Imagery Interventions in Health Behavior: A Meta-Analysis

Dominic Conroy

University of East London

Martin S. Hagger

Curtin University and University of Jyvaskyla

Author Note

Dominic Conroy, School of Psychology, University of East London, London, UK; Martin S. Hagger, Health Psychology and Behavioral Medicine Research Group, School of Psychology and Speech Pathology, Perth, Australia and Faculty of Sport and Health Sciences, University of Jyvaskyla, Jyvaskyla, Finland.

Correspondence concerning this article should be addressed to Dominic Conroy, School of

Psychology, University of East London, London, UK, email: d.conroy@uel.ac.uk

Abstract

Objective: Imagery-based interventions represent an inexpensive, potentially effective technique for changing health behavior and promoting adaptive health outcomes. However, research adopting mental imagery techniques in health behavior interventions has shown considerable variability in effects across studies. In the present analysis we present a quantitative synthesis of the effectiveness of mental imagery interventions in health behavior and tested effects of key moderators. *Method:* A systematic database search for studies adopting imagery interventions in health behavior and related outcomes was conducted with additional manual searches and direct author contact for unpublished studies. Data were extracted for imagery intervention effects on behavioral, psychological, and physiological outcomes, and for candidate moderators. *Results:* Twenty-six studies of mental imagery intervention effects comprising 33 independent data sets met eligibility criteria for inclusion in the review. Mental imagery interventions led to non-trivial, small averaged corrected effect sizes on post-intervention behavior, intention, perceived control, and attitude, and a small-to-medium sized effect on post-intervention physiological measures. Substantive heterogeneity in the effects meant that a search for moderators was warranted. Moderator analyses indicated larger effects of imagery interventions on health behaviors in studies on older, non-student samples, when detailed instructions were provided, in studies with higher methodological quality scores, and in studies of longer duration. Effect sizes for imagery on behavioral and physiological outcomes were larger than effects on psychological outcomes. *Conclusion:* Results support effects of mental imagery interventions on health behaviors, identify conditions in which they may be more effective, and point to how future imagery interventions might be optimized.

Imagery Interventions in Health Behavior: A Meta-Analysis

The global burden of chronic non-communicable illnesses is closely linked to behavior (Ford, Zhao, Tsai, & Li, 2011; World Health Organization, 2014). Clinicians and researchers seeking to develop effective behavioral interventions aimed at chronic disease prevention have turned to psychology and behavioral science to provide evidence-based techniques and strategies to promote sustained, self-initiated behavior change that obviates the need for costly in-person and intensive methods. Among these strategies are imagery techniques. Such techniques have been shown to be effective in promoting sustained health behavior change in several health domains (Andrade, Khalil, Dickson, May, & Kavanagh, 2016; Kim, Newton, Sachs, Giacobbi, & Glutting, 2011; Wynd, 2005).

However, considerable variability has been observed in the effects of interventions adopting imagery techniques on health behaviors with some studies demonstrating large effects (Andrade et al., 2016; Razon, 2012), and others small (Conroy, Sparks & de Visser, 2015; Knäuper et al., 2011) or null (Adams, Rennie, Uskul, & Appleton, 2015; Hagger et al., 2012a) effects. Furthermore, considerable variability in the conceptualization and implementation of imagery techniques as well as selection of the duration, dose, format, content, and population used has been noted. Considering this observed variability, a systematic synthesis of imagery interventions on behavioral outcomes in health contexts is important. We sought to provide cumulative evidence of the effectiveness of imagery interventions in promoting health behavior correcting for methodological biases and whether such biases account for the observed variability. We also tested the extent to which the effectiveness of imagery interventions may be dependent on conceptually-relevant moderators. We expected the synthesis to provide evidence to guide the development of effective imagery-based interventions and identify priority areas for future research.

Imagery Definition and Types

There is considerable variation in the operational definition of mental imagery across the literature. A common feature of most definitions is that imagery involves the mental representation of a future event, action, or task. For example, Taylor, Pham, Rivkin, and Armor (1998) suggest that imagery is "… the imitative representation of some event or series of events" (p. 430) and Driskell, Copper, and Moran (1994) describe imagery as "… the cognitive rehearsal of a task in the absence of overt physical movement" (p. 481). In addition, there is recognition that the goal of imagery is to increase an individual's preparation for, and motivation toward, a future event or action. Imagery interventions, therefore, involve self-directed imagining or visualizing specific events, actions, or outcomes, including concomitant feelings and responses, with the express purpose of increasing motivation toward a target action or task (Leventhal, Brissette, & Leventhal, 2003; Pham & Taylor, 1999; Taylor et al., 1998). Imagery is usually conducted by an individual on their own and directed by internal cues, but it can also be guided by others and can be conducted in groups,

Theories and Mechanisms of Mental Imagery

Accounts of mental imagery effects on behavioral outcomes have variously emphasized: the role of mental imagery in facilitating effective behavioral regulation by strengthening links between thought and goal-directed action (Pham & Taylor, 1999); the role of unconscious influence of substance-related mental imagery on craving/addictive processes in elaborated intrusion theory (May et al., 2012) and the bio-informational model position that imagery strengthens reciprocal relationships between mental imagery, emotional memory and physiological responses (Lang, 1979). Rehearsal of actions through mental imagery has also been theorized to involve a neural basis for mental imagery effects, with the consistency of mental imagery practice argued as an important factor involved in maintaining behavioral performance over time (Driskell et al., 1994). Taken together, these approaches

indicate that mental imagery may serve to activate links between stored representations of action and behavioral responses.

Research on Imagery in Health Behavior Contexts

There has been a recent resurgence of interest in the application of mental imagery interventions in health behavior contexts given their potential as an effective behavior change technique with relatively low cost and response burden (e.g., Andrade et al., 2016; Conroy et al., 2015; Hagger, Lonsdale, & Chatzisarantis, 2012b; Meslot, Gauchet, Hagger, & Allenet, 2016). However, mental imagery intervention studies conducted in health contexts have differed in terms of the intervention format, the length of time between the intervention and the follow-up outcome measure, and the inclusion of follow-up intervention components or a theoretical framework to understand imagery effects.

Some randomized controlled trials have demonstrated the efficacy of mental imagery interventions in bringing about significant changes in health behavior in numerous contexts including reducing alcohol consumption (Conroy et al., 2015; Hagger et al., 2012a), promoting physical activity participation (Kim et al., 2011; Razon, 2012), promoting healthy eating (Knäuper et al., 2011), and promoting smoking cessation (Wynd, 2005). Other studies have found no effects of mental imagery interventions on health behavior relative to controls (Adams et al., 2015; Hagger et al., 2012b; Meslot et al., 2016; Rennie, Harris & Webb, 2009).

The Present Study

Given the potential for imagery-based interventions to change health behavior, but also the observed variation in their effectiveness across studies, we performed a meta-analysis of empirical research testing the effects of mental imagery interventions on health behavior, health outcomes, and salient psychological mediators from theories on imagery. Application of meta-analytic methods enables us to evaluate the extent to which the observed

between-study variability in the effect size of imagery interventions can be attributed to

sampling error, and to identify the degree of true variability in the effect size. Given the

positive effects of imagery interventions on health behavior in primary research (e.g., Conroy

et al., 2015; Knäuper et al., 2011) and syntheses in other domains (e.g., Driskell, et al., 1994),

we predicted non-trivial overall effects for imagery on health behavior and outcomes across

studies after correcting for artefactual error using meta-analysis.

Based on observed variation in imagery intervention effects in health behavior

research, we also expected that the effects of mental imagery would exhibit substantive

heterogeneity across studies. As a consequence, we planned to examine effects of

theoretically-related (inclusion of a follow-up imagery intervention component, inclusion of

instructions, inclusion of health-related information, inclusion of a written component

alongside imagery), and methodological and demographic (study quality and methodological

bias, intervention duration, follow-up time period, sample type and age, health behavior

domain, study design, publication status) moderator variables expected to explain variance in

the effectiveness of imagery interventions on behavioral and psychological outcomes.

Based on the literature, studies that augmented the imagery exercises with elements designed

to promote imagery effectiveness (including a follow-up imagery component to the

intervention, instructions on how to conduct the imagery exercises, information about the

health behavior, including a written component alongside the imagery) could be expected to

have larger intervention effects. In addition, larger intervention effects could be expected in

studies of higher methodological quality, with lower methodological bias, of longer duration,

and conducted in older samples. Further, smaller intervention effects could be expected in

studies with a longer time period between the intervention and follow-up measures of

outcomes. We also tested whether imagery effects varied by domain of health behavior and

by sample type (student vs. non-student). Since randomized controlled trials are the gold

standard for investigation of treatment effects, we examined the effect of excluding studies

adopting alternative designs (e.g., non-randomized trials, non-controlled designs) on the

imagery effect size. Finally, we also examined the effect of publication status (i.e. whether

data was available from published or unpublished sources) on imagery intervention effects

which, combined with a visual inspection of the 'funnel' plot of study effect sizes against

their precision and associated regression test, may provide an indication of publication bias.

Method

Search strategy

Four electronic databases: MEDLINE, PsycINFO, PubMed and Scopus were searched

in October 2015 for English-language journal articles reporting interventions using imagery

as a technique to promote change in health behavior. Search terms were: "intervention" or

"program" or "behavi* change" and "imagery" or "mental simulation" or "mental practice"

or "mental rehearsal" or "mental preparation" or "visuali*". In order to ensure our search was

unrestricted and inclusive we did not specify any period filters. Where possible, searches

were restricted to human studies and adult populations. Reference lists of retrieved studies

were searched for further relevant citations. Given its potential relevance to the review, a

manual search of the contents pages of all volumes of the discontinued *Journal of Mental*

Imagery (1977-2012) was conducted for articles relevant to health behavior. The grey

literature search involved: searching two major dissertation repositories (ProQuest, EThOS),

posting requests for information about additional imagery-based interventions on relevant

electronic mailing lists viewed by behavioral researchers. Key authors in the field were

contacted to see if any unpublished imagery intervention studies were available for inclusion

in the review and to request raw data where available. The review protocol was pre-registered

with the Prospero registry of systematic reviews (Conroy & Hagger, 2015).

Study eligibility

Studies were included if they: (1) focused on changing a target health-related behavior as an outcome (e.g., physical activity, healthy eating, reduction in alcohol consumption) and (2) involved imagining the uptake or desistance of the health-promoting behavior[1]. Studies were excluded if they: (1) Reported research based on a clinical sample with mental health conditions (e.g., depression, current/ongoing substance abuse); or (2) focused exclusively on outcomes relating to psychological health (e.g., quality of life, optimism) rather than health behavior.

Data extraction

Study characteristics (e.g., sample size, sample type, gender distribution, target behavior etc.) and effect size data were extracted for each study included in the review. Effect size data were extracted for the target behavioral outcome (e.g., frequency of taking regular exercise), secondary psychological outcomes related to candidate psychological mediators (e.g., intention/motivation to take regular exercise), and physiological outcomes reflecting improvements in health (e.g., weight loss in kilograms).

Our data extraction approach followed a coding schedule designed to group measures of behavioral, physiological, and outcome variables into conceptually-related categories for meta-analytic synthesis. For example, psychological variables with virtually identical content were collapsed into single construct categories. For example, 'intention' encompassed measures of intention, motivation, and planning, 'perceived control' encompassed perceived

---

[1]Although we recognize the importance of studies adopting randomized controlled designs in providing high quality evidence when testing intervention effects, we did not include this as an eligibility criterion as we sought to produce a fully inclusive data set and evaluate the effect of study design on the effectiveness of mental imagery interventions in subsequent moderator analyses.

behavioral control and self-efficacy, and 'attitude' encompassed instrumental and affective attitudes. Similarly measures of behavioral and physiological outcomes were collapsed into broader categories for coding purposes. For example, the 'healthy eating' behavioral outcome category included measures of eating health-promoting foods and fruit and vegetable consumption. Where studies reported multiple time-points, outcome data for the most distal time point was extracted for two reasons: (1) it provides the most conservative estimate of the effect given that intervention effects are expected to wane over time; and (2) data on long-term outcomes is less frequently available in the literature given the difficulties and challenges with collecting longitudinal data with long-term follow-up of outcome measures. Study authors were emailed to clarify data queries and obtain additional data as required.

Moderator coding

In cases where moderators comprised logical categories, studies were coded as categorical variables: inclusion of a follow-up component to the imagery intervention such as a 'booster' session (yes vs. no), whether instructions about mental imagery were reported as included in the study (yes vs. no), whether health information was presented in the intervention (yes vs. no), including a written component alongside the imagery content of the intervention (imagining vs. imagining and writing), sample type (student vs. community), study design (RCT vs. other), and publication status (published vs. unpublished). For the written component moderator, studies were categorized as 'imagining only' when they involved a participant-driven exercise requiring effortful thought about a given health behavior with no written component. Studies were categorized as 'imagining and writing' when, in addition to the imagery exercise, participants were required to complete a written exercise in which they elaborated and/or reflected on the mental imagery exercise. For the study design moderator, the majority of studies adopted a randomized controlled design using

a no-intervention control group or a comparison group in which the imagery component was absent. Studies allocated to the 'other' design moderator group exclusively adopted pre-post designs. For the behavioral domain moderator, physical activity was the most frequently studied target behavior ($k = 17$). Studies other than those targeting physical activity were diffuse in focus (healthy eating, $k = 6$; reduction in alcohol consumption, $k = 6$; weight reduction, $k = 2$; smoking cessation, $k = 1$; multiple domains, $k = 1$). As a result, the moderator variable was coded as studies with 'physical activity' as the target behavior and studies with 'other' health behaviors as the target ($k = 16$).

Accounting for possible sources of bias in studies included in research syntheses is recognized as important to reduce threats to validity (Johnson, Low, & McDonald, 2014). We adopted two checklists previously used to evaluate study methodological quality (Downs & Black, 1998) and risk of bias (Higgins et al., 2011), respectively, and used these as moderators of imagery effects on study outcomes in the current analysis. The checklists included several items relating to the quality of study methods (27 items; e.g., "Are the main findings of the study clearly described?", Yes = 1 point, No = 0 points) and potential sources of bias in the conduct of the study (6 items; e.g., "Was the allocation sequence randomly generated?", Yes = 1 point, No = 0 points). Studies were scored by a researcher with experience in the use of methodological quality checklists. Summed scores provided overall statements of methodological quality and risk of bias scores for use in subsequent analyses. Studies were also independently scored by another researcher with high agreement between raters across items (mean agreement = 89.1%) and inter-rater reliability ($\kappa = .68$). Consistent with previous research on methodological quality, we expected to find larger imagery intervention effects in studies coded as higher quality and with lower methodological bias (Johnson et al., 2014).

Moderators that were continuous measures were retained as continuous variables in moderator analyses. The effects of continuous moderators were evaluated using meta-regression analyses in which the imagery effect size for each study was regressed on the continuous moderator variables: methodological quality using Downs and Black's (1998) checklist, bias score using Higgins et al.'s (2011) checklist, time gap between the intervention and follow-up outcome measures in days, percentage of sample comprising female participants, intervention duration in minutes, and sample age. Age was treated as a categorical variable in the moderator analyses (younger, 18-25 years old vs. older, 26+ years old) and as a continuous variable in the meta-regression analyses. The decision to treat age as a categorical variable for the moderation analysis was made on the basis that variation in age was roughly bi-modal: participants tended to be either students in their early twenties or drawn from a community sample aged over thirty years. Students were defined as individuals enrolled in a higher education program.

We sought to assess whether imagery type (e.g., process, outcome) moderated the effect of imagery interventions on the primary behavioral outcome across studies. However, relatively few studies reported multiple imagery interventions so it was not possible to explore types of imagery intervention in the meta-analysis. For this reason, data for all imagery groups were combined and assessed as a composite imagery group.

Meta-analytic procedure

Corrected effect size. To be included in the review studies had to contain sufficient statistical information such as cell means and standard deviations, F ratios, t statistics, zero-order correlations (r), or effect size statistics (e.g., Cohen's d). Where data was missing, relevant study authors were contacted. We used random effects meta-analysis using the

Comprehensive Meta Analysis (Version 2.2.064) software package to correct the effect size

data from the sample of studies included in our analysis for sampling error. The meta-

analysis was performed on independent pairs of comparisons for the effect of imagery on the

primary behavioral measure and secondary outcome measures at follow-up. The standardized

mean difference (d) was used as the appropriate effect size metric. Computation of study

effect sizes using means, standard deviations, and sample size data for the experimental and

control group at baseline and follow up was preferred. In the event these data were not

reported we used other available data to compute the effect size using standard formulas.

Prior to conducting the meta-analysis we applied Grubbs' (1950) test to detect the presence of

outlying effect sizes from the set of studies. Outliers identified were Winsorized to the next

highest value after removing the outlier and the Grubbs' test repeated to ensure no further

outliers were present. The effect size for each study was then weighted according to sample

size and averaged across the sample to produce the overall averaged corrected effect size (d^+).

Moderator analyses. In addition to the overall averaged corrected effect size, the

meta-analysis also provided summary statistics relating to critical hypothesis tests. First, the

confidence intervals about d^+ were computed which denote the degree of variability in the

effect across the sample of studies and indicates whether zero is a viable value for the effect

and, therefore, tests the null hypothesis of no effect. Three tests were included to examine the

degree of heterogeneity in the effect across studies. We used Q as a standard measure of the

extent to which the variability in the effect size across studies is accounted for by sampling

error (Hoaglin, 2016). A statistically non-significant value suggests that all of the variability

in the effect is due to sampling error and that the effect size is homogenous and a good

estimate of the true effect in the population. Since Q is considered over-sensitive, an

alternative is provided by the I^2 value which effectively provides an estimate of the

percentage of the variance in the effect size accounted for by extraneous factors, with values less than 25% reflecting low heterogeneity, values between 25% and 50% reflecting moderate heterogeneity, and values >50% reflecting high heterogeneity (Higgins & Thompson, 2002).

Assuming a high degree of heterogeneity, we explored whether our set of candidate moderators on the averaged corrected effect size of imagery on health behavior resolved the heterogeneity. We conducted separate meta-analysis for groups of studies assigned to each level of the categorical moderator and compared the effects of the moderator using the 95% confidence intervals for the averaged corrected effect size in each group. We also calculated Q and I^2 values in each group of studies defined by the moderators to examine whether the moderator resolved levels of heterogeneity in studies. For continuous moderators we conducted a meta-regression analysis in which we regressed the overall averaged effect size for imagery on our set of continuous moderator variables. The meta-regression analysis permits the evaluation of the unique effects of moderators in the presence of others. We also included the dichotomous moderator variables in the analysis. However, given the relatively large number of moderators and relatively small sample of studies, we adopted a stepwise method with backward selection of the variables to be included in the regression analysis. This meant that variables not meeting inclusion criteria for variance explained in the dependent variable were systematically eliminated with $p < .05$ as the criterion for a variable to be entered into the analysis and $p > .10$ as the criterion for the variable to be removed from the analysis. The final analysis, therefore, included the set of moderators that were viable candidates to explain any variance in the outcome and those with no explanatory power were eliminated.

Small study bias. We adopted two methods to examine the extent to which the

current set of studies was influenced by small study bias caused by disproportionately large

effects relative to their sample size, often interpreted as indicating publication bias. The first

was a plot of the effect size of each study by its precision, that is, its standard error. Given

that effect sizes of larger studies should lean toward the true effect size and smaller samples

should show considerable variability either side of the true effect the plot shape should be

'pyramid' or 'funnel' shaped. The second was Egger and Sterne's (2005) regression test in

which study precision is regressed on the effect size. A significant prediction suggests bias.

Results

Study characteristics

Full details of the decision-making process involved in the selection of studies for the

present review are presented in Figure 1. Twenty-six studies reporting 33 independent data

sets met eligibility criteria for inclusion in the review. A full list of studies included in the

meta-analysis is presented in Appendix A (supplemental materials). Study characteristics,

details of the outcome measures and moderator coding are presented in Appendix B

(supplemental materials), effect sizes for the behavioral outcome variable in each study are

provided in Appendix C (supplemental materials),[2] and a PRISMA checklist is provided in

Appendix D (supplemental materials).

Mental imagery intervention characteristics

Characteristics of the imagery intervention are also summarized in Appendix B

(supplemental materials). In trials with comparison conditions, effects of imagery

---

[2]Raw data used in the meta-analysis including effect sizes and moderator coding are available from
https://osf.io/peyxs/

interventions were compared to an 'active' control group receiving information about the behavior or outcome but not the imagery intervention (e.g., received a health leaflet, $k = 7$), a control group in which participants who completed an irrelevant imagery exercise to maintain uniformity in information load and contact time (e.g., imagery of preparing a meal, $k = 2$), or a control group in which participants received no information or manipulation ($k = 11$).

Review articles adopted a range of conceptual definitions and background theoretical approach. The most frequently reported definitions and theoretical approaches to mental imagery interventions were mental simulations ($k = 9$), visualisation ($k = 7$), mental imagery ($k = 6$), guided imagery ($k = 5$), functional imagery training ($k = 2$), defined in relation to the physical activity health domain ($k = 2$, e.g., Kim et al.'s 2011 "guided exercise imagery") or defined in relation to a specific attribute of physical activity mental imagery ($k = 2$, e.g., Stanley et al.'s 2010 "exercise enjoyment imagery"). Reporting of the theoretical basis for the mental imagery interventions revealed either a clearly stated theoretical basis ($k = 15$), diffuse theoretical underpinnings ($k = 3$), or no formally-stated theoretical basis ($k = 15$). Of those studies with clearly stated theoretical foundations, most studies referred to Taylor et al.'s (1998) mental simulation paradigm ($k = 10$), with the remaining studies referring to the bioinformational model ($k = 3$), and elaborated intrusion theory ($k = 2$).

Overall effect size

A screen for outliers using Grubbs' (1950) test identified one outlying effect size ($d = 3.08$, $z = 3.75$, $p < .05$; Razon, 2012), so this effect was Winsorized replacing it with the value of from study with the next highest effect size ($d^+ = 1.11$). No further outliers were identified after re-running the Grubbs test. Our analysis revealed small overall averaged effect sizes of mental imagery techniques on post-intervention behavior ($d^+ = 0.23$, 95% CI [0.07, 0.38])

and intention ($d^+ = 0.19$, 95% CI [0.05, 0.33]). Effects of imagery on perceived control ($d^+ = 0.08$, 95% CI [-0.01, 0.17]) and attitude ($d^+ = 0.12$, 95% CI [-0.03, 0.26]) were much smaller with confidence intervals that included zero. A small-to-medium overall averaged effect size was found for the effect of mental imagery interventions on post-intervention physiological measures ($d^+ = 0.29$, 95% CI [0.03, 0.55]). With the exception of perceived control, substantial heterogeneity ($I^2 > 25\%$) was demonstrated for the averaged effect sizes for all post-intervention outcome variables.

Moderator analyses

Results of the categorical moderator variable analysis are presented in Table 1. Despite observed differences in the mean effect sizes across moderator groups, there was substantive overlap in the confidence intervals about each effect size for the majority of the analyses. This was mirrored in the heterogeneity statistics for the effect size in each moderator group, which indicated that considerable heterogeneity remained in the majority of cases and suggested that the moderators did not reduce the variability and lead to any narrowing of the confidence intervals. Significant differences between moderator categories were tested using the mean differences in effect size values across moderator groups. We conducted one-tailed hypothesis tests for moderators that included components expected to improve the effectiveness of the imagery intervention (giving instructions, including a written component, including follow-up components, older/non-student samples). Two-tailed analyses were used where such inferences could not be made. Significant results were found for two moderators of behavioral outcomes with older samples ($t(4) = 2.82$, $p = .024$), and interventions providing detailed imagery instructions ($t(10) = 1.83$, $p = .049$) showing greater imagery intervention effects. In addition, studies that included follow-up intervention components ($t(2) = 2.64$, $p = .118$), and were conducted in non-student samples ($t(4) = 1.97$,

p = .060) demonstrated greater effects of the intervention on behavior, with test statistics

approaching conventional levels of statistical significance and minimal overlap in confidence

intervals about the effect size. Results of the meta-regression analyses in which the averaged

corrected effect size was regressed on categorical (inclusion of follow-up intervention

components, health behavior domain) and continuous (methodological quality, bias score,

time gap between intervention and follow-up measures, percentage of sample comprising

female participants, intervention duration) moderators are presented in Table 2. Results

revealed that quality score (β = 0.30, $t(18)$ = 2.42, p = .03) and intervention duration (β =

0.95, $t(18)$ = 7.61, p < .001) were statistically significant predictors of the effect size.

Specifically, studies with higher quality scores and longer intervention duration were more

likely to report larger effect sizes.

Small study bias

A 'funnel' plot of the corrected effect size for each study against its precision

(standard error) is presented in Figure 2. Visual inspection of the plot indicated no departures

from the expected symmetry. Egger and Sterne's (2005) regression test did not reveal a

significant prediction of the effect size, B_0 = 0.72, 95%CI [-1.36, 2.80], $t(20)$ = 0.72, p =

.480. Together these findings provided little evidence of small study bias in our sample of

studies and suggests that the current sample is free from publication bias.

Discussion

The purpose of the current study was to synthesize research examining the effects of

imagery techniques on health behavior and associated social cognitive, motivational and

physiological outcomes using meta-analytic techniques. We also tested effects of a set of

candidate moderators (inclusion of a follow-up imagery intervention component, inclusion of

instructions, inclusion of health-related information, inclusion of a written component alongside imagery, study quality and methodological bias, intervention duration, follow-up time period, sample type and age, health behavior domain, study design, publication status) on the influence of imagery on these outcomes. We found small, statistically significant positive effects of imagery on key outcomes including post-intervention health behavior, intention, perceived control, attitude, and physiological outcome measures (weight loss, resting heart rate, body mass index). Tests of moderators revealed that imagery interventions were more effective when the intervention contained a follow-up imagery component (e.g., 'booster' text messages, maintaining an imagery-related diary), and if the intervention included detailed instructions on how to conduct the imagery exercise. Imagery interventions were more effective in studies with higher methodological quality scores, in studies on older people and non-student samples, and when the interventions were longer in duration. We found no differences in the imagery effect size in studies that included health behavior information and no differences in studies including a written task alongside the imagery exercise. Similarly, we found no differences in effects in studies with lower methodological bias scores. Our analysis revealed little evidence of small study bias, but also indicated substantial heterogeneity in effect sizes across studies.

The current analysis revealed relatively small effect sizes of imagery on psychological outcomes while effect sizes for behavioral and physiological outcomes were larger. Given the prominence afforded to social cognitive explanations of imagery interventions and their mechanism of effect, this finding is somewhat surprising. Motivation and personal agency are conceptualized as salient psychological factors implicated in the process by which imagery interventions exert their effects and are, therefore, expected to mediate their effects (Armitage & Reidy, 2008). However, tests of mediation have produced inconsistent supporting evidence

(e.g., Conroy et al., 2015; Ross-Stewart, 2010; Knäuper et al., 2011). Few studies in the

current sample tested mediation effects, precluding a meta-analysis of mediation effects.

However, the small effects of imagery on the social cognitive variables compared to effects

on behavioral and physiological outcomes in the present analysis, suggests that any mediation

effects may be relatively small. This raises questions about which factors or processes, other

than those identified in the current analysis, account for imagery effects. One possible

explanation is that imagery interventions facilitate behavior change via non-conscious

channels, bypassing volitional factors linked to behavior change (e.g., Chen & Chaiken,

1999). This is consistent with research examining the neural bases of imagery effects on

behavior (e.g., Kosslyn & Moulton, 2009). Mental rehearsal of actions may stimulate neural

networks relating to the action similar to observational learning independent of social

cognitions related to motivation. The effects are also consistent with dual process accounts of

action (e.g., Hagger, 2017; Hagger, Trost, Keech, Chan, & Hamilton, 2017; Strack & Deutch,

2004), imagery interventions may help modify habits which obstruct health-related behavior

change (e.g., setting time in advance for daily physical activity) and by making health-

promoting prompts salient and accessible (e.g., recalling benefits of not smoking when

considering buying cigarettes). Further research is needed to model whether self-efficacy or

control beliefs mediate the influence of imagery interventions on changes in health-related

behavior in larger, representative samples.

The present findings provide cumulative evidence that imagery interventions are

effective in promoting small-to-medium sized changes in health behavior. However, the high

level of heterogeneity in the effect sizes meant that a search for moderators was warranted.

Analysis of the effects of candidate moderators indicated that the format and

operationalization of imagery interventions have important implications for their

effectiveness. For example, interventions that included instructions for participants on how to conduct imagery exhibited significantly larger effects. This is not surprising given that imagery can be a relatively complex and challenging technique, particularly for novices who have not engaged in such exercises in the past. Furthermore, research has identified individual differences in people's capacity to use imagery effectively (Knäuper et al., 2011; Kwekkeboom, Huseby-Moore, Ward, 1998). In the context of interventions administered on a general population scale, this finding suggests that there is likely to be substantial variability in participants' capacity to perform imagery exercises with sufficiently high quality. The inclusion of instructions may enhance imagery effects by providing important direction on the expectations and requirements of the exercise and allaying misunderstandings. The marked difference in effect sizes in our moderator analysis suggests that the inclusion of instructions will greatly benefit individuals engaging in imagery exercises with a relative modest cost in time and response burden.

Our moderator analysis also demonstrated that studies on non-student samples and older adults tended to have larger effects.[3] Older participants may have better experience with imagining future events and planning, which may transfer to capacity for effective imagery, analogous to findings that older adults have more advanced development in frontal brain regions linked to modulating capacities for self-regulation (Dahm et al., 2011). However, this speculative explanation would require empirical corroboration, and may also reflect that students were less attentive or engaged in the intervention, particularly if participating for course credit or as part of their program of study, as is often the case in psychological research.

---

[3]It is important to note that average sample age was strongly correlated to student status ($r = .73$)

A further salient moderator identified in our meta-regression was intervention duration. More intensive interventions have generally been shown to be more effective in many syntheses of other intervention methods and techniques in health contexts (Bero et al., 1998). This points to the importance of ensuring interventions are of sufficient duration. However, this has to be offset by the comparative cost and burden of longer duration interventions and, potentially, greater drop out. However, the benefits of imagery interventions is that they are relatively brief and self-administered, so the cost of extending the intervention duration is relatively low compared to the potential benefit of increased effectiveness. In fact, the interventions included in the current analysis were relatively short in duration (mean = 12.56 minutes) with the majority (63.6%) lasting less than 10 minutes. Therefore, extending the intervention will not add greatly to the duration or participant burden and has a high payoff in terms of increased effectiveness.

Our meta-regression also provided a clear demonstration of the importance of paying attention to methodological components such as setting clear objectives, attention to participant recruitment and representativeness, clear definition of outcomes, and appropriate design, measurement, and data analytic procedures when conducting primary research. This is congruent with the importance of accounting for effects of methodological quality on outcomes in research syntheses given its potential to alter interpretations. These findings are consistent with the advocacy for greater attention to methodological quality components when conducting primary research on imagery interventions and accounting for it when conducting systematic reviews and meta-analyses (Johnson et al., 2014).

Limitations and Recommendations for Future Research

The present meta-analysis has a number of strengths including a comprehensive literature search, a search for 'fugitive literature' and inclusion of unpublished studies, accounting for methodological quality and publication bias, and the testing of several theoretically-related, methodological and demographic moderators identified a priori. A further strength was our focus exclusively on mental imagery studies concerning behaviors linked to physical health. Although this resulted in the exclusion of studies on broader health-related issues (e.g., blood donation, Armitage & Reidy, 2008) and studies concerning psychological health (e.g., Blackwell et al., 2013), it meant we could produce a conceptually-coherent account of interventions designed exclusively to promote individual-level physical health. Future imagery research should focus on unrepresented behavioral settings (e.g., interventions to promote sexual health) and should be based on samples beyond university settings in the interests of greater generalizability to community settings.

Limitations include the relatively small number of studies in some moderator groups, the relatively narrow range of health behaviors targeted in the sample of studies, and limitations in availability of data on mediators that precluded formal tests of theoretical mediation processes using meta-analytic path analyses (Hagger, Protogerou, Chan, & Chatzisarantis, 2016). Our small sample size limited our ability to evaluate some of the candidate moderators we investigated and may have introduced additional bias in the average effect size (see Reynolds & Day, 1984). For example, the effect of imagery on physiological outcomes was based on very few studies relatively to effects on behavior. The small sample size also precluded an examination of potential interactions between moderator variables on the effectiveness of mental imagery interventions. For example, the significant moderation of imagery intervention effects by sample type (student vs. non-student) could be attributable to

study design in that researchers may have adopted non-randomized designs out of

convenience in order to fulfil students' course credit requirement.

We identified a number of additional inter-individual and content-related factors that

may serve to moderate the effect of imagery interventions on health behavior, but small

numbers of studies precluded a test of their effects. For example, imagery ability, inter-

individual differences in ability to effectively mentally represent and rehearse actions, has

been shown to determine the effectiveness of imagery on subsequent action (e.g., Adams et

al., 2015; Andrade et al., 2016; Chan & Cameron, 2012; Knäuper et al., 2011; Stanley, 2010).

In addition, research has demonstrated the importance of features of the content of imagery

may determine its effectiveness. For example, studies on mental contrasting demonstrated

that if individuals imagine future events with a focus on idealized outcomes, referred to as

'positive fantasy', rather than realistic expectations of successful performance, their goal

progress was hindered (Oettingen, 2012). There has also been research demonstrating that

imagining performance of an action from a first-person perspective (i.e., imagining oneself

performing the action) is more effective than imagining it being performed by another

(Rennie, Harris, & Webb, 2014), although research in other domains have found the opposite,

perhaps due to behavioral complexity (Vasquez & Buehler, 2007). In addition, a synthesis of

mental rehearsal interventions on performance demonstrated that the interventions were more

effective if the action involved more cognitive components (e.g., perceptual input, mental

operations, making decisions and judgements) relative to physical components (Driskell et

al., 1994). Imagery interventions that focus on the process of engaging in the action (e.g.,

imagining the steps required to perform a health behavior) have also been shown to be more

effective in promoting behavior change compared to imagery focusing on outcomes (e.g.,

imagining attaining salient outcomes resulting from the behavior) (Pham & Taylor, 1999).

However, there were insufficient numbers of studies adopting process and outcome focused imagery to conduct a moderator analysis. Related to this it is important to note that in some cases intervention content and design features had to be collapsed to produce a single effect size (e.g., separate process and outcome imagery interventions). In addition, insufficient study numbers meant we were not able to evaluate the unique and interactive effects of additional intervention components included alongside imagery interventions (e.g., implementation intentions) on health behavior outcomes. These confounding factors may have had an influence on the overall effect size. Future research should systematically manipulate these inter-individual (imagery ability) and imagery content (positive fantasy vs. realistic expectations of successful performance; self vs. other visual perspective of imagery; actions with high vs. low cognitive requirements; process vs. outcome mental simulation; imagery-only interventions vs. imagery with additional components) factors within imagery intervention studies using factorial designs to provide an evidence base of candidate moderators that magnify or diminish effects of imagery interventions.

Conclusions

The present review is the first to synthesize the effects of mental imagery interventions on health behavior and associated physiological and psychological outcomes. It provides an important analysis of conceptually-based and methodological moderators of the imagery effects. Results suggest that mental imagery interventions may be effective, low-cost means to produce change in health behaviors, but identified substantial heterogeneity in the effect size across studies. Intervention effects were larger in older, non-student samples and in studies that lasted longer, were of higher quality, and included follow-up imagery components and instructions. These findings have important implications on how imagery interventions could be implemented optimally. Results also point to several ways in which

the mental imagery literature can be developed with special attention to a wider range of

health behaviors to take the field in addition to physical activity and the need for research

testing effects of other salient moderators such as imagery ability.

References

Adams, C., Rennie, L., Uskul, A. K., & Appleton, K. M. (2015). Visualising future

behaviour: effects for snacking on biscuit bars, but no effects for snacking on fruit.

Journal of Health Psychology, 20, 1037-1048.

http://dx.doi.org/10.1177/1359105313506760

Andrade, J., Khalil, M., Dickson, J., May, J., & Kavanagh, D. J. (2016). Functional imagery

training to reduce snacking: Testing a novel motivational intervention based on

elaborated intrusion theory. *Appetite, 100,* 256-262.

http://dx.doi.org/10.1016/j.appet.2016.02.015

Armitage, C. J., & Reidy, J. G. (2008). Use of mental simulations to change theory of

planned behaviour variables. *British Journal of Health Psychology, 13,* 513-524.

http://dx.doi.org/10.1348/135910707X227088

Bero, L. A., Grilli, R., Grimshaw, J. M., Harvey, E., Oxman, A. D., & Thomson, M. A.

(1998). Closing the gap between research and practice: An overview of systematic

reviews of interventions to promote the implementation of research findings. *BMJ,*

317, 465-468. http://dx.doi.org/10.1136/bmj.317.7156.465

Blackwell, S. E., Rius-Ottenheim, N., Schulte-van Maaren, Y. W., Carlier, I. V., Middelkoop,

V. D., Zitman, F. G., Spinhoven, P. Holmes, E. A., & Giltay, E. J. (2013). Optimism

and mental imagery: A possible cognitive marker to promote well-being? *Psychiatry*

Research, 206, 56-61. http://dx.doi.org/10.1016/j.psychres.2012.09.047

Chan, C. K. Y., & Cameron, L. D. (2012). Promoting physical activity with goal-oriented

mental imagery: A randomized controlled trial. *Journal of Behavioral Medicine, 35*,

347-363. http://dx.doi.org/10.1007/s10865-011-9360-6

Chen, S., & Chaiken, S. (1999). The heuristic-systematic model in its broader context.

In Chaiken, S. and Trope, Y. (eds) (1999). *Dual-process Theories in Social*

Psychology, (pp. 73-96). Guildford Press: NY, U.S.

Conroy, D., & Hagger, M. S. (2015, March 15). A systematic review of mental simulation

and imagery intervention studies (CRD42015016943). Retrieved from

http://www.crd.york.ac.uk/PROSPERO/display_record.asp?ID=CRD42015016943

Conroy, D., Sparks, P., & Visser, R. (2015). Efficacy of a non-drinking mental simulation

intervention for reducing student alcohol consumption. *British Journal of Health*

Psychology, 20, 688-707. http://dx.doi.org/10.1111/bjhp.12133

Dahm, T., Neshat-Doost, H. T., Golden, A.-M., Horn, E., Hagger, M. S., & Dalgleish, T.

(2011). Age shall not weary us: Deleterious effects of self-regulation depletion are

specific to younger adults. *PLoS ONE*, *6*, e26351.

http://dx.doi.org/10.1371/journal.pone.0026351

Downs, S. H., & Black, N. (1998). The feasibility of creating a checklist for the assessment

of the methodological quality both of randomised and non-randomised studies of

health care interventions. *Journal of Epidemiology and Community Health*, *52*, 377-

384. http://dx.doi.org/10.1136/jech.52.6.377

Driskell, J. E., Copper, C., & Moran, A. (1994). Does mental practice enhance performance?

Journal of Applied Psychology, *79*, 481-492. https://dx.doi.org/10.1037/0021-

9010.79.4.481

Egger, M., & Sterne, J. A. C. (2005). Regression methods to detect publication and other bias

in meta-analysis. In H. Rothstein, A. Sutton & M. Borenstein (Eds.), *Publication Bias*

and Meta-analysis: Prevention, Assessments and Adjustments (pp. 99–109).

Chichester, UK: Wiley.

Ford, E. S., Zhao, G., Tsai, J., & Li, C. (2011). Low-risk lifestyle behaviors and all-cause

mortality: findings from the National Health and Nutrition Examination Survey III

Mortality Study. *American Journal of Public Health*, *101*, 1922-1929.

https://dx.doi.org/10.2105/AJPH.2011.300167

Grubbs, F. E. (1950). Sample criteria for testing outlying observations. *The Annals of*

Mathematical Statistics, *21*, 27-58. http://dx.doi.org/10.1214/aoms/1177729885

Hagger, M. S. (2017). Health behaviour and the reflective-impulsive model. In R. Deutsch,

B. Gawronski & W. Hoffman (Eds.), *Reflective and Impulsive Determinants of*

Human Behavior (pp. 157-172). New York: Routledge.

Hagger, M. S., Lonsdale, A., & Chatzisarantis, N. L. D. (2012a). A theory-based intervention

to reduce alcohol drinking in excess of guideline limits among undergraduate

students. *British Journal of Health Psychology, 17*, 18-43.

http://dx.doi.org/10.1111/j.2044-8287.2010.02011.x

Hagger, M. S., Lonsdale, A., Koka, A., Hein, V., Pasi, H., Lintunen, T., & Chatzisarantis, N.

L. (2012b). An intervention to reduce alcohol consumption in undergraduate students

using implementation intentions and mental simulations: a cross-national study.

International Journal of Behavioral Medicine, 19, 82-96.

http://dx.doi.org/10.1007/s12529-011-9163-8

Hagger, M. S., Chan, D. K. C., Protogerou, C., & Chatzisarantis, N. L. D. (2016). Using

meta-analytic path analysis to test theoretical predictions in health behavior: An

illustration based on meta-analyses of the theory of planned behavior. *Preventive Medicine, 89*, 154-161. http://dx.doi.org/10.1016/j.ypmed.2016.05.020

Hagger, M. S., Trost, N., Keech, J., Chan, D. K. C., & Hamilton, K. (2017). Predicting sugar consumption: Application of an integrated dual-process, dual-phase model. *Appetite*. http://dx.doi.org/10.1016/j.appet.2017.04.032

Higgins, J. P., Altman, D. G., Gøtzsche, P. C., Jüni, P., Moher, D., Oxman, A. D., Savović, J., Schulz, K. F., Weeks, L., & Sterne, J. A. (2011). The Cochrane Collaboration's tool for assessing risk of bias in randomised trials. *British Medical Journal*, *343*, d5928. http://dx.doi.org/10.1136/bmj.d5928

Higgins, J. P. T., & Thompson, S. G. (2002). Quantifying heterogeneity in a meta-analysis. *Statistics in Medicine, 21*, 1539-1558. http://dx.doi.org/10.1002/sim.1186

Hoaglin, D. C. (2016). Misunderstandings about Q and 'Cochran's Q test' in meta-analysis. *Statistics in Medicine*, *35*, 485-495. http://dx.doi.org/10.1002/sim.6632

Johnson, B. T., Low, R. E., & MacDonald, H. V. (2014). Panning for the gold in health research: Incorporating studies' methodological quality in meta-analysis. *Psychology & Health, 30*, 135-152. doi: 10.1080/08870446.2014.953533

Kim, B. H., Newton, R. A., Sachs, M. L., Giacobbi, P. R., & Glutting, J. J. (2011). The effect of guided relaxation and exercise imagery on self-reported leisure-time exercise behaviors in older adults. *Journal of Aging and Physical Activity, 19*, 137-146. http://dx.doi.org/10.1123/japa.19.2.137

Knäuper, B., McCollam, A., Rosen-Brown, A., Lacaille, J., Kelso, E., & Roseman, M. (2011). Fruitful plans: adding targeted mental imagery to implementation intentions increases fruit consumption. *Psychology & Health, 26*, 601-617. http://dx.doi.org/10.1080/08870441003703218

Kosslyn, S. M., & Moulton, S. T. (2009). Mental imagery and implicit memory. In K. D.

Markman, W. M. P. Klein & J. A. Suhr (Eds.), Handbook of Imagination and Mental

Simulation. New York: Hove.

Kwekkeboom, K., Huseby-Moore, K., & Ward, S. (1998). Imaging ability and effective use

of guided imagery. *Research in Nursing & Health*, *21*, 189-198.

http://dx.doi.org/10.1002/(SICI)1098-240X(199806)21:3<189::AID-

NUR2>3.0.CO;2-D

Lang, P. J. (1979). A bio-informational theory of emotional imagery. *Psychophysiology*, *16*,

495-512. http://dx.doi.org/10.1111/j.1469-8986.1979.tb01511.x

Leventhal, H., Brissette, I., & Leventhal, E. A. (2003). The commonsense model of self-

regulation of health and illness. In Cameron, L. D. & Leventhal, H. (Eds.), *The self-

regulation of Health and Illness Behaviour* (2003). (pp. 42–65). New York, U.S.:

Routledge.

May, J., Andrade, J., Kavanagh, D. J., & Hetherington, M. (2012). Elaborated Intrusion

theory: A cognitive-emotional theory of food craving. *Current Obesity Reports*, *1*,

114-121. http://dx.doi.org/10.1007/s13679-012-0010-2

Meslot, C., Gauchet, A., Allenet, B., François, O., & Hagger, M. S. (2016). Theory-based

interventions combining mental simulation and planning techniques to improve

physical activity: Null results from two randomized controlled trials. *Frontiers in

Psychology, 7*, 1789. http://dx.doi.org/10.3389/fpsyg.2016.01789

Oettingen, G. (2012). Future thought and behaviour change. *European Review of Social

Psychology, 23*, 1-63. http://dx.doi.org/10.1080/10463283.2011.643698

Pham, L. B., & Taylor, S. E. (1999). From thought to action: Effects of process-versus outcome-based mental simulations on performance. *Personality and Social Psychology Bulletin*, *25*, 250-260. http://dx.doi.org/10.1177/0146167299025002010

Razon, S. (2012). *The effects of imagery on perceived exertion, attention, and exercise adherence.* (Doctoral dissertation). Retrieved from DigiNole: Florida State University's digital repository. (Identifier: FSU_migr_etd-5129 (IID))

Rennie, L. J., Harris, P., & Webb, T. (2009, September). *Perspective, imagination and health behaviours: the moderating role of behavior difficulty.* Paper presented at the Twenty-third European Health Psychology Society 2009 Conference, Pisa, Italy.

Rennie, L. J., Harris, P. R., & Webb, T. L. (2014). The impact of perspective in visualizing health-related behaviors: first-person perspective increases motivation to adopt health-related behaviors. *Journal of Applied Social Psychology, 44*, 806-812. http://dx.doi.org/10.1111/jasp.12266

Reynolds, S., & Day, J. (1984, August). *Monte Carlo studies of effect size estimates and their approximations in meta-analysis.* Paper presented at the American Psychological Association 1984 Annual Meeting, Toronto, Canada.

Ross-Stewart, L. (2010). *The effect of a one time imagery intervention on self-efficacy and exercise frequency in a non-exercising population.* (Doctoral dissertation). Retrieved from The University of Hong Kong Libraries electronic resources (ISBN: 9781109565393)

Stanley, D. M., & Cumming, J. (2010). Not just how one feels, but what one images? The effects of imagery use on affective responses to moderate exercise. *International*

Journal of Sport and Exercise Psychology, 8, 343-359.

http://dx.doi.org/10.1080/1612197X.2010.9671957

Strack, F., & Deutsch, R. (2004). Reflective and impulsive determinants of social behavior.

Personality and Social Psychology Review, 8, 220-247.

http://dx.doi.org/10.1207/s15327957pspr0803_1

Taylor, S. E., Pham, L. B., Rivkin, I. D., & Armor, D. A. (1998). Harnessing the imagination:

Mental simulation, self-regulation, and coping. *American Psychologist*, *53*, 429-439.

http://dx.doi.org/10.1037/0003-066X.53.4.429

Vasquez, N. A., & Buehler, R. (2007). Seeing future success: Does imagery perspective

influence achievement motivation? *Personality and Social Psychology Bulletin, 33*,

1392-1405. http://dx.doi.org/10.1177/0146167207304541

World Health Organization (2014). *Global status report on noncommunicable diseases 2014*.

Geneva, Switzerland: World Health Organization. Retrieved from

http://www.who.int/nmh/publications/ncd-status-report-2014/en/

Wynd, C. A. (2005). Guided health imagery for smoking cessation and long-term abstinence.

Journal of Nursing Scholarship, 37, 245-250. http://dx.doi.org/10.1111/j.1547-

5069.2005.00042.x/abstract

Table 1

	Behavior						Intention						Physical					
	k	d	95% CI		Q	I^2	k	d	95% CI		Q	I^2	k	d	95% CI		Q	I^2
			LL	UL					LL	UL					LL	UL		
Follow-up component included																		
No	13	0.07	-0.11	0.25	31.98**	62.48	8	0.19	0.05	0.33	9.75	28.19	0	–	–	–	–	–
Yes	9	0.45	0.21	0.69	28.26***	71.69	5	0.22	-0.10	0.55	13.63**	70.66	6	–	–	–	–	–
Sample type																		
Non-student	8	0.42	0.17	0.67	17.45*	59.88	6	0.21	-0.07	0.48	17.82**	71.95	3	0.23	-0.11	0.56	3.01	33.59
Student	14	0.12	0.05	0.22	47.74***	72.77	7	0.12	0.00	0.24	5.18	0.00	3	0.43	-0.10	0.97	6.23	67.90
Sample age (yrs)																		
Older (26+)	8	0.49	0.23	0.75	20.84**	66.41	6	0.17	-0.07	0.40	12.88*	61.18	3	0.10	-0.15	0.36	2.67	25.16
Younger (18-25)	14	0.07	-0.08	0.23	32.54**	60.05	7	0.20	0.02	0.39	10.87	44.82	3	0.58	0.23	0.92	1.18	0.00
Imagery instructions given?																		
No	5	-0.01	-0.24	0.22	8.51	53.01	2	0.18	-0.20	0.56	1.32	24.48	0	–	–	–	–	–
Yes	17	0.30	0.13	0.47	53.76***	70.24	11	0.19	0.04	0.35	22.80*	56.14	6	–	–	–	–	–
Health information given?																		
No	12	0.13	-0.10	0.36	43.83***	74.91	5	0.31	-0.08	0.69	14.77**	72.91	4	0.40	-0.03	0.82	6.49	53.79
Yes	10	0.33	0.14	0.52	23.60**	61.86	8	0.17	0.03	0.30	9.18	23.75	2	0.17	-0.14	0.48	1.61	37.74
Including written component																		
Imagining	15	0.28	0.03	0.54	71.02***	80.29	7	0.30	0.03	0.58	18.18**	66.99	6	–	–	–	–	–
Imagining and writing	7	0.17	0.07	0.27	2.42	0.00	6	0.08	-0.03	0.20	1.28	0.00	0	–	–	–	–	–
Health behavior domain																		
Other	11	0.24	0.08	0.39	23.03*	56.59	9	0.16	0.03	0.28	11.68	31.50	1	–	–	–	–	–
Physical activity	11	0.23	-0.06	0.53	49.00***	79.59	4	0.29	-0.19	0.78	11.70**	74.37	5	–	–	–	–	–
Design																		
RCT	19	0.25	0.10	0.39	44.49***	59.54	13	–	–	–	–	–	5	–	–	–	–	–
Other	3	0.11	-0.50	0.72	25.82***	92.25	0	–	–	–	–	–	1	–	–	–	–	–
Publication status																		
Published	17	0.28	0.13	0.43	41.41***	61.36	13	–	–	–	–	–	6	–	–	–	–	–
Unpublished	5	0.04	-0.37	0.45	20.35***	80.34	0	–	–	–	–	–	0	–	–	–	–	–

Moderator Analyses of the Effect of Imagery Interventions on Health Outcomes

Note. k = Number of studies; d = Standardized mean difference for the effect; 95%CI = 95% confidence intervals of the effect size; LL = Lower limit of the 95% confidence interval; UL = Upper limit of the 95% confidence interval; Q = Cochrane's Q statistic; I^2 = Huedo-Medina et al.'s (2006) I^2 statistic; RCT = Randomized controlled design.
* $p < .05$ ** $p < .01$ *** $p < .00$

Table 2

Meta-Regression of Effect Size of Imagery Interventions for Behavioral Outcomes on Candidate Moderators

Variables entered	Model 1 (β)	Model 2 (β)	Model 3 (β)	Model 4 (β)	Model 5 (β)	Model 6 (β)
Follow-up components	-.26	-.26	-.24	-.22	–	–
Health behavior domain	.11	.11	.10	–	–	
Quality score	.24	.27	.28*	.30	.29*	.30*
Bias score	.06	–	–	–	–	–
Sample %female	-.28	-.28	-.26	-.27	-.16	–
Follow-up time period	-.06	-.05	–	–	–	–
Intervention duration	.82***	.81***	.81***	.81***	.93***	.95***
R^2	.81	.81	.81	.80	.78	.76
Model F	8.72***	10.72***	13.59***	17.16***	21.20***	29.33***

Note. Models 1-5 represent results of linear multiple regression using a stepwise backward entry method beginning with a model in which all moderators were included (Model 1) followed by progressive elimination of moderators in each model using $p < .05$ as the entry criterion and $p < .10$ as an exit criterion. Standardized beta (β) coefficients reported.

* $p < .05$ ** $p < .01$ *** $p < .001$

Figure 1. Flow diagram illustrating literature search and study selection and retention for meta-analysis.

```
┌──────────────────────────────┐        ┌──────────────────────────────┐
│ Records identified through   │        │   Additional records         │
│ database searching (n =      │        │ identified through other     │
│ 2021)                        │        │ sources including grey        │
│                              │        │ literature search (n = 68)   │
└──────────────┬───────────────┘        └──────────────┬───────────────┘
               │                                        │
               └────────────────┬───────────────────────┘
                                ▼
                ┌──────────────────────────────────────┐
                │   Records after duplicates removed    │
                │            (n = 1170)                 │
                └────────────────┬─────────────────────┘
                                 ▼
                ┌──────────────────────────┐      ┌──────────────────────────┐
                │ Abstracts screened       │─────▶│ Records excluded          │
                │ (n = 638)                │      │ (n = 532)                │
                └────────────┬─────────────┘      └──────────────────────────┘
                             ▼
                ┌──────────────────────────┐
                │ Full-text records        │
                │ assessed for eligibility │
                │ (n = 106)                │
                └────────────┬─────────────┘
                             ▼
                ┌──────────────────────────┐
                │ Articles included in     │
                │ analysis (n = 27)        │
                └────────────┬─────────────┘
                             ▼
                ┌──────────────────────────┐
                │ Studies included in      │
                │ analysis (n = 34)        │
                └──────────────────────────┘
```

Full-text records excluded, with reasons (n = 79)
- Correlational research (n = 29)
- Did not concern personal physical health (n = 18)
- Alternative imagery intervention (e.g., relaxation/mediation exercise, n = 13)
- Clinical sample (e.g., individuals with schizophrenia, n = 6)
- Sports-related sample (e.g., athletes, n = 2)
- No control group or pre-test measures (n = 3)
- Data necessary to compute effect size unavailable (n = 4)
- Unclear what imagery intervention consisted of (n = 1)
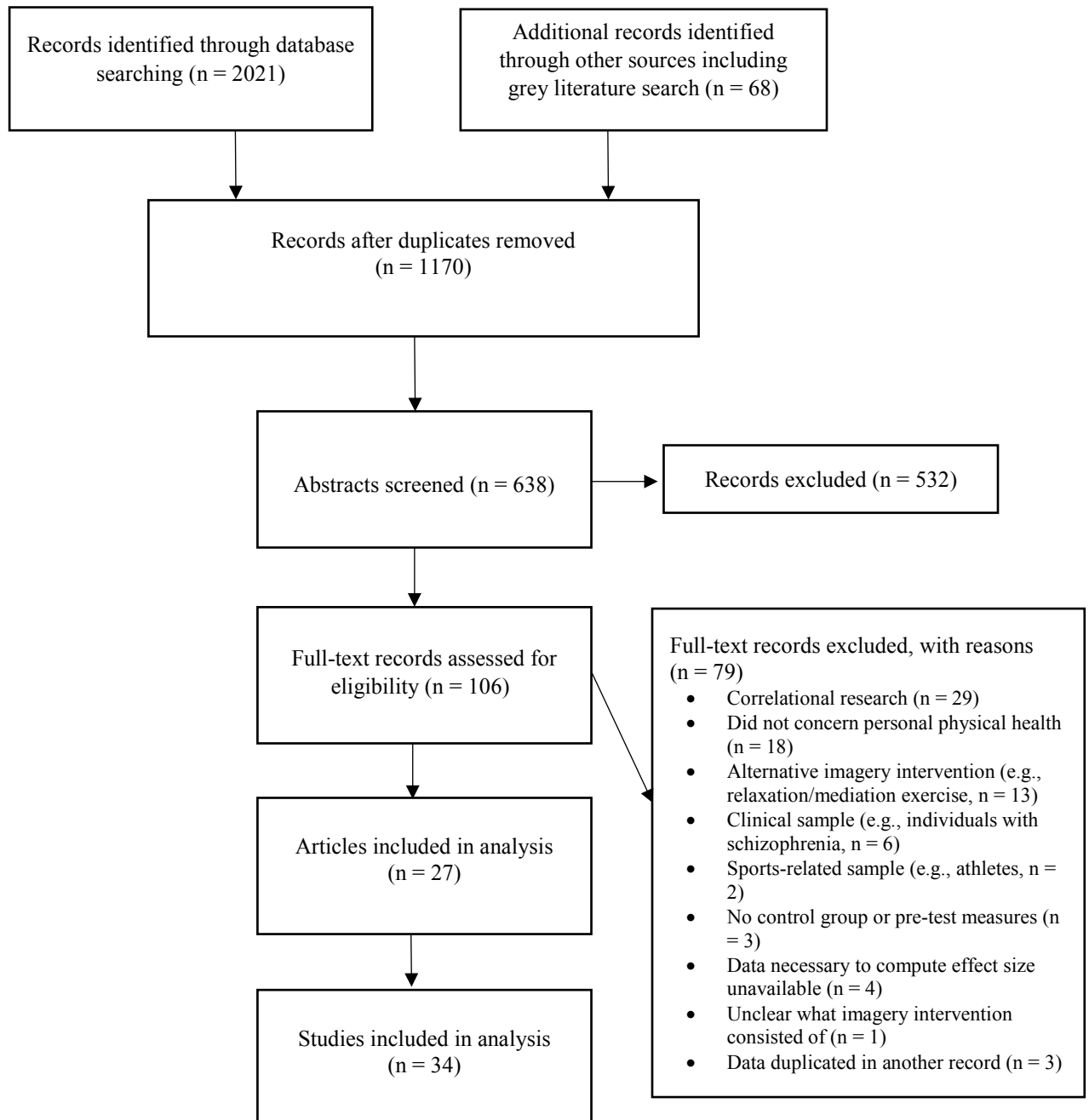- Data duplicated in another record (n = 3)

Figure 2. Funnel plot of imagery effect size on behavioral outcomes (standardized difference in means) against study precision (standard error) for visual inspection of publication bias. Std diff in means = Standardized difference in mean effect size for each study in the meta-analysis.