work on playful technologies), and expose shortcomings along with strengths of present research to help guide discourse and future work in HCI. Moving beyond critical analysis, this paper outlines challenges and opportunities that need to be addressed in order to create technology that offers room for the lived experiences of older adults, and empowers them to re-gain ownership of their embodied experiences of PA.

Background

In response to concerns over increasing costs of healthcare for older adults, there has been growing focus upon the benefits of active lifestyles during old age in both the natural sciences (Chodzko-Zajko et al., 2009; Nelson et al., 2007; Taylor et al., 2004) and in social science (Tulle, 2008a; Tulle & Phoenix, 2015). Several competing discourses exist in terms of how the need for older adults to adopt and maintain active lifestyles is conceptualised. For example, many studies in the natural sciences emphasise the link between sedentary behaviours and risk of ill health amongst older adults (Gard et al., 2016; Tulle, 2008a), and there is overwhelming evidence to suggest the adoption and maintenance of active lifestyles is beneficial for older adults (Chodzko-Zajko et al., 2009; Nelson et al., 2007; Taylor et al., 2004). Such work tends to be based upon the notion of promoting PA as a means of attenuating physical and psychological decline (amongst other problems) and health risk factors associated with old age (Nelson et al., 2007). Indeed, the majority of interventions designed to promote PA amongst older populations can be situated

within this general narrative of 'treating' age-related decline. Moreover, the need for such PA interventions is often couched in terms of prevention of illness, treating existing health problems or age/related diseases, or reducing healthcare expenditure. Hence, old age is problematized. Such interventions have tended to use technology in a very functional manner, often in order to set or monitor performance targets, or monitor physical progress. For example, commonly utilised technological solutions in Sports Science include use of pedometers and accelerometers to monitor PA frequency, duration and intensity in combination with other motivational methods, such as PA consultations or prompts via mobile telephone (Bravata et al., 2007; Chen, 2005; De Cocker et al., 2008; Fitzsimons et al., 2008; King et al., 2013). Similarly, technological tools are commonly used to measure biophysical measures of performance, including heart rate monitors (Meyer & Broocks, 2000; Nelson et al., 2007) and cycle ergometers (Pang et al., 2005), for example. Such tools can serve to objectify older adults' bodies, however, and interventions associated with their use tend to focus upon promotion of 'age-appropriate' forms of PA, such as walking (Ogilvie et al., 2007) and swimming (Evans & Sleap, 2013). Sport England, for example, even advocate the avoidance of the word 'sport' in programmes designed to encourage activity in older populations (Sport England 2017).

Conversely, the closely related 'successful,' 'healthy' or 'active' ageing paradigms tend to promote a more positive, anti-decline narrative of old age (Rowe & Kahn, 1997) which places emphasis on active engagement and the presentation of later life as a time of leisure, freedom, pleasure, activity, challenge and growth (Gard et al., 2016; Katz & Calasanti, 2015; Phoenix & Orr, 2014; Tulle & Phoenix, 2015). More specifically, the 'active ageing' approach maintains that increased and long-term 'participation' in social, economic, cultural, spiritual and civic issues are beneficial for older adults (Mendes, 2013). Behaviour change interventions are therefore common in terms of promoting PA in this way (Bauman et al., 2016), often with the aim of encouraging individuals to adopt healthy lifestyles via motivational prompts (Fitzsimons et al., 2008) and provision of opportunities. This can be empowering for some groups of older adults, particularly those with the resources and means to maximise new and existing opportunities to engage and remain active (Gard & Dionigi, 2016; Gard et al., 2016; Phoenix & Sparkes, 2009).

Arguably, interactive systems might address a number of the challenges associated with encouraging older people to 'get active'. Products which are easily accessible and inexpensive hold the promise of addressing gaps associated with reductions in public expenditure, and unsurprisingly, considerable investment has been made in the development of digital resources aimed at supporting policy for older people to get/remain physical active with the aim of increasing healthy years of life. This is in line with developments in Human-Computer Interaction research which has over the past decade directed significant attention to the potential of interactive systems to support PA among older adults. Moving beyond the application of commercially available systems, the HCI research community has developed systems directly addressing older people as end-users (e.g., to encourage PA and motivate behaviour change similar to systems provided for younger audiences; Albaina et al., 2009), or to provide therapy and rehabilitation (e.g., many of the systems analysed in this paper – see Table 2). Likewise, HCI research has

provided recommendations to inform the design of technology to support PA among older adults, exploring accessibility requirements (e.g., Gerling et al., 2012) along with preferences and values that may influence how older adults perceive technology in the context of PA (e.g., Fan et al., 2012). However, system uptake beyond research settings remains low (e.g., anecdotal evidence suggests that many of the movement-based gaming systems acquired by long-term care facilities that were enthusiastically reported on in fact, remain unused by residents). In this context, it is unclear to which extent currently available systems match needs and preferences of older adults, and how ongoing discourse on policy and ageing (such as the active ageing paradigm) are reflected in technology, possibly affecting its adoption.

A Review of Technology to Support PA in Late Life

Here we present a systematic review of research in Human-Computer Interaction with a focus on older adults and PA. The core research question we address is whether and how policy on the expansion of disability-free years and active ageing is represented in Human-Computer Interaction research, and how it affects resulting technological artefacts. In this section, we provide an outline of our methodology and describe our results.

Systematic Retrieval of Relevant Publications

To explore how discourse on ageing as decline and active ageing affects research within HCI that addresses PA and older adults, we carried out a systematic review of publications between 1997 (when the idea of active ageing was first propagated) and 2017, spanning a total of 20 years of research.

Our literature search was carried out in several steps. First, we identified the most cited publication venues in Human-Computer Interaction according to Google Scholar's citation indices. On this basis, we identified the top ten journals and conferences to be searched. For an overview of venues along with publications considered for and included in analysis, please see Table 1.

Table 1. Publications considered in analysis in descending order of recognition based on h5-index.

Publication name	Papers on PA (PA & Older Adults)	Papers included
ACM SIGCHI Conference on Human Factors in Computing Systems (CHI)	408 (16)	13
ACM Conference on Computer-Supported Cooperative Work & Social Computing (CSCW)	42 (2)	0
ACM Symposium on User Interface Software and Technology (UIST)	23 (0)	0
ACM Conference on Pervasive and Ubiquitous Computing (UbiComp)	89 (1)	0
IEEE Transactions on Affective Computing	17 (0)	0
ACM/IEEE International Conference on Human Robot Interaction (HRI)	52 (2)	1
International Journal of Human-Computer Studies	369 (2)	0
Mobile HCI	35 (2)	1
ACM Transactions on Computer-Human Interaction (TOCHI)	15 (0)	0
Behaviour & Information Technology	343 (6)	2

Overall	**1,393 (31)**	**17**

We carried out ten separate searches in the respective databases only including results occurring within the specified publication (e.g., we searched the ACM Digital Library specifically for papers published at CHI) and in the given timeframe. The search terms applied in this first round were addressing the theme of movement in the context of ageing, including the following: PA, physical stimulation, exercise, sport, occupational therapy, physical therapy, and rehabilitation. Across all venues, the initial search returned 1,393 results. We then carried out a manual search to identify papers addressing older adults, building on search terms applied by Vines et al. (2015): ageing, aging, older people, older adults, seniors, elderly, later life, age-related, retiree, retired, elders, geriatric, life course, grandparent, grandmother, grandfather. Manuscripts were included for further analysis if they made reference to these terms in any section of their work excluding related literature and references to ensure ageing was a central theme. This reduced the initially identified set of papers to 63 results. We then further screened the remaining manuscripts for quality according to reviewing process (e.g., we excluded extended abstract conference presentations) to focus on high-quality peer-reviewed content.

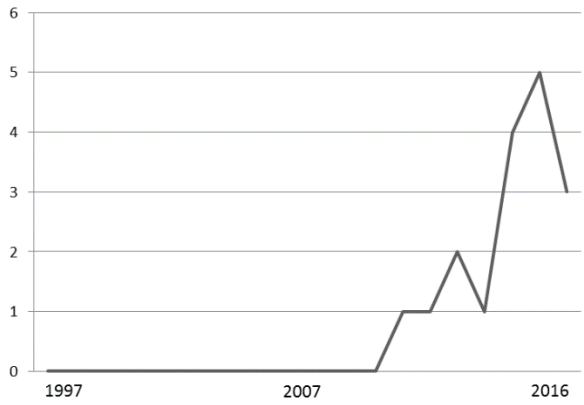

Figure 1. Number of papers on older adults, technology, and PA published per year between the years of 1997 and 2016.

This further reduced the included papers to 31. We then thoroughly read the remaining papers to identify those that address PA, and either develop or apply technology to reach this goal. Out of the remaining 20 papers, we excluded two pieces of work that aim to restrict rather than encourage movement (addressing 'wandering' in older adults in long-term care), and a further paper that only made passing reference to older adults, but did not focus on the audience in system development. Out of the remaining 17 papers, we aggregated three publications addressing the same project (Uzor et al., 2012; Uzor & Baillie, 2013; Uzor & Baillie, 2014), resulting in 15 unique systems included in analysis.

Data Analysis

Our analysis approach applies Deductive Thematic Analysis (Fereday & Muir-Cochrane, 2006) and was carried out following processes outlined by Braun & Clarke (2006). It addresses the overarching research question of understanding existing perspectives on technology and PA

among older adults within the HCI research community by drawing from questions raised by critical gerontology to identify perspectives on ageing and views on older adults, and explore how these are reflected in the design of technology to motivate PA among older adults through the lens of sports science.

More specifically, our analysis is guided by two key questions: (1) How are older adults and ageing viewed in the HCI research community and what is the prevalence of paradigms focusing on ageing as decline and active ageing, emphasising deficits and functionalist aspects along with narrative of individual responsibility to remain active? (2) How are these views reflected in technology to support PA? We focus on how research is motivated, design decisions are justified, and how findings are explained; in this context we address the presence or absence of a perspective on ageing as a disease and process of decline, and health economics. We further analyse how older adults are described and involved in research to understand the role they are allocated, and how they are perceived as users of technology. Specifically investigating the dimension of PA, our work builds on sports science studies that address PA among older adults and explores its integration with respect to agency and flexibility, setting in which the activity takes place, and overarching goals it contributes to.

All papers were read and annotated by one researcher, where themes within each of the overarching categories were identified. In total, 190 codes were assigned to the papers that fell within three main categories (we scored every paper once per code as we were interested in prevalence on a broader level rather than individual reference, e.g., if a paper made reference to age-related illness in the introduction and discussion of study participants, we only assigned one code). In the following section, we present the most prominent themes and discuss them in the light of our research question.

To guide the reader throughout the remainder of this paper, Table 2 and Table 3 provide an overview of projects included in analysis. Table 2 offers an overview of included systems and specifies intended target audience and system purpose to give context to some of the analysis outcomes discussed in our paper.

Table 2. Categorization and description of included systems along with reference to intended target audience as identified within the paper and overarching purpose of the system.

Authors	Category	Description	Target Audience	Purpose
Alankus et al. 2010 [1]	Game	Custom-designed motion-based game; camera-based and accelerometer-based movement tracking	People who had a stroke, Older Adults in particular	Rehabilitation
Ayoade & Baillie 2014 [2]	Interactive system	Stationary interactive system; accelerometer-based movement tracking for in-home knee rehabilitation	People undergoing knee replacement surgery including older people	Rehabilitation
Fang & Chang 2016 [3]	Wearables	System to facilitate health monitoring; neck-worn, arm-	Healthy and chronically ill older	Health monitoring,

		worn and wrist-worn options	people	sedentarism
Gerling et al. 2012 [4]	Game	Custom-designed motion-based game; camera-based movement tracking	Institutionalised older adults	Sedentarism
Gerling et al. 2015 [5]	Game	Custom-designed motion-based game and commercially available games; camera-based movement tracking	Older adults in independent living settings and institutionalised older adults	Sedentarism
Hebesberger et al. 2016 [6]	Robotic	Robotic walking companion for group-use in long-term care	Institutionalised older adults with dementia	Occupational therapy, sedentarism
Mazilu et al. 2014 [7]	Wearables	System to support training instruction and auditory assistance for freezing episodes in Parkinson's patients	People with Parkinson's including older people	Occupational therapy, assistance
Micallef et al. 2016 [8]	Mobile app	Application on phone/tablet/watch to deliver exercise reminders for post-stroke upper limb rehabilitation	People who had a stroke including older people	Rehabilitation
McNaney et al. 2015 [9]	Game	Custom-designed motion-based game to support people with Parkinson's; camera-based movement tracking	Older people with Parkinson's	Occupational Therapy
Sáenz-de-Urturi et al. 2015 [10]	Game	Custom-designed motion-based game; camera-based movement tracking	Older adults with and without age-related impairment	Occupational Therapy
Smeddinck et al. 2015 [11]	Game	Custom-designed motion-based games; camera-based movement tracking	Anyone including older adults	Occupational Therapy
Tang et al. 2015 [12]	Interactive system	System to provide in-home therapy; on-screen instruction and feedback; camera-based movement tracking	People with joint and muscle injury including older people	Occupational therapy
Taylor et al. 2011 [13]	Video conferencing tool	Video conferencing system to connect people with COPD and therapists for group-based in-home rehabilitation	People with COPD including older people	Rehabilitation
Threatt et al. 2014 [14]	Robotic	Autonomous table to support upper-limb rehabilitation	People who struggle to live independently	Rehabilitation Occupational

		(among other purposes)	including older people	Therapy Assistance
Uzor and Baillie 2012, 2013, 2014 [15]	Game	Custom-designed motion-based games for falls prevention; accelerometer-based movement tracking	Older adults, people who have had a fall and those at risk	Occupational Therapy

Table 3 provides an overview of design and evaluation approaches employed in each of the projects. We categorise projects according to their focus on end-users, and explore whether they employ user-centred design (UCD; i.e., maintain focus on user needs through methods that need not necessarily include direct user involvement) or participatory design (PD; i.e., a design approach that directly involves end-users as co-designers). We further provide an overview of evaluation approaches to support our analysis provided below.

Table 3. Overview of design and evaluation approaches employed by projects included in analysis.

Authors	**Design approach**	**Evaluation approach**
Alankus et al. 2010 [1]	User-Centred Design with therapists, some user participation and iterative adaption	Qualitative short-term study, location unclear; 4 women who had a stroke
Ayoade & Baillie 2014 [2]	User-Centred Design with therapists and former patients	Quantitative long-term study (six weeks), field research at hospital and participants' homes; 15 patients undergoing knee surgery, age-range 47-85 (Med=70)
Fang & Chang 2016 [3]	Unclear – no hints at UCD or PD	Quantitative short-term study, field research; 24 participants aged 50+ (54% aged 65+)
Gerling et al. 2012 [4]	User-Centred Design with therapist and based on literature	Quantitative short-term study at long-term care facility; 12 older adults, age range 60-90 (M=76.7, SD=10.6)
Gerling et al. 2015 [5]	User-Centred Design based on literature	Qualitative long-term study (3 months) at care home and senior residence; 16 older adults, average age 73.5 (SD=4.18) at CH, 79.9 (4.8) at SR
Hebesberger et al. 2016 [6]	User-Centred Design with therapists	Mixed-method long-term study at care home; number of older adults with dementia involved unclear
Mazilu et al. 2014 [7]	User-Centred Design with clinicians, engineers, and patients	Quantitative medium-term study (one week) at a hospital; 5 people with Parkinson's, average age 75.5 (SD=4.7)
Micallef et al. 2016 [8]	User-Centred Design with therapists, health professionals, and prospective end-users	Quantitative home-based medium-term study (three days); 15 people who had a stroke, age range 36-74
McNaney et al. 2015	Participatory Design with therapists	Qualitative lab-based medium-term study (two sessions); 8 people with Parkinson's, age range

[9]	and patients; invisible design	48-78
Sáenz-de-Urturi et al. 2015 [10]	User-Centred Design with therapists	Quantitative short-term study at care home; 14 older adults (3 people with MCI); age range 65-94 (M=89, SD=8.94)
Smeddinck et al. 2015 [11]	User-Centred Design with therapists	Mixed-method long-term study (5 weeks) at outpatient practice; 29 patients with chronic spine problems, average age 66 (1^{st} Qu=59, 3^{rd} Qu=73)
Tang et al. 2015 [12]	User-Centred Design with therapists	Quantitative lab-based short-term study; 16 graduate students
Taylor et al. 2011 [13]	Participatory Design with clinicians and patients	Mixed-methods home-based long-term study (8 weeks); 4 people with COPD aged 65-79
Threatt et al. 2014 [14]	User-Centred Design with therapists	Quantitative lab-based short-term study; 11 healthcare experts
Uzor and Baillie 2012, 2013, 2014 [15]	Participatory Design with older adults (2012)	Mixed-method short-term study (2013), 11 older adults aged 68-79; mixed-method long-term study (12 weeks; 2014), 17 older adults, average age 75.5

Results

Here we discuss the main themes that emerged throughout analysis. First, we discuss the two themes that reflect the active ageing paradigm, (1) Views on Older Adults and Ageing Communicated Through Research on Technology and PA, and (2) Views Reflected Through Technology to Support PA. Finally, we discuss a third theme that emerged from the interaction between (1) and (2) and that focuses on (3) Older Adults' Engagement and Experience With Technology and PA.

(1) Views on Older Adults and Aging Communicated Through Research on Technology and PA

This theme focuses on the views on older adults and aging that are prominent in HCI research that explores technology to support PA. Here, we give an overview of subthemes that emerged when examining the goals and motivation of research as communicated by the authors, descriptions of older adults, along with an analysis of how older people were engaged in the research process.

1.1 Goals and Motivation of Research

When analysing goals and motivation of research, functionalist and deficit-focused perspectives were prevalent in the majority of projects. Only one made explicit reference to capabilities of older people, suggesting that thoughts on older adults as strong individuals were generally absent.

In terms of research goals, improved functioning and the mitigation of medical issues were referred to by 10/15 projects (e.g., rehabilitation to re-gain upper limb control after stroke [1]), and another 5/15 projects discussed activity-motivating technology as a means of risk-reduction in late life (e.g., reduction of falls risk [15]), with one paper explicitly mentioning the potential of

movement-based technology to extend the lives of older adults [4]. Although implicit in some papers which addressed functional limitations or commented on the goal of prolonged independence in older adults, only four projects explicitly commented that improved quality of life among older adults was an overarching goal of research.

An overwhelming number of projects made reference to a deficit-focused perspective on aging with regards motivation for research. In this context, 11/15 papers made reference to age-related changes and 'deficits', and another 12/15 projects focused on disease associated with later life, e.g., stroke [1, 8], dementia [6], and Parkinson's disease [7, 9]. Additionally, five projects explicitly commented on health economics, lack of contribution to economic wealth of society (e.g., difficulty returning to the work force [1]) and generally increasing financial pressures on the healthcare system (e.g., high cost of fractions as a result of falls in late life [15]). In contrast, only one project recognised the economic strength of older adults as customer base, suggesting that their wealth introduced significant opportunity for digital development and economic growth [10].

Along these lines, none of the projects makes further reference to the strengths of older adults and positive changes that go along with late life; only one project makes mention of a life-span of perspective, a thought that was introduced by older adult study participants [13].

1.2 Description of Older Adults

Older adults were described in various ways, reporting more general aspects along with reference to more specific ideas that revealed a range of perspectives on the older person.

When analysing how older adults were portrayed as end-users of outcomes of the research projects and study participants, most descriptions of older people were brief, with 12/15 projects focusing on characteristics such as age, gender, and medical conditions resulting in disabilities relevant to the research. Only one project also reflected on the wider psychological impact whilst simultaneously taking a deficit-based approach by commenting on an individual's frustration regarding her physical impairment [1]. Further exploring the prevalence of this deficit-based approach, only four out of eleven projects which explicitly made reference to medical conditions and deficits of study participants applied standardised tests to evaluate prevalence and extent (e.g., applying the Mini Mental State Exam as an indicator of cognitive functioning [5, 10].

Moving beyond generalising descriptions of older adults, 8/15 projects recognised heterogeneity among either older people in general or their participants as a core challenge throughout the research process and technology uptake. However, there was a strong focus on heterogeneity in functional ability as an accessibility concern (7/8 projects), and only 2/8 projects discussed heterogeneity in terms of preferences and interests (e.g., [15] involving older adults through participatory design that enabled them to contribute their own ideas).

Additionally, a number of papers make detailed reference to characteristics of older adults to be considered in the research process. The most prominent themes that emerged throughout analysis focused on difficulties and risks, i.e., issues around non-compliance, and vulnerability of older adults as a result of age-related changes. With regards to non-compliance, 3/15 projects

commented on the *lazy* or *unruly* older person lacking the motivation to exercise or being unable to adhere to activity routines without exploration of underlying reasons, and, in a similar vein, one further project raised concerns around social dynamics that might introduce difficulties when deploying technology in a social setting. Adopting a different perspective, another subset of three papers addressed issues surrounding vulnerability that can be exposed through engagement with technology, e.g., drawing attention to age-related changes due to the physical nature of interaction paradigms [5] and emphasizing disease progression [9], suggesting that older adults sometimes need protection in the context of technology design and deployment. In contrast, one project also discussed the role of older adults as customers, adopting a perspective that puts the older person into a role that implies agency rather than protection or guidance.

1.3 Involvement of Older Adults in Research Process

Across the various projects, the involvement of older adults in the research process was realised in contrasting ways. Here, we discuss the inclusion of older people in the design and evaluation stages.

In terms of design, a vast majority of projects (14/15) adopted a user-centred design approach that considered the needs of older adults at early stages of the development process. While not all projects directly involved older adults as active research participants in the design stages, efforts were made to adopt their perspective through literature analysis (e.g., [5]) or the application of personas (e.g., [14, 15]), and through the involvement of experts such as therapists and carers (e.g., [6]). Only two projects [9, 15] followed a fundamentally participatory design approach in the initial stages that directly involved older adults as co-designers. Particularly regarding [15], older adults were included as design partners and made detailed suggestions and created entire concepts that they would like to engage with; however, in the course of the research it remains unclear whether participant suggested solutions were implemented, as those prominently presented as part of the follow-up papers represented solutions suggested by the research team.

Regarding the involvement of older people in the evaluation stages, almost all projects (13/15) directly involved older adults as study participants to varying extents, e.g., through long-term field research (e.g., in care facilities [4, 6] and home-based research such as [15]), evaluations in clinical settings (e.g., 13), or participation in lab studies (e.g., [9, 11]). Despite working on technology that the authors considered useful for older adults, two further projects did not include older adults at the evaluation stage, working with young adults and therapists instead [12, 14].

(2) Views on Older Adults Reflected Through Technology to Support PA

In this theme we describe the resulting systems to support PA among older adults with a focus on their general nature and goals, and the way they integrate PA.

With 7/15 systems, a large share of projects implemented game-based solutions, and two systems applied gaming technologies but no game elements; two further projects developed autonomous systems, two projects explored the potential of wearables for older adults, and one offered a video conferencing solution. In terms of system design, all projects made executive decisions on the type of system to be developed, and did not involve older people in this process.

Regarding project goals, 11/15 systems have an application context within the space of rehabilitation and occupational therapy, for example, addressing upper limb rehabilitation after stroke [1], preventative measures to reduce the risk of falls [5], or supporting older people living with Parkinson's disease [9, 7]. Additionally, four projects focus on the reduction of sedentarism and aim to provide physical stimulation rather than addressing specific therapeutic goals. Likewise, another three projects focus on self-monitoring and change of general behaviour and healthcare-relevant aspects of life. This demonstrates an overwhelmingly functional approach with all projects addressing disease- or otherwise health-related aspects associated with PA. For example, there was no system that explored technology to support PA among older adults with a primary focus on enjoyment or skill development in a leisurely context.

In terms of delivery of PA, we analysed setting and nature of activities provided by the systems along with flexibility they offer for end-users. Regarding the setting, 12/15 were intended for home-based use or use in care or healthcare-related facilities. Only 3/15 systems could also be used away from home (wearable systems with a focus on tracking [8] and assistance [7]). Additionally, there were differences in the social nature of the application context, with 12/15 systems being designed for individual use, and 3/15 systems inviting participation of two or more older adults, for example, in co-located group activity [5] or remote participation of multiple users [13]. In this context, only 2/15 systems were designed to flexibly accommodate individual or multi-user participation depending on the preference and further requirements of end-users. Further investigating the way PA was integrated, only one out of 15 systems [3] offered older adults flexibility regarding the kind of activities they would like to carry out. The vast majority (14/15) systems integrated PA in a way that was mostly prescriptive, giving detailed instruction regarding the kinds of movements to be carried out that would also define the overall nature of the activity (e.g., most of the game-based solutions required specific player movements for game input). While some systems integrated calibration routines to adapt movements to individual factors (e.g., player range of motion in [11]), these elements were either carried out together with therapists, or system-sided and determined through algorithms, leaving little room for agency among end-users to individually adapt movement routines to their preferences or daily abilities. This aspect was picked up by older adult participants rather than researchers of one of the projects [5] in which older adults engaged with the initially proposed game-based solution, but then moved on to explore commercially available products in accordance with their preferences.

(3) Older Adults' Emergent Interaction and Experience With Technology and PA

This final theme developed throughout analysis and brings together the previously discussed topics, focusing on the experience that emerges from older adults' interaction with technology

that focuses on PA. In particular, there was a strong focus on usability and user experience across all projects, analysis revealed discussion of aspects relating to user engagement and technology acceptance, and there was reflection on challenge, goal-setting, and goal-tracking in the context of technology, PA, and older people.

Generally, all projects reflected on the experience that older users would have with the system, with a prevalence of functionalist perspectives addressing issues related to accessibility and usability. Moving beyond these basic requirements, a number of projects also explored whether enjoyment emerged throughout interaction; however, while part of many evaluations this aspect was only central to few, and often discussed retrospectively, e.g., [1] commenting that they "*have not fully explored how to ensure that [older adults] will find the games motivating*". Along these lines, hardware design and overall system appearance in the living space of the older person were only discussed by one project [13] with regards to hedonic aspects. In stark contrast, another project [3] received user feedback suggesting one of the proposed wearable solutions resembled a dog collar, outlining the need for designers to reflect upon the look and feel of resulting technology as a means of positively engaging end-users.

This leads to a further sub-theme that focuses on user engagement with technology to support PA along with issues surrounding technology acceptance. Generally, few projects explored the integration of technology as a self-directed activity (e.g., [3] proposing the use of wearables to allow older adults to independently monitor their own health), while many others – particularly those with an application purpose in therapy and rehabilitation - focused on either prescribed frequency and duration of engagement (e.g., [15]) or supervision by therapists. In terms of non-engagement, only three projects discuss this case with the desire to understand older adults' motives, in contrast, 5/15 projects take a technology acceptance perspective where acceptance is the ultimate goal and concerns are not followed up on, e.g., one project pointing out that some older adults were sceptical of game-based occupational therapy, but not offering any explanation, and [10] explicitly commenting that "*[older adults] initial rejection will be reduced*" if they engage with the system often enough.

Finally, the last sub-theme that emerged focused on older adults' perspectives on challenge, goal-setting, and goal-tracking within technology to support PA, suggesting conflicting perspectives depending on end-user preferences. Particularly regarding challenge and goal-setting (e.g., level of difficulty in game-based interventions), some projects reported participant perspectives that suggest a risk of vulnerability if skills and abilities are not well-matched with system requirements. Likewise, older adults involved in [6] strongly felt that they would not like to be 'tracked' by the system, ensuring that progress is experienced individually but not quantified through the system. In contrast, a number of projects commented on the potential of tracking and scoring to provide feedback and increase engagement, e.g., [5] discussing the value of 'adequate' challenge, [2] commenting on benefits of goal-setting and –tracking, and [1] outlining the potential that tracking could have for review by healthcare professionals.

Discussion

This paper presents a summary of research in Human-Computer Interaction that addresses PA among older adults through the design of technical interventions. We provide an overview of 15 research projects specifically addressing aspects relating to PA in late life, and demonstrate that policy on the extension of disability-free years and active ageing has had a profound impact on this area of research. This is reflected in perspectives on older adults involved in the research process and as prospective end-users, ageing and associated concepts, and directly impacts the design of resulting technology. When viewed critically from the perspective of Gerontology and Sports Science, this suggests a number of limiting factors that may impede uptake and benefits of resulting solutions. Here, we discuss the relationship between policy on active ageing, Human-Computer Interaction research, and core challenges that need to be addressed to be able to deliver effective and empowering technology that can support PA in late life.

Active Ageing, Technology, and PA in HCI Research

Our analysis reveals that policy on the extension of disability-free years and active ageing and its interpretation have trickled down into research in Human-Computer Interaction, impacting the motivation of research, the purpose of developed systems, and perspectives on older adults involved in the research process and beyond. Findings are in line with previous discourse analysis of general HCI research addressing older adults (Vines et al., 2015), and reflect findings in the field of Ubiquitous Computing reported by Cozza et al. (2017). Here, we discuss how policy on ageing is reflected in HCI work addressing PA among older adults, how this relates to Critical Gerontology, and we discuss the integration of PA in currently available systems from the perspective of Sport Science.

Policy on Ageing, Its Impact on Technology, And Views From Critical Gerontology

Research in HCI has adopted contemporary policy on active ageing along with deficit-focused perspectives on the process of ageing as a key motivator for its research. Phoenix and Grant (2009) have argued a need to broaden attention from this dominant biomedical approach, arguing that it would illuminate the complexities of ageing and PA, including: individual identity, life experience, individual beliefs and values and the impact of the environment. Given the tendency to construct old age in binary opposites, Katz and Calasanti (2015) have argued that the flip side of terms such as 'active' or 'successful' ageing is 'inactive' and 'unsuccessful'. The danger is that the responsibility – and 'blame' - is placed on individual older people who have somehow failed to live up to notions of successful activity often fails to consider the impact of life course experience, structural inequalities and cultural factors which may impact on activity and health status (Lupton, 2014; Phoenix and Grant, 2009). A focus on biomedical approaches to inform the development of technology for older people raises questions as to the need to reflect a more complex and situated experience of older age. Moreover, Lupton (2014) has raised concerns about the ways in which technology may transform concepts of the body, health and illness.

PA Integration in Technology and Views From Sport Science

Integration and narrative accompanying PA are important aspects to be considered in the design of technology to support PA routines for any audience, including older adults. The strongly functionalist perspective pervading present HCI research along with prescriptive technology-supported activity regimes is one which resonates with the manner in which PA interventions are designed and implemented within sport science. However, more recent results from sports science also suggest that the integration of technology in a very functional manner, and often at the level of individual behaviour change over the short-term, have limited results over the long term (Kelly & Barker, 2016). Thus, there is a growing recognition that engendering longer-term behaviour change may require a more nuanced understanding of what it actually means to be active during old age (Phoenix & Grant, 2009), together with a shift away from the paternalistic 'prescription' of PA (Malcolm, 2016). Given the prevalence of comparable approaches in HCI research as identified by our work, this suggests that the research community needs to explore ways of encouraging agency and flexibility in how PA is carried out. For example, a shift away from the use of technology to primarily prescribe and monitor activity levels amongst older, passive recipients of physically activity programmes would seem to offer significant potential to overcome these problems and empower older participants.

Reflecting on Core Challenges for Technology to Support PA to Put Older Adults at the Heart of the Research Process

There are a number of challenges that emerged from our analysis that need to be addressed by the HCI research community to ensure that technology to motivate PA among older adults supports agency and positive experiences. Here we focus on four main aspects that offer opportunity for the HCI community to re-focus on the needs and preferences of older adults, and put them at the heart of the research process.

Challenge 1: Communicating agency through choice instead of creating prescriptive interventions.

HCI research often makes a priori decisions on the technology to be used, as well as the integration of PA routines, leaving little room for older adults to voice their preferences, or adapting PA to individual situations. We believe that this may introduce difficulty as it reduces agency of the older person, and in some instances introduces additional barriers to PA rather than acting as a facilitator.

For example, many projects set out to leverage games to engage end-users. However, there were many instances in which games were chosen because gameplay could easily be mapped onto pre-existing movement patterns. As a result, many of the systems still remain prescriptive and do not encourage agency in the way activity is carried out, and while this often represents a requirement for systems to support therapy and rehabilitation, it also bears the risk of carrying over challenges related to patient engagement. Along these lines, the question whether older adults would be motivated by games was often treated as an afterthought. To address this challenge, future research in HCI should reflect on the choice of technology and possibly involve end-users in the decision-making process at early stages, and explore technologies that would allow a more flexible integration of PA that gives the older person a say in the nature of their engagement.

Likewise, the topic of non-engagement with technology (also see Waycott et al., 2015) is one that warrants further discussion in the context of older adults, PA, and technology. In terms of emphasizing agency and empowering older adults to take ownership of PA, we need to be open to end-users deciding not to engage with systems in certain situations, carefully explore reasons, and also accept that technology may not be the answer for every older person wishing to remain physically active or engage in physical therapy.

Challenge 2: Reconciling participatory design and design by proxy.

In terms of representing older adults' interests throughout the research process, the level of direct involvement of end-user is another challenge that needs to be addressed by our research community. Our analysis revealed that most projects adopted a user-centred design approach that moves beyond the use of surrogates reported by Cozza et al. (2017); however, only a small number of projects directly involved older adults through practice of co-design. Instead, many papers reported the involvement of therapists or carers in lieu of the older person, and while their perspective is certainly helpful and very relevant in the context of systems to support therapy and rehabilitation or when designing for groups of end-users with limited ability to express their needs and desires, designing by proxy – asking other stakeholders to represent the interests of the intended group of end-users – bears the risk of systematically misrepresenting the interests of older people. In the future, HCI research should further address the challenge of balancing the needs of all stakeholders, while maintaining a strong perspective on not only needs but also preferences of older people as end-users of technology. Where possible, one way of addressing this issue would be the further exploration and adaptation of interdisciplinary and participatory design approaches, directly involving older adults not only in the evaluation but also in the design of technology.

Challenge 3: Building on strengths and offer challenge, but being mindful of vulnerability.

As suggested by research included in our review, creating systems that adequately challenge older adults offers the opportunity of enabling them to build skill in an empowering way. However, this may increase the risk of vulnerability for certain groups of end-users, for example, if exercises are too difficult or therapeutic goals are overly ambitious. To this end, there is an opportunity in ability-based design that focuses on strengths of users (also see Wobbrock et al., 2011); this could be coupled with adaptive systems that dynamically adjust difficulty of activity to user performance (an approach commonly applied in games; Hunicke, 2005). Beyond better accommodating a broad range of users, this approach offers potential for compassionate design, for example, by dynamically adapting to daily performance of vulnerable users. Further, it would generally facilitate a positive user experience that emphasise competence through a good fit between user ability and challenge provided.

Challenge 4: Combining functionalism and hedonism, and designing to improve quality of life.

The final challenge is the tension that exists between functionalism and hedonism. While the accessibility community has previously highlighted the importance of older adults' values when creating technology to support PA (Fan et al., 2012), only one paper made reference to the

importance of hedonism, and ideas around the wider appeal of technology (e.g., in terms of visual presentation or technical devices used) being widely absent from the remaining projects. In this context, it is important to recognize the importance of functionalist perspectives to ensure basic suitability of technology, but also be mindful of the challenges this approach might create throughout the research process, possibly introducing a dehumanizing focus on abilities and physical functioning. The conflict between functionalism and hedonism was also present in the articulation of research goals. Many of the analysed projects focused on the potential of technology to improve functioning through PA, but fell short of raising questions around the quality of life. To this end, we would like to challenge the HCI research community to treat functionalism and hedonism as equally important aspects of technology design for older adults, reflecting broader discourse on technology and older adults (Vines et al., 2015) along with wider societal debate on quality of life in late life.

Conclusion

HCI research recognises the potential that technology has to support PA among older adults, but is largely driven by contemporary policy that adopts a deficit-based perspective on ageing, while simultaneously promoting ideas on active ageing that put potentially harmful pressure on the individual to live up to notions of successful activity. Moving beyond functionalist approaches to technology design offers the opportunity of creating systems that recognise these risks, and strive to leverage the full opportunity that technology has to contribute to the lives of older people when reflecting their values, and embracing needs and preferences not only in terms of physical health, but with a broader view on the emphasis of agency, enjoyment, and overall well-being in late life.

Summary of Impact

Through cross-disciplinary collaboration between critical gerontology, sports science, and HCI, our paper aims to make three contributions to a research agenda that encourages critical reflection on discourse around ageing and the technologies we build to advance the design of relevant and respectful technology to support PA in late life.

1. We challenge the research community to look beyond the potential of technology to deliver prescriptive PA interventions for older adults. Together, we want to consider alternative narratives for technologies that support older adults' adaptation and development of new modalities of embodied competence, rather than reducing their role to passive recipients of PA technologies.

2. Through a systematic analysis of existing technology interventions to encourage PA among older adults, we do not only offer constructive criticism of previous work and reflection on our own designs, but also contribute a framework to inform future research and technology design, offering a tool for others looking to ensure that technology they create for older users is not only accessible and acceptable, but also empowering and respectful.

3. Drawing from this systematic analysis, we provide an overview of shortcomings and positive outcomes of technology design focusing on PA among older adults, and how they relate to findings from gerontology and sports science. Thereby, our paper aims to inform a cross-disciplinary research agenda around technology, PA, and older adults that puts the older person and their needs at the heart of technology design.

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Biography (150 words)

Adam Evans joined the Department of Nutrition, Exercise and Sport (NEXS) at KU in July 2015 (see http://www.nexs.ku.dk). Previously worked at the School of Sport and Exercise Science, University of Lincoln, University of Strathclyde (Glasgow) and studied at the University of Hull (PhD) Loughborough University (BSc hons and MSc) and University of Leeds (MSc). Adam is the is co-founder of the HART research group (see www.hartresearch.org.uk/).

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