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Effective techniques for changing physical activity and healthy eating intentions and behaviour: A systematic review and meta-analysis

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Purpose. The primary aim of this study was to review the evidence on the impact of a change in intention on behaviour and to identify (1) behaviour change techniques (BCTs) associated with changes in intention and (2) whether the same BCTs are also associated with changes in behaviour.

Methods. A systematic review was conducted to identify interventions that produced a significant change in intention and assessed the impact of this change on behaviour at a subsequent time point. Each intervention was coded using a taxonomy of BCTs targeting healthy eating and physical activity. A series of meta-regression analyses were conducted to identify effective BCTs.

Results. In total, 25 reports were included. Interventions had a medium-to-large effect on intentions ($d_+ = 0.64$) and a small-to-medium effect ($d_+ = 0.41$) on behaviour. One BCT, 'provide information on the consequences of behaviour in general', was significantly associated with a positive change in intention. One BCT, 'relapse prevention/coping planning', was associated with a negative change in intention. No BCTs were found to have significant positive effects on behaviour. However, one BCT, 'provide feedback on performance', was found to have a significant negative effect. BCTs aligned with social cognitive theory were found to have significantly greater positive effects on intention ($d_+ = 0.83$ vs. 0.56, $p < .05$), but not behaviour ($d_+ = 0.35$ vs. 0.23, *ns*), than those aligned with the theory of planned behaviour.

Conclusions. Although the included studies support the notion that a change in intention is associated with a change in behaviour, this review failed to produce evidence on how to facilitate behaviour change through a change in intention. Larger meta-analyses incorporating interventions targeting a broader range of behaviours may be warranted.

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Statement of contribution

What is already known on this subject?

- Prior research on the causal relationship between intention and behaviour has produced mixed findings.
- Further experimental research to determine the precise nature of these variables is clearly warranted.
- However, precise guidance on *how* to change intention is still lacking.

What does this study add?

- This study aimed to identify behaviour change techniques associated with changes in intention and behaviour.
- Techniques with positive effects on intention were identified; however, these did not have an impact on behaviour.
- Larger meta-analyses incorporating interventions targeting a broader range of behaviours may be warranted.

Increasing the intention to act, a variable considered to capture the motivational factors that influence behaviour (Ajzen, 1991), is the primary aim of many interventions aiming to facilitate health behaviour change. This is due to several key theories viewing intention as the variable most proximal to behaviour. The association between intention and behaviour is well established, with an average correlation of .53, accounting for 28% of the variance across multiple behaviours (Sheeran, 2002). The role of intention as a mediator of behaviour change has also been demonstrated, albeit in a less convincing fashion. In the largest study undertaken to date on this topic, a meta-analysis of 47 experimental tests of the intention–behaviour relationship, also across multiple behaviours, found that a medium-to-large change in intention (d = 0.66) leads to a small-to-medium change in behaviour (d = 0.36) (Webb & Sheeran, 2006).

This finding is in contrast, however, to a more recent meta-analysis (Rhodes & Dickau, 2012) conducted in the context of a single behaviour, physical activity. That study found weaker effects of interventions both on intention (d = 0.45) and on behaviour (d = 0.15) and concluded that '*meaningful changes in intention appear to result in trivial changes in behaviour which challenges the utility of the intention–behaviour connection*' (p. 726). Clearly, further research, ideally experimental studies, examining the causal link between intention and behaviour is warranted. However, in spite of the myriad interventions and experimental tests described in the literature, precise guidance on *how* to change the cognitive determinants of behaviour, such as intention, is still lacking (Michie & Abraham, 2004).

Fortunately, an important development in behavioural science has taken place in recent years that enables researchers to identify the active ingredients of interventions, the creation of taxonomies of behaviour change techniques (BCTs). A key aim of that work was to allow direct comparisons between the content of individual interventions, thus enabling the identification of components that can effectively change behaviour. The original BCT taxonomy has been found to provide a reliable method for coding techniques reported in intervention descriptions (Abraham & Michie, 2008). This methodology has been used to identify effective BCTs for interventions targeting behaviours such as physical activity and healthy eating (Dombrowski *et al.*, 2012; Michie, Abraham, Whittington, McAteer, & Gupta, 2009) amongst others (e.g., Michie, Hyder, Walia, & West, 2011). Those studies, however, have focussed on identifying which BCTs are associated with changes in behaviour, without paying attention to their impact on

theoretical mediators such as intention. This is limiting from a theoretical standpoint as it inhibits our ability to build on these contradictory meta-analytic findings and experimentally test the central premise of intention-based models, that is that a change in intention leads to a change in behaviour.

Although a number of previous reviews have sought to identify BCTs associated with changes in theoretical mediators of behaviour change (physical activity self-efficacy; French, Olander, Chisholm, & Mc Sharry, 2014; Olander *et al.*, 2013; Williams & French, 2011), to date, no study has identified BCTs associated with a change in intention. The above-mentioned review conducted by Webb and Sheeran (2006) did code interventions that successfully changed intention for *behaviour change methods*. However, in addition to utilizing an untested method to code for techniques, as this study was conducted prior to the publication of the first BCT taxonomy in 2008, the authors also failed to statistically test whether the use of specific methods in interventions was associated with a greater impact on intention compared to those that did not use such methods. The primary aim of the current study, therefore, was to expand on previous meta-analyses that have reviewed the experimental evidence of the impact of a change in intention on behaviour by identifying BCTs associated with changes in intention, and examining whether those BCTs that change intention are the same as those that change behaviour.

In addition to investigating the effectiveness of individual BCTs in changing intention and behaviour, this review also compared the effectiveness of different theoretical approaches to achieving intention change. The theory of planned behaviour (Ajzen, 1991) primarily advocates the provision of information to facilitate change, using BCTs such as providing information on consequences (e.g., of performing or not performing the behaviour) and providing information about others' approval (e.g., whether others will approve or disapprove of the change in behaviour) (Abraham & Michie, 2008). Other theories propose more complex approaches. For example, social cognitive theory (Bandura, 1997) provides recommendations for changing self-efficacy, of which intentions (termed *proximal goals*) are both a direct determinant and a mediator of its effect on behaviour, using both information-based and behavioural approaches. Correspondingly, in addition to providing information on the consequences of behaviour, BCTs mapped onto this theory include the following: modelling or demonstrating the behaviour (e.g., showing someone how to correctly perform a behaviour) and setting graded tasks (e.g., through setting easy tasks, and gradually increasing the difficulty until target behaviour is performed) (Abraham & Michie, 2008).

The current review was conducted in the context of two health behaviours, physical activity and healthy eating, which have established associations with intention-based models of behaviour (Hagger, Chatzisarantis, & Biddle, 2002; McDermott *et al.*, 2015) and which have previously been examined in tandem by reviews seeking to identify effective BCTs (Dombrowski *et al.*, 2012; Michie *et al.*, 2009). Suboptimal levels of these behaviours are also amongst the highest contributors to the overall burden of disease worldwide (World Health Organization, 2009). Therefore, the design of effective behaviour change interventions is clearly warranted for each.

Methods

The design, conduct, and reporting of this systematic review were informed by the Preferred Reporting Items for Systematic Reviews and Meta-Analyses guidelines (PRISMA (Moher, Liberati, Tetzlaff, & Altman, 2009); the PRISMA checklist is available as

Appendix S1). As the study involved the secondary analysis of existing data sets, ethical approval was not sought. The funding organization for this study had no role in the collection, analysis, and interpretation of data, or the right to approve the finished manuscript prior to publication. As this study was conducted as a pilot for a larger programme of research, no study protocol was produced.

Selection criteria

The PICOS (population, intervention, comparison, outcome, study design) approach (Moher & Tricco, 2008) was used to formulate the selection criteria. We included studies where participants were drawn from any population provided the other inclusion criteria were met. We included studies describing any intervention where the stated aim was to facilitate healthy eating, physical activity, or both. In line with previous reviews of experimental tests of the intention–behaviour relationship (Rhodes & Dickau, 2012; Webb & Sheeran, 2006), interventions must have produced a significant, experimentally induced change in intention. Studies must also have reported interventions where BCTs differed between trial arms. For example, we excluded two studies (Darker, French, Eves, & Sniehotta, 2010; Irvine, Ary, Grove, & Gilfillan-Morton, 2004) using a wait list control design where both conditions received the same BCTs prior to the assessment of behaviour. Studies must have included the following comparisons: a post-intervention comparison of intention between conditions, followed by a comparison of behaviour between conditions conducted at a later time point. Studies must have reported data on the following outcomes: Baseline intention must have been measured and reported, as a low baseline intention may be considered as a 'boundary condition' for the impact of BCTs on intentions (Armitage, 2015; Peters, de Bruin, & Crutzen, 2015), a post-intervention assessment of intentions, and an assessment of behaviour taken at a later time point, to allow an inference of causality for the effect of a change in intention on behaviour. We included any experimental study design where participants receiving the intervention were compared with a control group (e.g., randomized, quasi-randomized). In addition, studies needed to be published in the English language.

Study identification

An electronic search strategy was developed first for use in PsycINFO before being adapted for other databases (see Appendix S2). We searched PsycINFO, MEDLINE (both via Ovid), Web of Science, and CINAHL (via EBSCOhost). We also searched ProQuest Dissertations & Theses to locate unpublished studies in order to address the 'file-drawer' problem (Rosenthal, 1979). Final searches were conducted in January 2016. One author pre-screened the database containing all titles and abstracts for possible inclusion. Selected studies were then selected for inclusion, again by the same author. The accuracy of selection was verified by a second reviewer on a subset of 15% of studies selected for full-text examination. Cohen's kappa was used to determine agreement between the two raters for selecting studies at the full-text screening stage. Agreement was moderate (Landis & Koch, 1977) ($\kappa = .561$). Any discrepancies were resolved by consensus.

Data extraction

We extracted effect size data, sample size, and target behaviour (physical activity or healthy eating) from each study. In line with previous work investigating the association between

BCTs and cognitive mediators (Olander *et al.*, 2013), where studies reported data on intentions at several time points, we extracted data from the first time point following the intervention's end where possible. Where behaviour was reported at multiple time points, to maximize the chances of finding a causal effect of change in intention on behaviour we extracted data from the first time point following the post-intervention assessment of intention. Where different assessments of behaviour were used, we extracted data from the measure that most closely matched the measure of intention to maximize compatibility (Ajzen & Fishbein, 1977). Details of the measures employed in each study can be found in Appendix S4. We also coded baseline intention for the experimental group (or overall sample if not available) in each study as high or low depending on whether baseline scores were above or below the mid-point of the scale used (e.g., >4 on a seven-point scale). Full details of the variables extracted from each study can be found in Appendix S5.

BCT coding

Both experimental and control interventions in each study were coded for BCTs using a taxonomy for interventions targeting healthy eating and physical activity (CALO-RE; Michie, Ashford, *et al.*, 2011). Where both physical activity and healthy eating were targeted within the same study, care was taken to ensure that techniques were coded separately for each behaviour. In some instances, the post-baseline assessment of intentions was conducted prior to the end of the intervention. In those cases, only BCTs delivered up to the post-test assessment of intention were coded. Where multiple eligible experimental interventions were reported in studies, each was coded and treated as independent data provided it had a significant impact on intentions compared to a control condition. To control for the effects of BCT co-occurrence, BCTs were coded for both experimental and control groups following the technique described by Prestwich *et al.* (2014) with variation in the use of BCTs in studies coded as +1 if the BCT was used in the experimental condition only; 0 if the BCT was used in both the experimental and control condition or neither; and −1 if the BCT was used in the control group only. All studies were coded for BCTs by the first author. The accuracy of this coding was verified by the second author, who independently coded 83% of included studies. Both coders had completed online training in the identification of BCTs (http://www.bct-taxonomy.com/). Agreement between the two coders was 74.2%. Any discrepancies were resolved by consensus.

Data analysis

For the impact of interventions on intentions and behaviour, we computed effect sizes from means and standard deviations, controlling for baseline levels where reported. Where these data were not available, we entered effect size data directly from the report or calculated effect sizes using sample sizes and the results of the appropriate between groups *F*-test. Calculation of the pooled mean effect size (d_+) was conducted using inverse-variance-weighted random-effects meta-analysis (Borenstein, Hedges, Higgins, & Rothstein, 2009). Random-effects meta-analysis was used as significant heterogeneity between effect sizes was expected due to variation in, for example, settings, participants, and the methods used to measure variables (Borenstein *et al.*, 2009). We also estimated the heterogeneity across studies, using both the Q (a significant result indicates significant heterogeneity (Borenstein *et al.*, 2009) and I^2 (values of 25%, 50%, and 75% indicate low, moderate, and high heterogeneity, respectively; Higgins, Thompson, Deeks, & Altman, 2003) statistics.

A series of random-effects meta-regression analyses were conducted to identify BCTs associated with changes in intention and behaviour. BCTs were included in these analyses if they were present in two or more interventions. These analyses followed the protocol recommended by Borenstein *et al.* (2009) with the effect size of an intervention on intention or behaviour as the criterion variable, the presence or absence of a BCT as the predictor variable, and studies being weighted by their inverse-variance weights. It was our original intention to examine differential effects of BCTs (e.g., those targeting motivation) based on whether participants were categorized as having 'low' or 'high' baseline intention. This was not possible, however, as only three of the included studies (Cheval, Sarrazin, Isoard-Gautheur, Radel, & Friese, 2015; Lee, Cameron, Wünsche, & Stevens, 2011; Mayurachat, Warunee, Jutamas, Patcharaporn, & Kennedy, 2013), with no common BCTs, recruited participants with 'low' baseline intention (i.e., where mean scores were below the mid-point of the scale used).

The available data did, however, provide the opportunity to compare the effectiveness of BCTs aligned with two of the most commonly applied intention-based models (Glanz & Bishop, 2010; Painter, Borba, Hynes, Mays, & Glanz, 2008): the theory of reasoned action/planned behaviour (TRA/TPB) and social cognitive theory (SCT). BCTs were matched to theory according to the scheme detailed in Abraham & Michie (Abraham & Michie, 2008). The included interventions contained two BCTs based on the provision of information that were aligned with both the TRA/TPB and SCT ('provide information on the consequences of behaviour in general'; 'provide information on the consequences of behaviour to the individual') and five behaviour-focussed BCTs aligned with SCT ('barrier identification/problem solving'; 'provide instruction on how to perform the behaviour'; 'model/demonstrate the behaviour'; 'set graded tasks'; 'facilitate social comparison'). All analyses were performed using Comprehensive Meta-Analysis (CMA) version 3.0 (Borenstein, Hedges, Higgins, & Rothstein, 2014).

Results

Search results and description of included studies

The electronic search strategy retrieved 9,928 unique records. In total, 23 journal articles and two dissertations met the inclusion criteria. A full list of included studies is available in Appendix S3. Full details of the screening process can be seen in the PRISMA flow chart (Figure 1). Two studies were reported in more than one article (Hardeman, Kinmonth, Michie, & Sutton, 2009; Kinmonth *et al.*, 2008; Vallance, 2008; Vallance, Courneya, Plotnikoff, & Mackey, 2008), meaning that 23 studies were included. Six studies (Guillaumie, Godin, Manderscheid, Spitz, & Muller, 2012; Karimi-Shahanjarini, Rashidian, Omidvar, & Majdzadeh, 2013; Parrott, Tennant, Olejnik, & Poudevigne, 2008; Sniehotta *et al.*, 2005; van Stralen, de Vries, Mudde, Bolman, & Lechner, 2011; Zhang & Cooke, 2012) described two interventions that each had a significant effect on intentions compared to a control group. Therefore, a total of 29 interventions were coded and included in analyses.

A total of 15 of the included interventions targeted physical activity only, nine targeted healthy eating only, and five targeted both behaviours (see Appendix S4). Sample sizes ranged between 43 and 1,011. Participants were diverse with regard to age, which ranged from 11 to 64 years, and gender, with the proportion of females in each sample ranging between 49% and 100%. A total of 14 studies referred to the TRA/TPB as the theoretical background for their study, either alone or in combination with another model. The next most commonly cited model was SCT (n = 5). Follow-up periods for the impact of

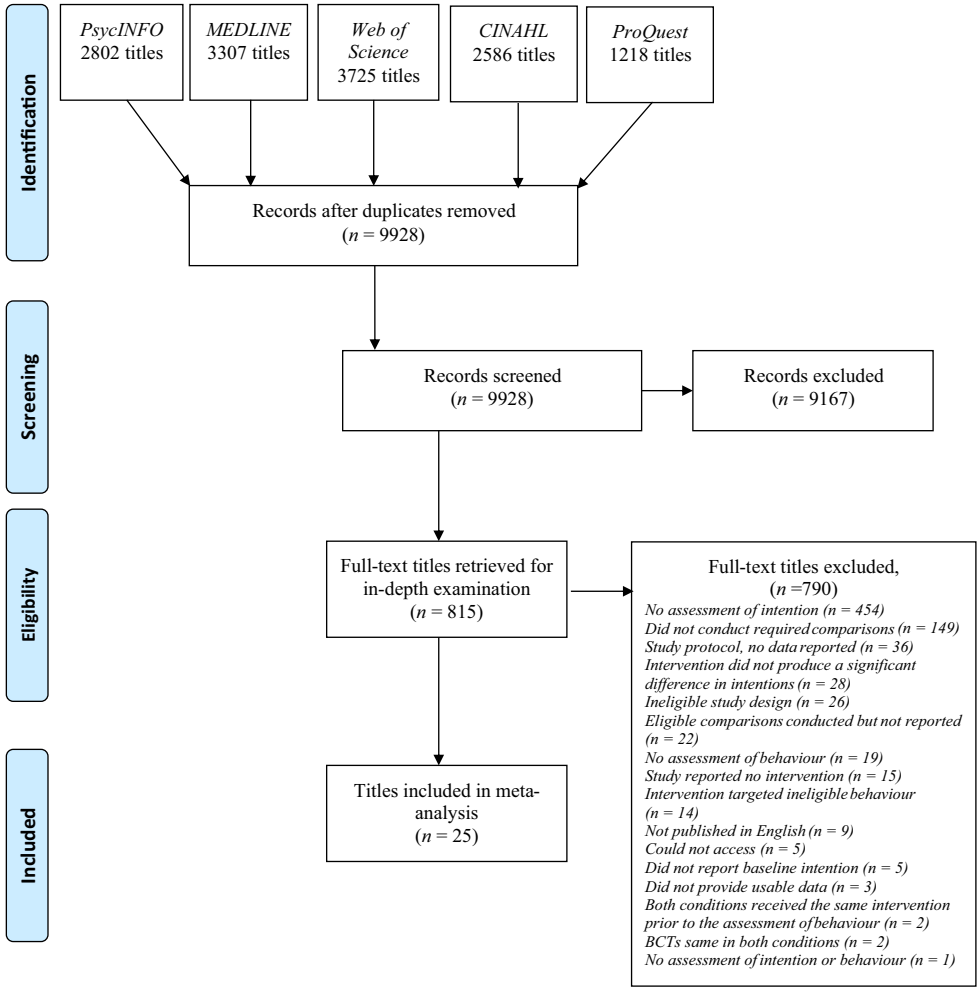

Figure 1. PRISMA flow chart.

interventions on intentions ranged from immediately post-intervention to 6 months for intentions and from 1 week to 12 months for behaviour. A mean of 5.2 (SD = 3.0, range = 1–12) BCTs were tested per experimental intervention. We were able to test for the effect of 22 of 40 BCTs from the CALO-RE taxonomy. The BCTs most commonly used were as follows: action planning (n = 18); goal setting (behaviour) (n = 17); prompt self-monitoring of behaviour (n = 15); and barrier identification/problem solving (n = 15).

Effects of interventions on intentions and behaviour

Results of the random-effects meta-analysis showed that the included interventions had a medium-to-large effect on intentions, d_+ = 0.64 (95% CI 0.52–0.77), and a small-to-medium effect on behaviour, d_+ = 0.41 (95% CI 0.28–0.54). Forest plots for each association can be found in Appendix S6.

There was no difference in the effect of interventions on intentions by target behaviour. Included studies had a mean effect of d_+ = 0.79 (95% CI 0.45–1.12) on healthy

eating intentions and a mean effect of $d_+ = 0.57$ (95% CI 0.46–0.68) on the intention to do physical activity, $\chi^2(1) = 1.87$, *ns*. In contrast, the effect of interventions on behaviour was found to differ by target behaviour, $\chi^2(1) = 5.65$, $p < .05$, with mean effects of $d_+ = 0.59$ (95% CI 0.35–0.83) on healthy eating and $d_+ = 0.29$ (95% CI 0.15–0.42) on physical activity, respectively. Examination of the *Q*-statistic ($Q = 273.27$ and 205.31, both $p < .001$ for change in intentions and behaviour, respectively) and I^2 (87.92% and 83.93%, respectively) indicated significant heterogeneity supporting the use of meta-regression to search for moderators such as the inclusion of specific BCTs.

BCTs associated with changes in intention and behaviour

Associations between BCTs, intention, and behaviour are shown in Table 1. One BCT was significantly associated with positive changes in intention: 'provide information on the consequences of behaviour in general' ($d_+ = 0.85$ vs. $d_+ = 0.54$, $p < .05$). One BCT was also significantly associated with negative changes in intention compared to those interventions not using this BCT: 'relapse prevention/coping planning' ($d_+ = 0.37$ vs. $d_+ = 0.77$, $p < .01$). There was no evidence that any BCT was significantly associated with a positive change in behaviour. However, one BCT was significantly associated with a negative change in behaviour: 'provide feedback on performance' ($d_+ = 0.13$ vs. $d_+ = 0.46$, $p < .05$).

Theory-linked BCTs associated with changes in intention and behaviour

Using the links between BCTs and theory described in Abraham and Michie (2008), we divided interventions into one of three categories: interventions including BCTs targeting intention change by providing information only (aligned with both TRA/TPB and SCT), through behavioural means (aligned with SCT) and those using both types of technique (aligned with SCT). There was evidence that this categorization significantly moderated the effect size of interventions on intentions, $\chi^2(2) = 6.51$, $p < .05$. Studies using a combination of both types of BCTs ($k = 11$, $d_+ = 0.83$) had a significantly larger effect on intention than those providing information alone ($k = 4$, $d_+ = 0.56$) or targeting behaviour alone ($k = 13$, $d_+ = 0.45$). There was no evidence, however, that this theoretical categorization moderated the effect size of interventions on behaviour ($d_+ = 0.35$, 0.23, 0.46, respectively, $\chi^2(2) = 1.38$, *ns*).

It is possible that the larger impact of interventions combining information-oriented and behaviourally oriented BCTs aligned with SCT on intentions might simply be due to a greater number of BCTs being utilized in those studies. However, we found no evidence that the overall number of BCTs in each intervention moderated the impact of interventions, either on intentions ($B = -.01$ (95% CI = −0.06 to 0.05), *ns*) or behaviour ($B = -.01$ (95% CI = −0.06 to 0.04), *ns*).

Discussion

To our knowledge, the current study is the first to seek to identify effective behaviour change techniques in experimental tests of the intention–behaviour association using meta-analysis. Whilst the included studies are supportive of the notion that a change in intention is associated with a change in behaviour, the current review failed to produce evidence on precisely *how* to facilitate behaviour change through a change in intention. When we examined the component parts of these interventions, it was possible to

Table 1. Associations between BCTs, intention, and behaviour

	Intentions					Behaviour				
	Present		Not present			Present		Not present		
BCT	*k*	*d*	*k*	*d*	*z*	*k*	*d*	*k*	*d*	*z*
1. Provide information on consequences of behaviour in general	11	0.85	23	0.54	2.56*	11	0.40	23	0.42	−0.14
2. Provide information on consequences to the individual	4	0.44	30	0.68	−1.25	4	0.11	30	0.45	−1.64
4. Provide normative information about others' behaviour	4	1.04	30	0.61	1.82	4	0.47	30	0.41	0.27
5. Goal setting (behaviour)	22	0.61	12	0.69	−0.66	20	0.44	14	0.35	0.66
7. Action planning	18	0.55	16	0.72	−1.56	20	0.38	14	0.45	−0.53
8. Barrier identification/problem solving	18	0.69	16	0.59	0.50	18	0.42	16	0.38	0.26
9. Set graded tasks	5	0.81	29	0.62	1.02	5	0.29	29	0.43	−0.68
10. Prompt review of behavioural goals	3	0.64	31	0.65	−0.07	3	0.17	31	0.44	−1.23
12. Prompt rewards contingent on effort or progress towards behaviour	4	0.81	30	0.62	0.85	4	0.33	30	0.42	−0.39
16. Prompt self-monitoring of behaviour	17	0.60	17	0.66	−0.72	17	0.45	17	0.36	0.60
19. Provide feedback on performance	5	0.44	29	0.68	−1.30	5	0.13	29	0.46	−2.03*
20. Provide information on where and when to perform the behaviour	2	0.39	32	0.66	−1.05	2	0.03	32	0.44	−1.51
21. Provide instruction on how to perform the behaviour	10	0.66	24	0.64	0.07	10	0.39	24	0.41	−0.01
22. Model/demonstrate the behaviour	3	0.68	31	0.64	0.17	3	0.42	31	0.41	0.24
23. Teach to use prompts/cues	4	0.63	30	0.66	−0.18	4	0.26	30	0.43	−0.72
26. Prompt practice	6	0.62	28	0.65	−0.07	6	0.40	28	0.41	0.05
28. Facilitate social comparison	4	0.32	30	0.68	−1.75	4	0.16	30	0.44	−1.15
29. Plan social support/social change	5	0.61	29	0.65	−0.17	5	0.23	29	0.44	−1.15
34. Prompt use of imagery	5	0.46	29	0.68	−1.25	5	0.32	29	0.43	−0.61
35. Relapse prevention/coping planning	10	0.37	24	0.77	−3.20**	10	0.43	24	0.39	0.18
37. Motivational Interviewing	2	0.86	32	0.63	0.95	2	0.23	32	0.43	−0.75

Note. BCTs were coded using the CALO-RE taxonomy. *$p < .05$; **$p < .01$.

identify BCTs that were significantly associated with increased intention. Furthermore, we were able to identify combinations of BCTs aligned with theory that were associated with significantly larger, positive effects on intention than alternative approaches. In each of these cases, a corresponding impact on behaviour was not found. Given this discordance, it is possible that the current findings challenge the utility of targeting a change in intention to achieve behaviour change. However, the current study had several limitations, and therefore, some important caveats must be considered.

First, our ability to identify BCTs associated with positive effects both on intention and on behaviour was hampered by the fact that we failed to identify any individual BCT that was associated with positive effects on behaviour. One potential cause of this was the small number of studies meeting the inclusion criteria, which may have limited the power to detect effective BCTs. However, other, larger reviews have produced similar findings. A meta-analysis comprised of 121 evaluations conducted by Michie *et al.* (2009) also failed to identify individual BCTs significantly associated with a positive change in the same two behaviours that were examined here. These authors did, however, find evidence in support of theoretical combinations of BCTs, with those interventions using BCTs aligned with control theory having larger effects on behaviour than those not employing such techniques. Theory-based combinations of BCTs were also examined here. Studies using BCTs aligned with SCT that targeted both motivation and behaviour had a significantly larger effect on intention than those targeting motivation alone (i.e., aligned with the TPB). This did not appear to be attributable to a simple case of a greater number of BCTs leading to larger effects. Despite this promising finding, however, this theoretical combination of BCTs was also not associated with a larger effect on behaviour.

The small sample of included studies also restricted our ability to examine the impact of BCTs alongside key study elements such as the following: the targeted population, who delivered the intervention; setting; mode of delivery; and intensity and duration (Davidson *et al.*, 2003). It is possible that the inclusion of some of these additional variables may have aided our interpretation of those BCTs found to be associated with negative effects on intention and behaviour. These were not readily understood and stand in contrast to previous findings. For example, 'relapse prevention/coping planning', identified here as impacting negatively on intention, has elsewhere been identified as having positive effects in healthy eating and physical activity interventions (Dombrowski *et al.*, 2012). Similarly, 'provide feedback on performance', significantly associated here with negative effects on behaviour, has been found in a previous meta-analysis to be associated with positive effects on behaviour (Olander *et al.*, 2013).

Second, and on a related point, the results may be confounded by the finding that the effects of interventions on behaviour were moderated by the behaviour targeted in the intervention. Included interventions had medium-to-large effects on the intention to eat healthily and to do physical activity. However, these intentions were translated into medium-sized effects on healthy eating behaviour, and small effects on physical activity. This suggests that the likelihood of achieving a change in physical activity behaviour through a change in intention is limited, mirroring the result of a previous meta-analysis (Rhodes & Dickau, 2012).

Finally, and perhaps most importantly, baseline intention across studies was almost universally high, which violates an important 'boundary condition' for the effect of BCTs on intentions. Levels of motivation in studies may already have been sufficiently high to facilitate behaviour change, limiting the ability of analyses to detect BCTs that changed participants' intentions to a degree that it translated into a change in behaviour. Future meta-analyses should seek to identify a sample of studies including participants with low

baseline intention prior to drawing clear conclusions on the links between BCTs, behaviour, and *changes* in intention.

The current review also had a number of strengths. These include the use of rigorous criteria (Moher *et al.*, 2009) to guide the design, conduct, and reporting of the study and the independent full-text selection and coding of BCTs by trained raters using a taxonomy specific to the targeted behaviours (Michie, Ashford, *et al.*, 2011). There were issues, however, with calculating agreement between these raters for the coding of BCTs. Unfortunately, data were collected in such a way that calculating percentage agreement was the only method available to determine agreement. Clearly, this strategy was not optimal, and future studies should seek to collect sufficient information to use methods that can account for chance agreement between raters, such as kappa. Kappa was used to calculate the level of agreement for the selection of studies at the full-text screening stage. Agreement at this stage was, however, only moderate. This was most likely due to differing levels of experience between the two reviewers, one of whom had completed his doctoral studies 5 years previously whereas the other had recently completed their undergraduate degree.

A broad search strategy was also employed, targeting both published and unpublished research. The representativeness of the included studies is suggested by the similarity of the intervention-level findings with of Webb and Sheeran's (2006) seminal study, that is that a medium-to-large effect on intention is associated with a small-to-medium effect on behaviour. When we examined the component parts of these interventions, it was possible to identify one BCT that was significantly associated with increased intention. Furthermore, the link between that BCT and its positive effects on intentions could be readily understood. 'Provide information on the consequences of behaviour in general', for example by describing the links between physical activity and improved health, is likely to impact positively on intention by increasing a participants' positive attitudes (TRA/TPB) or outcome expectations (SCT), towards that behaviour. Finally, the inclusion only of studies that experimentally manipulated intentions and measured an impact of this change on behaviour measured at a subsequent time point allows us to infer a causal link between these BCTs, intention, and behaviour.

Conclusions

Although the current study failed to identify BCTs with a positive impact both on intention and on behaviour, given the above limitations, the reported results should be considered as provisional and subject to confirmation. Future research should seek to verify these findings, first through larger meta-analyses incorporating interventions targeting a broader range of behaviours, and second in a series of experimental studies. In addition to providing important theoretical insight, this information will also be valuable from a practical standpoint, as not knowing how to change intention limits our ability to design effective interventions based on this approach. Linking BCTs to causal processes and mechanisms allows researchers to explain *how* and *why* an intervention works, and enables the application of BCTs to different settings, populations, and behaviours (Michie & Abraham, 2004). Without such knowledge, researchers and practitioners have limited *a priori* reason to select BCTs to include in interventions, as the effectiveness of specific BCTs could be limited to the specific characteristics of the studies included in the meta-analysis. A common criterion for a 'useful' behaviour change theory is that in addition to providing a means to predict behaviour, they should also provide a foundation for planning effective interventions (Head & Noar, 2014). It is arguable that intention-based models of behaviour do not currently meet either criterion.

Conflict of interest

All authors declare no conflict of interest.

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Supporting Information

The following supporting information may be found in the online edition of the article:

Appendix S1. PRISMA 2009 Checklist.

Appendix S2. Electronic search strategies.

Appendix S3. Articles included in the systematic review.

Appendix S4. Details of measures used to assess intention and behaviour in each study.

Appendix S5. Summary of studies.

Appendix S6. Forest plots showing the impact of interventions on intentions and behaviour.
Figure S1. Forest plot showing the impact of interventions on intentions.
Figure S2. Forest plot showing the impact of interventions on behaviour.