Which behaviour change techniques are effective in promoting physical activity among older people with dementia? A call for research into three underexplored avenues

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People with dementia represent a growing proportion of the older adult population. Estimates suggest 46.8 million people worldwide had dementia in 2015, that this figure will rise to 131.5 million by 2050 (Prince et al., 2015), and that 90% of people with dementia are aged 65 and above (World Health Organization, 2012). These degenerative diseases gradually impair memory, executive functioning, and communication (Butler & Radhakrishnan, 2012; Prince et al., 2015). Nonetheless, people with dementia should be encouraged to continue to enjoy good health for as long as possible as part of a public health strategy and for their continued quality of life (Ginis et al., 2017; Nyman & Szymczynska, 2016).

Behaviour change techniques (BCTs) are widely used in health promotion interventions and in particular the promotion of physical activity. However, the use of BCTs in physical activity promotion that rely on cognitive processes may be ineffective among people with dementia because of their cognitive impairment. There is currently no direct evidence to address this issue amongst people with dementia and so it is open to empirical study (van der Wardt et al., 2017). Inconclusive evidence comes from a recent systematic review of BCTs used to promote physical activity among people with dementia (Nyman, Adamczewska, & Howlett, 2018). While potential promise was found for goal setting (behaviour), this BCT was not used in isolation but used with other BCTs that also had potential promise: social support (unspecified) and using a credible source. Therefore, the effectiveness of these three BCTs when used in isolation with people with dementia is unknown, and the remaining BCTs reviewed were either used too infrequently to identify potential promise or were only used in ineffective interventions. Therefore, research is

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needed to identify which BCTs are effective in promoting physical activity among people with dementia.

In this editorial, I encourage physical activity researchers and clinicians working with older people with dementia to explore the use of approaches that do not rely on cognitive processes. These approaches may be shown to be more effective when working with people with cognitive impairment given the nature of their condition, and stimulate novel strategies for encouraging uptake and adherence to physical activities. Further research might also illuminate when particular BCTs are more useful in considering the severity of an individual's dementia symptoms. People with dementia are heterogeneous and may have relatively mild, moderate, or severe symptoms. Therefore the trajectory of use of BCTs that do not rely on cognitive processes may gradually become more useful as a person with dementia's severity worsens. In the following, I illustrate the predominant use of BCTs that rely on cognitive processes with reference to a widely-used taxonomy of BCTs (Michie et al., 2013). I then propose three avenues of research where BCTs could be more effectively tested with people with dementia: partnership with carers, behaviourist approaches, and choice architecture.

Predominant use of behaviour change techniques that rely on cognitive processes

By way of illustration, a taxonomy of BCTs and two systematic reviews of BCTs used in physical activity interventions demonstrate the current predominant use of BCTs that rely on cognitive processes. A widely used taxonomy identified 93 BCTs to use in health promotion (Michie et al., 2013). Of these, the majority rely on cognitive processes (n=65), with the remaining relying on non-conscious processes (18 and 10 that can be categorised under behaviourist and choice architecture approaches respectively) (see Table 1, online supplementary material). Similarly, researchers have predominantly used BCTs that rely on

cognitive processes (see Sheeran, Klein, & Rothman, 2017), as shown in a sample of two systematic reviews that have used Michie et al.'s (2013) taxonomy or similar with older people (French, Olander, Chisholm, & McSharry, 2014) and people with dementia (Nyman et al., 2018) (see Table 2, online supplementary material). Similar observations can be drawn from other recently conducted systematic reviews of BCTs used to improve exercise adherence among older people (Room, Hannink, Dawes, & Barker, 2017) and by physiotherapists to promote physical activity (Kunstler et al., 2018). From these systematic reviews, it is evident that the potential for BCTs that do not rely on cognitive processes is relatively underexplored. Rather than use BCTs that rely on the cognitive processing ability of people with dementia, three alternative approaches hold promise for future physical activity interventions that are outlined below.

Partnership with carers

The cognitive processing of informal carers could be enlisted to support people with dementia to engage with BCTs for the purpose of promoting physical activity. Enlisting the support of carers is perhaps the most frequently used approach by clinicians working with people with dementia (e.g. by physiotherapists co-developing therapeutic goal plans). Carers could be effectively used in numerous BCTs, including sharing the task of setting goals, action and coping planning, or reminding the people with dementia of distal rewards. While there is currently no direct evidence of shared cognitive processing for behaviour change among people with dementia and their informal carers, there are some studies with the general adult population that have tested the use of working with couples rather than individuals to enact behaviour change. For example, a randomised controlled trial tested a couple-based telephone intervention where individuals made goals and action plans for behaviour change and their partners were encouraged to support these plans. While the goals

and plans were not jointly created by couples, the couple-based intervention led to an improvement in health behaviours such as an increase in moderate physical activity and reduction in fat consumption, among patients who needed to reduce their cholesterol to avert coronary heart disease (Voils et al., 2013). Other studies suggest that the social support of a partner may well facilitate behaviour change efforts. For example, a study found that couples where both partners participate in a physical activity intervention are more likely to increase their physical activity levels than couples where only one partner participates or among those with no intimate partner (Gellert, Ziegelmann, Warner, & Schwarzer, 2011).

While there is potential for enlisting the support of carers of people with dementia in the use of BCTs to promote physical activity, a systematic review found self-regulatory BCTs to be associated with both lower levels of physical activity self-efficacy and behaviour among adults aged 60+ (French et al., 2014). This is in contrast to previous systematic reviews that identified evidence for the use of self-regulatory BCTs with the general adult population to improve diet and physical activity participation (Greaves et al., 2011; Michie et al., 2009). A recent systematic review also suggests greater potential for self-regulatory BCTs to improve exercise adherence among older people (Room et al., 2017). In addition, as noted above, a recent systematic review identified potential promise for the use of self-regulatory BCTs to promote physical activity among people with dementia (Nyman et al., 2018). Further experimental studies will be able to clarify the effectiveness of self-regulatory BCTs among older people and people with dementia, and under what conditions shared cognitive processing with an informal carer might facilitate behaviour change.

As people with dementia's symptoms worsen and they become more dependent on their informal carers, it is then likely that the role of the carer becomes increasingly important in facilitating physical activity. However this may come at a cost of to the carer and potentially lead to carer burden (van Alphen, Hortobágyi, & van Heuvelen, 2016). In future

research there are four challenges that may arise when working in partnership with informal carers to promote physical activity. First, one assumes that there is an informal carer available to provide support for the people with dementia. In the UK, approximately a third of people with dementia in the community live alone and therefore are not supported by a spouse (Miranda-Castillo, Woods, & Orrell, 2010). Second, for people with dementia who are supported by a spouse, the carer may not be able to support them in the prescribed manner. Informal caregivers themselves may have poor health; one study with informal carers found that 81.5% had at least one chronic illness and 60.5% had two or more (Wang, Robinson, & Carter-Harris, 2014). Measures of burnout and depression among carers of people with dementia have also been reported to be as high as 23-42% and 30% respectively (Schoenmakers, Buntinx, & De Lepeleire, 2009; Truzzi et al., 2012). Third, some BCTs engage individuals to take ownership of their regular physical activity level through goal-setting and a plan of implementation. If this process for the people with dementia is shared with their carer, then ownership of the goal and its associated plan may become diluted. This may become a barrier to adherence especially if the people with dementia's memory of setting the goal and forming the action plan diminishes. Prompting by the carer to continue to adhere to the action plan and reach the goal may then be perceived as purely in the carer's interest, and performance of the behaviour would shift from intrinsic motivation (to meet a goal that one wants to achieve) to extrinsic (to comply with another's wishes), which may negatively impact on adherence (Deci & Ryan, 2000). Fourth, the above approach assumes that people with dementia want to be supported by their informal carer, which is usually their spouse. A previous study has found that for a weight-loss programme, while women achieved greater weight loss when supported by their husband, men achieved greater weight loss when working alone (Wing, Marcus, Epstein, & Jawad, 1991). Therefore, the demographic factors, individual circumstances, and wider sociocultural context may have great influence on the

relationship dynamic and whether the people with dementia will be facilitated or inhibited in their physical activity behaviour change by the support of their carer.

Behaviourist approaches

Non-conscious approaches to promoting health could be used as an alternative to relying on the cognitive processing ability of people with dementia. It has been demonstrated that people can learn behaviours implicitly, i.e. via non-conscious processes (Hollands, Marteau, & Fletcher, 2016; Marteau, Hollands, & Fletcher, 2012; Zwart, Vissers, Kessels, & Maes, 2017). While the role of cognitive processes in implicit learning has been acknowledged (Kirsch, Lynn, Vigorito, & Miller, 2004; Papies, 2016; Shanks & St John, 1994), the essence of behaviourist approaches is on non-conscious processes for behaviour change (Johnston, 2015).

Behaviourist approaches such as operant and classical conditioning could be more widely applied with people with dementia to promote physical activity. Such approaches have been used in a therapeutic context to reduce unsociable behaviours and symptoms that can develop among people with dementia (Rabins, 1994). For example, operant conditioning has been used to reduce aggressive behaviour among people with dementia in long-term care (Vaccaro, 1988). With classical conditioning, the pairing of two stimuli could develop expectation of one feature in the environment to arise on presentation of the other and vice versa (Pavlov, 1927). For example, one could stimulate people with dementia to engage in exercise or facilitate their memory of particular exercises through repeated pairing of stimulus such as always conducting them to the same music.

Previous studies have shown people with dementia can learn behaviours implicitly via cue-outcome associations despite impaired explicit memory (Eldridge, Masterman, & Knowlton, 2002). To promote physical activity, one could stimulate the development of

muscle or kinaesthetic memory whereby movements are performed in a set pattern and are repeated. This would reflect other motor tasks that once learned are performed without conscious awareness (e.g. to ride a bike) (Lally & Gardner, 2013). This route of learning holds particular promise due to the simplicity of implicit learning approaches and as motor tasks are the last form of memory to decline in people with dementia (van Halteren-van Tilborg, Scherder, & Hulstijn, 2007). However, the challenge for testing implicit learning BCTs is to design studies where they can be isolated from other BCTs. For example, classical conditioning experiments in care homes could be difficult to test if routines are already established that pair stimuli.

Choice architecture

Another approach to the use of non-conscious processes for behaviour change is choice architecture or 'nudging' (Thaler & Sunstein, 2008). The approach is not new, in that it builds on the last century's psychological and sociological knowledge of the impact of the environment on behaviour. Though, its appeal lies in encouraging people to adopt healthy behaviours without the use of legislation, regulation, or altering economic incentives (Marteau, Ogilvie, Roland, Suhrcke, & Kelly, 2011). Choice architecture has potential for increasing public health by 'nudging' people to choose a healthy behavioural choice at the point when the behaviour is required. For example, this might be encouraging people to use the stairs in a shopping centre by displaying a sign at the elevator that informs people of the health benefits of using the stairs. Use of such signage or 'point-of-decision prompts' have been effective in increasing stair use in public places (Soler et al., 2015).

For behaviour change with people with dementia, this approach has promise as an avenue for future research as its premise is that the desired behaviour (e.g. walking up the stairs) is prompted by altering the environment to be performed immediately (i.e., does not

require planning ahead or remembering to do an action later) and with minimal cognitive effort (i.e., not by attempting to change an individual's beliefs but only their behaviour at that particular moment), assuming that the point of decision prompts are not cognitively demanding to read and process. Use of this approach may also be desirable for simultaneously achieving both public health and inclusivity agendas including the promotion of active and healthy ageing (Annear et al., 2014; World Health Organization, 2002, 2010) and for communities and societies be more inclusive and 'dementia friendly' (Department of Health, 2012; World Health Organization, 2012). For example, environments designed to encourage people to be more physically active via non-cognitively demanding interventions (e.g. making outdoor shopping areas more pleasant to walk around, provide benches for people to rest, and restricting motor traffic in such areas) may be effective in promoting physical activity for people of all ages and abilities. Choice architecture interventions may also be useful for dementia-specific contexts. For example, the frequency of behaviours among people with dementia that carers find challenging - disorientated walking, repetition (e.g. picking or vocalisations), and inappropriate sexual behaviour - have been reduced in an institutional setting through changes to the environment, for example, through the use of colour cues to reduce disorientated walking (Hussian, 1982).

However, caution has been raised about the lack of rigorous scientific evidence to support choice architecture (Marteau et al., 2011). The effectiveness of a choice architecture intervention would also depend on the nature of the specific intervention deployed and its context (Skov, LourenÇo, Hansen, Mikkelsen, & Schofield, 2013). Recent work has provided a typology of choice architecture interventions in micro-environments and mapped available evidence to this typology (Hollands et al., 2013; 2017). However, there is currently no guidance on which specific choice architecture interventions should be deployed and with whom.

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Conclusion

In testing the effectiveness of BCTs to promote physical activity, researchers have predominantly used approaches that rely on cognitive processes. Such approaches may be ineffective among people with dementia due to their cognitive impairment. Three avenues for future research have been proposed that may be more effective in promoting physical activity among people with dementia by drawing on the cognitive processing of others (partnership with carers), and non-conscious processes (behaviourist and choice architecture approaches). Researchers are encouraged to test the effectiveness of each of these promising approaches to identify when, where, and with whom such BCTs may be most effective in promoting physical activity among people with dementia to better promote health amongst this growing segment of the older adult population.

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References

Annear, M., Keeling, S., Wilkinson, T., Cushman, G., Gidlow, B., & Hopkins, H. (2014). Environmental influences on healthy and active ageing: A systematic review. *Ageing & Society, 34*(4), 590-622.

Butler, R., & Radhakrishnan, R. (2012). Dementia: Systematic review 1001. *BMJ Clinical Evidence, Accessed 22/02/2017*. doi: http://clinicalevidence.bmj.com/x/systematic-review/1001/overview.html.

Deci, E. L., & Ryan, R. M. (2000). The "what" and "why" of goal pursuits: Human needs and the self-determination of behavior. *Psychological Inquiry, 11*(4), 227-268.

Department of Health. (2012). *Prime Minister's challenge on dementia - Delivering major improvements in dementia care and research by 2015.* London: Department of Health.

Eldridge, L. L., Masterman, D., & Knowlton, B. J. (2002). Intact implicit habit learning in Alzheimer's disease. *Behavioral Neuroscience, 116*(4), 722-726.

French, D. P., Olander, E. K., Chisholm, A., & McSharry, J. (2014). Which behaviour change techniques are most effective at increasing older adults' self-efficacy and physical activity behaviour? A systematic review. *Annals of Behavioral Medicine, 48*(2), 225-234.

Gellert, P., Ziegelmann, J. P., Warner, L. M., & Schwarzer, R. (2011). Physical activity intervention in older adults: Does a participating partner make a difference? *European Journal of Ageing, 8*(3), 211-219.

Ginis, K. A., Heisz, J., Spence, J. C., Clark, I. B., Antflick, J., Ardern, C. I., et al. (2017). Formulation of evidence-based messages to promote the use of physical activity to prevent and manage Alzheimer's disease. *BMC Public Health, 17*(1), e209. DOI: 10.1186/s12889-017-4090-5.

Nyman, S. R. (in press). Which behaviour change techniques are effective in promoting physical activity among older people with dementia? A call for research into three underexplored avenues. *Journal of Aging and Physical Activity*.

Greaves, C. J., Sheppard, K. E., Abraham, C., Hardeman, W., Roden, M., Evans, P. H., . . . Group, I. S. (2011). Systematic review of reviews of intervention components associated with increased effectiveness in dietary and physical activity interventions. *BMC Public Health, 11*, e119. doi: https://doi.org/10.1186/1471-2458-11-119.

Hollands, G. J., Bignardi, G., Johnston, M., Kelly, M. P., Ogilvie, D., Petticrew, M., . . . Marteau, T. M. (2017). The TIPPME intervention typology for changing environments to change behaviour. *Nature Human Behaviour, 1,* 0140. doi: 10.1038/s41562-017-0140

Hollands, G. J., Marteau, T. M., & Fletcher, P. C. (2016). Non-conscious processes in changing health-related behaviour: A conceptual analysis and framework. *Health Psychology Review, 10*(4), 361-394.

Hollands, G. J., Shemilt, I., Marteau, T. M., Jebb, S. A., Kelly, M. P., Nakamura, R., . . . Ogilvie, D. (2013). Altering micro-environments to change population health behaviour: Towards an evidence base for choice architecture interventions. *BMC Public Health, 13*, e1218. doi: https://doi.org/10.1186/1471-2458-13-1218.

Hussian, R. A. (1982). Stimulus control in the modification of problematic behavior in elderly institutionalized patients. *International Journal of Behavioral Geriatrics, 1*(1), 33-42.

Johnston, M. (2015). What more can we learn from early learning theory? The contemporary relevance for behaviour change interventions. *British Journal of Health Psychology, 21*(1), 1-10.

Kirsch, I., Lynn, S. J., Vigorito, M., & Miller, R. R. (2004). The role of cognition in classical and operant conditioning. *Journal of Clinical Psychology, 60*(4), 369-392.

Kunstler, B. E., Cook, J. L., Freene, N., Finch, C. F., Kemp, J. L., O'Halloran, P. D., & Gaida, J. E. (2018). Physiotherapists use a small number of behaviour change

Nyman, S. R. (in press). Which behaviour change techniques are effective in promoting physical activity among older people with dementia? A call for research into three underexplored avenues. *Journal of Aging and Physical Activity*.

techniques when promoting physical activity: A systematic review comparing experimental and observational studies. *Journal of Science and Medicine in Sport, 21*(6), 609-615.

Lally, P., & Gardner, B. (2013). Promoting habit formation. *Health Psychology Review, 7*(Suppl 1), S137-S158.

Marteau, T. M., Hollands, G. J., & Fletcher, P. C. (2012). Changing human behavior to prevent disease: The importance of targeting automatic processes. *Science, 337*, 1492-1494.

Marteau, T. M., Ogilvie, D., Roland, M., Suhrcke, M., & Kelly, M. P. (2011). Juding nudging: Can nudging improve population health? *BMJ, 342*, d228, Published online 25 January. doi: https://doi.org/10.1136/bmj.d228.

Michie, S., Abraham, C., Whittington, C., McAteer, J., & Gupta, S. (2009). Effective techniques in healthy eating and physical activity interventions: A meta-regression. *Health Psychology, 28*(6), 690-701.

Michie, S., Richardson, M., Johnston, M., Abraham, C., Francis, J., Hardeman, W., . . . Wood, C. E. (2013). The behavior change technique taxonomy (v1) of 93 hierarchically clustered techniques: Building an international consensus for the reporting of behavior change interventions. *Annals of Behavioral Medicine, 46*(1), 81-95.

Miranda-Castillo, C., Woods, B., & Orrell, M. (2010). People with dementia living alone: What are their needs and what kind of support are they receiving? *International Psychogeriatrics, 22*(4), 607-617.

Nyman, S. R., Adamczewska, N., & Howlett, N. (2018). Systematic review of behaviour change techniques to promote participation in physical activity among people with dementia. *British Journal of Health Psychology, 23*(1), 148-170.

Nyman, S. R. (in press). Which behaviour change techniques are effective in promoting physical activity among older people with dementia? A call for research into three underexplored avenues. *Journal of Aging and Physical Activity*.

Nyman, S. R., & Szymczynska, P. (2016). Meaningful activities for improving the wellbeing of people with dementia: Beyond mere pleasure to meeting fundamental psychological needs. *Perspectives in Public Health, 136* (2), 99-107.

Papies, E. K. (2016). Health goal priming as a situated intervention tool: How to benefit from nonconscious motivational routes to health behaviour. *Health Psychology Review, 10*(4), 408-424.

Pavlov, I. P. (1927). *Conditioned reflexes*. Oxford: Oxford University Press.

Prince, M., Wimo, A., Guerchet, M., Ali, G.-C., Wu, Y.-T., & Prina, M. (2015). *World Alzheimer report 2015. The global impact of dementia: An analysis of pravalence, incidence, cost and trends*. London: Alzheimer's Disease International.

Rabins, P. V. (1994). The phenomenology of behavior: An overview of behavioral principles. *Alzheimer Disease and Associated Disorders, 8*(Suppl 3), 61-65.

Room, J., Hannink, E., Dawes, H. & Barker, K. (2017). What interventions are used to improve exercise adherence in older people and what behavioural techniques are they based on? A systematic review. *BMJ Open*, *7*(12), e019221. DOI: 10.1136/bmjopen-2017-019221.

Schoenmakers, B., Buntinx, F., & De Lepeleire, J. (2009). The relation between care giving and the mental health of caregivers of demented relatives: A cross-sectional study. *European Journal of General Practice, 15*(2), 99-106.

Shanks, D. R., & St John, M. F. (1994). Characteristics of dissociable human learning systems. *Behavioral and Brain Sciences, 17*(3), 367-447.

Sheeran, P., Klein, W. M. P., & Rothman, A. J. (2017). Health behavior change: Moving from observation to intervention. *Annual Review of Psychology, 68*, 573-600.

Skov, L. R., LourenÇo, S., Hansen, G. L., Mikkelsen, B. E., & Schofield, C. (2013). Choice architecture as a means to change eating behaviour in self-service settings: A systematic review. *Obesity Reviews, 14*, 187-196.

Soler, R. E., Leeks, K. D., Buchanan, L. R., Brownson, R. C., Heath, G. W., Hopkins, D. H., & Services, t. T. F. o. C. P. (2015). Point-of-decision prompts to increase stair use: A systematic review update. *American Journal of Preventive Medicine, 38*(2S), S292-S300.

Thaler, R. H., & Sunstein, C. R. (2008). *Nudge: Improving decisions about health, wealth and happiness*. London: Yale University Press.

Truzzi, A., Valente, L., Ulstein, I., Engelhardt, E., Laks, J., & Engedal, K. (2012). Burnout in familial caregivers of patients with dementia. *Revista Brasileira de Psiquiatria, 34*(4), 405-412.

Vaccaro, F. J. (1988). Application of operant procedures in a group of institutionalized aggressive geriatric patients. *Psychology and Aging, 3*(1), 22-28.

van Alphen, H. J. M., Hortobágyi, T., & van Heuvelen, M. J. G. (2016). Barriers, motivators, and facilitators of physical activity in dementia patients: A systematic review. *Archives of Gerontology and Geriatrics, 66*, 109-118.

van der Wardt, V., Hancox, J., Gondek, D., Logan, P., Nair, R.D., Pollock, K., Harwood, R. (2017). Adherence support strategies for exercise interventions in people with mild cognitive impairment and dementia: A systematic review. *Preventive Medicine Reports, 7*, 38-45.

van Halteren-van Tilborg, I. A. D. A., Scherder, E. J. A., & Hulstijn, W. (2007). Motor-skill learning in Alzheimer's disease: A review with an eye to the clinical practice. *Neuropsychology Review, 17*(3), 203-212.

Nyman, S. R. (in press). Which behaviour change techniques are effective in promoting physical activity among older people with dementia? A call for research into three underexplored avenues. *Journal of Aging and Physical Activity*.

Voils, C. I., Coffman, C. J., Yancy Jr, W. S., Weinberger, M., Jeffreys, A. S., Datta, S., . . . Bosworth, H. B. (2013). A randomized controlled trial to evaluate the effectiveness of CouPLES: A spouse-assisted lifestyle change intervention to improve low-density lipoprotein cholesterol. *Preventive Medicine, 56*(1), 46-52.

Wang, X. R., Robinson, K. M., & Carter-Harris, L. (2014). Prevalence of chronic illnesses and characteristics of chronically ill informal caregivers of persons with dementia. *Age and Ageing, 43*(1), 137-141.

Wing, R. R., Marcus, M. D., Epstein, L. H., & Jawad, A. (1991). A "family-based" approach to the treatment of obese type II diabetic patients. *Journal of Consulting and Clinical Psychology, 59*(1), 156-162.

World Health Organization. (2002). *Active ageing: A policy framework.* Geneva: World Health Organization.

World Health Organization. (2010). *Global recommendations on physical activity for health.* Geneva: World Health Organization.

World Health Organization. (2012). *Dementia: A public health priority*. Geneva: World Health Organization.

Zwart, F. S., Vissers, C. T. W. M., Kessels, R. P. C., & Maes, J. H. R. (2017). Procedural learning across the lifespan: A systematic review with implications for atypical development. *Journal of Neuropsychology, Published online 08 October*. doi: 10.1111/jnp.12139.

Supplementary material

Table 1

List of behaviour change techniques as reported in the BCT Taxonomy V1 (Michie et al., 2013) and categorised for use in future with people with dementia according to reliance on cognitive processes (partnership with carers) or non-conscious processes (behaviourist approaches or choice architecture)

Behaviour change technique	Category
1.1. Goal setting (behaviour)	Partnership with carers
1.2. Problem solving	Partnership with carers
1.3. Goal setting (outcome)	Partnership with carers
1.4. Action planning	Partnership with carers
1.5. Review behaviour goal(s)	Partnership with carers
1.6. Discrepancy between current behaviour and goal	Partnership with carers
1.7. Review outcome goal(s)	Partnership with carers
1.8. Behavioural contract	Partnership with carers
1.9. Commitment	Partnership with carers
2.1. Monitoring of behaviour by others without feedback	Partnership with carers
2.2. Feedback on behaviour	Partnership with carers
2.3. Self-monitoring of behaviour	Partnership with carers
2.4. Self-monitoring of outcome(s) of behaviour	Partnership with carers
2.5. Monitoring of outcome(s) of behaviour without feedback	Partnership with carers
2.6. Biofeedback	Partnership with carers
2.7. Feedback on outcome(s) of behaviour	Partnership with carers
3.1. Social support (unspecified)	Partnership with carers
3.2. Social support (practical)	Partnership with carers

3.3. Social support (emotional)	Partnership with carers
4.1. Instruction on how to perform the behaviour	Partnership with carers
4.2. Information about antecedents	Partnership with carers
4.3. Re-attribution	Partnership with carers
4.4. Behavioural experiments	Partnership with carers
5.1. Information about health consequences	Partnership with carers
5.2. Salience of consequences	Partnership with carers
5.3. Information about social and environmental consequences	Partnership with carers
5.4. Monitoring of emotional consequences	Partnership with carers
5.5. Anticipated regret	Partnership with carers
5.6. Information about emotional consequences	Partnership with carers
6.1. Demonstration of the behaviour	Partnership with carers
6.2. Social comparison	Partnership with carers
6.3. Information about others' approval	Partnership with carers
7.1. Prompts/cues	Choice architecture
7.2. Cue signalling reward	Choice architecture
7.3. Reduce prompts/cues	Choice architecture
7.4. Remove access to the reward	Choice architecture
7.5. Remove aversive stimulus	Behaviourist
7.6. Satiation	Behaviourist
7.7. Exposure	Behaviourist
7.8. Associative learning	Behaviourist
8.1. Behavioural practice/rehearsal	Behaviourist
8.2. Behaviour substitution	Behaviourist
8.3. Habit formation	Behaviourist

8.4. Habit reversal	Behaviourist
8.5. Overcorrection	Behaviourist
8.6. Generalisation of target behaviour	Behaviourist
8.7. Graded tasks	Behaviourist
9.1. Credible source	Partnership with carers
9.2. Pros and cons	Partnership with carers
9.3. Comparative imagining of future outcomes	Partnership with carers
10.1. Material incentive (behaviour)	Partnership with carers
10.2. Material reward (behaviour)	Partnership with carers
10.3. Non-specific reward	Partnership with carers
10.4. Social reward	Partnership with carers
10.5. Social incentive	Partnership with carers
10.6. Non-specific incentive	Partnership with carers
10.7. Self-incentive	Partnership with carers
10.8. Incentive (outcome)	Partnership with carers
10.9. Self-reward	Partnership with carers
10.10. Reward (outcome)	Partnership with carers
10.11. Future punishment	Partnership with carers
11.1. Pharmacological support	Partnership with carers
11.2. Reduce negative emotions	Partnership with carers
11.3. Conserving mental resources	Partnership with carers
11.4. Paradoxical instructions	Partnership with carers
12.1. Restructuring the physical environment	Choice architecture
12.2. Restructuring the social environment	Choice architecture
12.3. Avoidance/reducing exposure to cues for the behaviour	Choice architecture

12.4. Distraction	Choice architecture
12.5. Adding objects to the environment	Choice architecture
12.6. Body changes	Choice architecture
13.1. Identification of self as role model	Partnership with carers
13.2. Framing/reframing	Partnership with carers
13.3. Incompatible beliefs	Partnership with carers
13.4. Valued self-identify	Partnership with carers
13.5. Identity associated with changed behaviour	Partnership with carers
14.1. Behaviour cost	Partnership with carers
14.2. Punishment	Behaviourist
14.3. Remove reward	Behaviourist
14.4. Reward approximation	Behaviourist
14.5. Rewarding completion	Partnership with carers
14.6. Situation-specific reward	Behaviourist
14.7. Reward incompatible behaviour	Behaviourist
14.8. Reward alternative behaviour	Behaviourist
14.9. Reduce reward frequency	Behaviourist
14.10. Remove punishment	Partnership with carers
15.1. Verbal persuasion about capability	Partnership with carers
15.2. Mental rehearsal of successful performance	Partnership with carers
15.3. Focus on past success	Partnership with carers
15.4. Self-talk	Partnership with carers
16.1. Imaginary punishment	Partnership with carers
16.2. Imaginary reward	Partnership with carers
16.3. Vicarious consequences	Partnership with carers

Table 2

Frequency of behaviour change techniques reported in two systematic reviews of interventions to promote physical activity

	Systematic review	
	French et al. (2014)	Nyman et al. (2018)[1]
Population	Older adults	People with dementia
Behaviour change technique reported using numbers from BCT taxonomy V1 (Michie et al., 2013)[2]		
Partnership with carers (frequency %)	*88%*	*77%*
1.1. Goal setting (behaviour)	12	3
1.2 Problem solving	10	
1.2 Relapse prevention	3	
1.4 Action planning	7	1
1.5 Review behaviour goal(s)	6	
2.1 Monitoring of behaviour by others without feedback		1
2.2 / 2.7 Provide feedback on performance	6	
2.3 Self-monitoring of behaviour	9	1
2.4 Self-monitoring of outcome(s) of behaviour		1
3.1 Social support (unspecified)		3
3.1 Plan social support/ social change	10	
3.1 Motivational interviewing	2	
3.3 Social support (emotional)		1

Nyman, S. R. (in press). Which behaviour change techniques are effective in promoting physical activity among older people with dementia? A call for research into three underexplored avenues. *Journal of Aging and Physical Activity*.

4.1 Instruction on how to perform the behaviour	11	5
4.1 Provide information on where and when to perform the behaviour	3	
5.3 / 5.6 Provide information on consequences		
5.3 / 5.6 Provide information on consequences of behaviour in general	11	
5.3 / 5.6 Provide information on consequences of behaviour for the individual	6	
6.1 Demonstration of the behaviour	7	5
6.2 Social comparison	4	
9.1 Credible source		3
10.2 /10.3/10.4/10.9/10.10 Provide contingent rewards		
10.2 /10.3/10.4/10.9/10.10 Provide rewards contingent on successful behaviour	3	
10.2 /10.3/10.4/10.9/10.10 Provide rewards contingent on effort or progress towards behaviour	2	
11.2 Reduce negative emotions	3	
15.2 Mental rehearsal of successful performance	2	
15.3 Focus on past success	3	
Behaviourist approaches (frequency %)	*11%*	*23%*
8.1. Behavioural practice/rehearsal	13	5
8.7 Graded tasks	2	2
Choice architecture (frequency %)	*1%*	*0%*
7.3. Reduce prompts/cues	2	
Total	137	31

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Note. [1]Only trials that reported physical activity behaviour were included. [2]Where BCT reporting was ambiguous in relation to the taxonomy, more than one behaviour change technique is listed together (e.g. “provide feedback on performance” could be either 2.2 feedback on behaviour or 2.7 feedback on outcome(s) of behaviour. Separate lines have been included in instances where the behaviour change technique was detailed with greater specificity than the taxonomy (e.g. “1.2 Prompt barrier identification includes relapse prevention).

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