

Running head: EFFECT OF BMIS ON MOTIVATION FOR CHANGE

DO BRIEF MOTIVATIONAL INTERVENTIONS INCREASE MOTIVATION FOR
CHANGE IN DRINKING AMONG COLLEGE STUDENTS?
A META-ANALYSIS OF INDIVIDUAL PARTICIPANT DATA

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Dedication

To my parents,
my wife, Tian,
&
our daughter, Nora

Abstract

Brief Motivational Interventions (BMIs) have been identified as one of the most effective individually focused alcohol intervention strategies for college students in the United States. Despite the central role of motivation for change in BMIs, whether BMIs increase motivation for change has rarely been investigated. The current study conducted a meta-analysis of individual participant data (IPD; 15 studies, $N = 5,903$) from Project INTEGRATE (Mun et al., 2015) to examine whether BMIs increase motivation for change in drinking. Different measures and responses used in the original trials were harmonized across studies, and effect size estimates were derived from a model that adjusted for baseline motivation and demographic variables for each study (step 1) and subsequently combined in a random-effects meta-analysis model (step 2). After adjustment for baseline levels of motivation level and demographic variables, the intervention effects of BMIs on motivation for change was not statistically significant (standard mean difference [SMD]: 0.026, 95% *CI*: [-0.001, 0.053], $p = .06$, $k = 19$). Subsequent meta-regression analyses among BMI subtypes indicated that the intervention effect did not differ between individually delivered motivational interviewing with personalized feedback (MI+PF), stand-alone personalized feedback (PF), and group-based motivational interviewing (GMI). Among all BMI subtypes, only GMI had a statistically significant intervention effect on motivation compared to controls (SMD: 0.055, 95% *CI*: [0.007, 0.103], $p = .025$, $k = 5$). Within the first three months post-intervention, there was a decrease in SMD of 0.05 (95% *CI*: [0.01, 0.08]) in motivation per month. However, no statistically significant difference in the intervention effects was found between studies with short-term vs. long-term follow-up. Although the results from the current study do not support the hypothesis that BMIs improve

motivation for change, the evidence as a whole suggests ways in which motivation may be improved following intervention and can be tested in future studies.

Keywords: Brief motivational interventions, motivation for change, subtype of BMIs, individual participant data, meta-analysis, Project INTEGRATE

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Introduction

Background and Significance

In the United States (US), the prevalence of alcohol use in a given month among 18- to 25-year-olds is 54.3% (Substance Abuse and Mental Health Services Administration, 2020). Within this age group, 52.5% of full-time college students ages 18 to 22 drank alcohol in the past month, and 33.0% had heavy use of alcohol (four or more drinks at the same time or within a couple of hours of each other for females and five or more drinks on the same occasion for males on five or more days in the past 30 days) (Substance Abuse and Mental Health Services Administration, 2020). This heavy alcohol use pattern among college students is associated with a wide range of negative consequences, including academic problems, assault, sexual assault, alcohol use disorder, injuries, hospitalization, and death (Hingson, Zha, & Smyth, 2017; Hingson, Zha, & White, 2017). To reduce such harm from alcohol misuse, several individually focused intervention strategies have been developed and utilized, including education and awareness programs (Lovecchio, Wyatt, & DeJong, 2010), cognitive-behavioral skills-based approaches (Morgenstern & Longabaugh, 2000), motivation and feedback-related approaches, and behavioral interventions by health professionals (Walters et al., 2009). These strategies focus on changing students' alcohol-related knowledge, attitude, and behaviors so that they can drink less and experience fewer harmful consequences.

Among individually focused interventions aimed at changing college students' attitudes or behaviors related to alcohol use, brief motivational interventions (BMIs; Larimer et al., 2004/2005) patterned after the Brief Alcohol Screening and Intervention for College Students (BASICS; Dimeff et al., 1999), which incorporate personalized feedback (PF) with motivational interviewing (MI; Miller & Rollnick, 2002), have shown effectiveness in reducing alcohol use

(Cronce et al., 2018). College students generally have little motivation to change their drinking behavior as they are less likely to recognize their drinking problems while overestimating their peer's drinking norms (Baer, 2002; Cox et al., 2019; Perkins et al., 2005). Through contrasting students' perceptions with the actual drinking norms of peers and contrasting their current drinking behaviors with desired life values and goals, it has been theorized that BMIs develop discrepancies to increase students' awareness of alcohol-related negative consequences (Borsari & Carey, 2001; Miller & Rollnick, 2013; Neighbors et al., 2004), and subsequently evoke and increase their motivation for change in their drinking behavior (Larimer et al., 2021; Miller & Rollnick, 2013). Despite being a critical mechanistic link for the efficacy of BMIs, there is a dearth of evidence on the intervention effect of BMIs on motivation for change in drinking behavior.

BMIs and Motivation for Change

BMIs represent a class of interventions that are brief (typically less than 2 hr). They typically offer college students personalized feedback on alcohol use, descriptive norms, and perceptions of norms to increase awareness of social norms around drinking, identify potential problems they may encounter, and support strategies to limit harm. Evolving from the Alcohol Skills Training Program (ASTP), a group-based cognitive-behavioral skills-focused intervention (Kivlahan et al., 1990), BMIs are highly personalized and delivered via utilizing the principles of MI (Miller & Rollnick, 1991). BMIs are nonconfrontational and nonjudgmental, and support individual autonomy in exploring and resolving ambivalence about change and setting goals for drinking and harm reduction (Harris et al., 2008; Miller & Rollnick, 2013). BMIs are presumed to evoke motivation for change in drinking behavior through developing two types of discrepancy—normative discrepancy and self-ideal discrepancy; the former reflects the

difference between the individual's perceived and the actual drinking levels of peers, and the latter reflects the difference between the individual's drinking behavior and personal values or goals (Miller & Rollnick, 2013).

Transtheoretical Model and Motivation for Change

One way to think about motivation in the context of BMIs is through the lens of the transtheoretical model for behavior change progress (Prochaska et al., 1992). In the transtheoretical model of change, Prochaska et al. (1992) outlined five stages of behavior change: precontemplation, contemplation, preparation, action, and maintenance. Individuals in the precontemplation stage may not consider themselves as having a behavior problem in need of change. Individuals enter the contemplation stage when they recognize a behavior problem and begin to consider taking action. Those in this stage often exhibit the most ambivalence about changing (DiClemente & Velasquez, 2002). The occurrence of change talk is evidence of movement from contemplation to preparation (Carey et al., 2006; Miller & Rollnick, 2002, 2013). Preparation involves committing to change in the near future. This commitment is demonstrated in the individual's verbal behavior by moving from tentative to more certain language. The action stage is entered when an individual starts making behavioral changes related to the problem behavior. Finally, the maintenance stage is entered when the individual works to retain the changes for at least six months, such as in treatment populations.

Within the context of the transtheoretical model, motivation for change plays a critical role in initiating the process of behavior change. Developing the normative and self-ideal discrepancy may be important in making people realize their drinking requires change (Miller & Rollnick, 2013). Although individuals in BMIs may be in different stages of changing their

drinking behavior, motivation for change remains critical in the intervention process to help individuals move forward across stages in the direction of behavior change and maintenance.

The Current Literature and Knowledge Gap

Despite the central role of motivation for change in BMIs, few individual randomized controlled studies have examined the intervention effects of BMIs on motivation for change among college students. Findings from the few available studies have been mixed or inconclusive (Barnett et al., 2007; Borsari et al., 2009; Murphy et al., 2010; Ostafin & Palfai, 2012). Barnett et al. (2007) observed increased motivation post-BMI; however, the effects were investigated as indirect comparisons of within-group changes rather than direct between-group tests of differences. In a study that analyzed unpublished motivation data from three separate published trials, Borsari et al. (2009) found that the post-intervention difference in motivation for change there was statistically insignificant in the data from Carey et al. (2006) and Murphy et al. (2004), but a statistically significant change in the data from Borsari and Carey (2000). Borsari et al. (2009) used individual participant data. However, the study was limited by a small number of studies that were analyzed ($n = 3$). Further, Borsari et al. (2009) conducted a separate analysis of three data sets without quantitatively combining data. Murphy et al. (2010) and Ostafin and Palfai (2012) observed increased motivation for change post-BMI. However, the sample sizes of the studies were relatively small ($n = 74$ in study 1 and $n = 133$ in study 2 in Murphy et al. [2010], and $n = 87$ in Ostafin and Palfai [2012]). As noted in Mun et al. (2015), small individual studies may be more prone to biased statistical findings than a larger sample study or a meta-analysis because it is common to find large effects in small studies, which often fail to replicate. In sum, it is unclear whether BMIs increase motivation for change as indicated in theory because of the inconsistent findings across a handful of studies. Because of the paucity of research

addressing the intervention effect of BMIs on motivation, the extent to which BMIs enhance motivation to change is unclear. Meanwhile, the evidence of BMIs' efficacy on motivation is urgently needed to help guide adaptive alcohol intervention designs aimed at college students (Patrick et al., 2021) and, more broadly, young adults to optimize the content and delivery of BMIs based on their motivation for change.

Given the importance of motivation to the field of alcohol interventions and BMIs, it is unfortunate that sparse empirical evidence exists on motivation for change. If this scarcity of evidence is due to selective reporting—results selectively withheld from publication due to statistical non-significance, then meta-analysis can be a useful tool to access and pool information from the “grey literature.” Furthermore, a meta-analysis may provide much-needed clarity regarding whether and to what extent BMIs influence motivation for change among college students.

Project INTEGRATE and the Current Study

The current study conducted an individual participant data (IPD) meta-analysis to address the knowledge gaps regarding the effect of BMIs on motivation, using IPD from Project INTEGRATE (Mun et al., 2015) – the largest IPD meta-analysis project in alcohol intervention research for college students. Project INTEGRATE has supported multiple IPD meta-analysis studies using large-scale data to examine the effectiveness of BMIs in reducing alcohol-related problems (Jiao et al., 2020), alcohol consumption (Huh et al., 2015), and driving after drinking (Mun et al., 2022). The collective work of Project INTEGRATE has highlighted the major advantages of IPD meta-analysis compared to the standard meta-analysis of aggregate data or individual studies.

For the current study, Project INTEGRATE provides an ideal data source to examine the intervention effects of BMIs on motivation for change in drinking because it includes multiple independent studies that assessed motivation using multiple measures among samples with diverse participant characteristics. The use of various measures for motivation for change helps to examine whether an overall intervention effect exists and is robust when such diverse outcome measures are used. Meanwhile, the combined samples with diverse participant characteristics and intervention/comparison groups help to examine the robustness of the intervention effect and the boundaries of the robustness in the context of the heterogeneous sample characteristics. Furthermore, IPD meta-analysis provides a built-in replication of the effect across studies.

The current study aimed to investigate whether and to what extent BMIs affect motivation for change in drinking. Project INTEGRATE data include three major subtypes of BMIs: individually delivered motivational interviewing with personalized feedback (MI+PF), stand-alone personalized feedback (PF), and group-based motivational interviewing (GMI). We explored two more granular questions. First, we examined whether MI+PF has a greater effect than PF or GMI. MI+PF may be more effective than stand-alone PF or group-based formats in lowering resistance to change, and the inclusion of individually tailored motivational interviewing may promote greater awareness of problem drinking, contemplation of action, and setting goals for change. Second, we examined whether the intervention effect of BMIs on motivation for change is better retained in the studies with a follow-up assessed within six months vs. long-term (> 6 months). Any immediate change in motivation following intervention may decay post-intervention. This decay may help explain a “rebound” in drinking behavior over the long-term follow-up (Jiao et al., 2020). We hypothesized that BMIs (all subtypes included vs. control) would be associated with greater motivation for change in drinking behavior among

college students at the first follow-up. We also hypothesized that MI + PF would have a greater effect on motivation for change in drinking behavior than PF or GMI at the first follow-up, compared to control, and any intervention effect of BMIs on motivation for change would be limited in time.

Methods

Participants

The present analyses utilized data from Project INTEGRATE (Mun et al., 2015), an ongoing large-scale synthesis study aimed at examining the comparative effectiveness of BMIs for reducing alcohol misuse among college students by utilizing IPD. Of the 24 studies with available IPD ($N = 12,630$ participants at baseline) that were obtained from the original investigators, 15 studies met the following inclusion criteria of the current study: (a) at least two-arm randomized trials with a control group and (b) available outcome measures (i.e., motivation for change in drinking behavior) at baseline and a follow-up within 12 months post-intervention (see Table 1). At baseline, IPD from 7,433 participants from 15 studies were available. Of those, 1,530 participants did not have outcome data at the first follow-up within 12 months post-intervention, resulting in a sample of 5,903 participants (41% male, 72% White, and 59% first-year student) across the 15 studies (see Figure 1).

All BMIs were delivered individually in person, in group, via mail, or computer/online. All BMIs were considered brief but differed in the content topics covered and levels of personalization (Ray et al., 2014). The intervention content component of each intervention group per study was checked and coded. Motivation-related intervention content included whether it included decisional balance information on weighing the pros and cons of alcohol use

or barriers to change or discussion of change content relating to changing one's alcohol use behaviors (see Table 2).

The analysis of the current study was limited to complete cases. Thus, complete cases were compared on baseline characteristics between those included and excluded (missing) cases at follow-ups. In addition, we examined whether missing responses were related to observed data but not unobserved data (i.e., missing at random [MAR]). In alcohol interventions, MAR has been assumed reasonable in prior studies (Huh et al., 2021; Mun et al., 2009).

Measures

Readiness. The primary outcome of interest was motivation for change in drinking behavior. Three measures of motivation for change were used: (1) the 12-item Readiness to Change Questionnaire (RCQ; Heather, Rollnick, & Bell, 1993; see Supplemental Table 1 for items), (2) the 13-item University of Rhode Island Change Assessment (URICA; McConaughy, Prochaska, & Velicer, 1983; see Supplemental Table 2 for items), and (3) the Contemplation Ladder (Biener & Abrams, 1991; see Supplemental Table 3 for the item). To differentiate motivation as a construct from motivation as a measure, we used the term “readiness” to refer to the measures summarized in Table 3 for the 15 studies included in this IPD meta-analysis (see Table 3). No studies assessed more than one measure of readiness, so there was no overlap in measures across studies.

In addition, the same questionnaire may still vary across different studies, including, at the item level, similar items could be slightly differently worded (“No thought of changing” vs. “I’ve never needed to change my drinking” in the Contemplation Ladder); at the questionnaire level, Study 14 used a subset (Items 1, 3, 5, 6, 8) of the items in the URICA. For item response value, all RCQ responses were assigned scores ranging from -2 to 2, except that in Study 18, the

responses ranged from 1 to 5; and in Study 10, precontemplation items (Items 1, 2, 5, 10) had already been reversely coded in the original primary study (see Supplemental Tables 1–3). Both the RCQ and the URICA used a 5-point Likert scale ranging from “Strongly Disagree” to “Strongly Agree.” The Contemplation Ladder used a 1 to 10 scale from “No thought of changing” to “Take action to change”, except that a 1 to 5 scale was used in Study 12. To harmonize these differences among the same measures across studies, we carefully reviewed codebooks for item content and response item scores. If necessary, some of the items were recoded, including reverse coding Items 1, 5, 10, and 12 for studies that used the RCQ except Study 10. In addition, response options for Study 18 were recoded to make them consistent with other studies that used the RCQ. Responses to the Contemplation Ladder in Study 12 were also appropriately changed (see recoding details in Supplemental Tables 1–3).

Follow-up schedule. With respect to the timing of the first follow-up assessment, 67% ($n = 10$) of the studies had a short-term follow-up (1–3-months post intervention) as the first follow-up assessment, and 33% ($n = 5$) of studies had a long-term follow-up (12-months post intervention), as the first follow-up.

Demographic information. Demographic variables included sex (men vs. women), race (White vs. non-White), first-year student status (first-year vs. non first-year).

Data Analysis

All IPD were checked for any errors, outliers, and assumption violations prior to data analysis. Precontemplation items (see Supplemental Table 4) were checked and reverse coded where needed (see Table 4 for Cronbach’s α of the measure pre- and post-reverse coded for precontemplation items). Different measures and responses used in primary trials were harmonized across studies (see Supplemental Tables 1–3 for details). Because of measurement

differences, a 2-step IPD meta-analysis was conducted, in which summary data (i.e., coefficients or effect sizes) were derived from IPD in the first step and subsequently combined in the second step, similar to previous studies from Project INTEGRATE (Mun et al., 2022; White et al., 2015).

The standardized mean difference, a standard effect size measure for continuous variables between intervention and control group at the first follow-up, was used as a summary statistic in the meta-analysis. Due to the various measures of motivation across the included studies with different means and standard deviations (see Table 5), it was necessary to standardize the results across the studies to a uniform scale before they could be combined meaningfully. The standardized mean difference (SMD) expressed the size of the intervention effect in each study relative to the sampling variability observed in that study. Prior to summarizing the effect sizes of each study, the baseline level of readiness and the distribution of demographic characteristics were compared between the intervention and control groups.

Because some studies showed differences in readiness and demographic characteristics across randomized groups, in the first step of the IPD meta-analysis, we estimated intervention effect sizes within each study while accommodating baseline readiness scores (Model 1) and baseline readiness scores and demographic characteristics (Model 2). This approach ensured that the effect sizes were derived from the same model in all primary studies. Any imbalance across randomized groups could be adjusted. Further, the inclusion of baseline readiness scores and known covariates explained what may be unaccounted for in the model. Finally, estimated effect sizes would reflect the influence of these variables on outcomes, which could be meaningful, especially for studies that only contained freshman or female participants.

Model 1 models the post-intervention comparison of intervention group(s) (MI + PF, PF, or GMI) compared to controls in readiness at the first follow-up, controlling for baseline readiness scores and can be presented as the following Equation (1):

$$\text{POST_MOT}_i = b_0 + b_1\text{MIPF}_i + b_2\text{PF}_i + b_3\text{GMI}_i + b_4\text{BL_MOT}_i + e_i, \quad (1)$$

Equation (2) presented Model 2, which added demographic covariates (sex, race, and first-year student status) to Model 1:

$$\text{POST_MOT}_i = b_0 + b_1\text{MIPF}_i + b_2\text{PF}_i + b_3\text{GMI}_i + b_4\text{BL_MOT}_i + b_5\text{WHITE}_i + b_6\text{MALE}_i + b_7\text{FIRSTYR}_i + e_i, \quad (2)$$

where b_0, b_1, \dots, b_7 are regression coefficients and e_i is a participant-specific residual error term.

$\text{MIPF}_i, \text{PF}_i,$ and GMI_i are dummy-coded variables that indicate random allocation to MI + PF, PF, or GMI, respectively (each coded 1), compared to controls (coded 0). The regression coefficients $b_1, b_2,$ and b_3 quantify the covariate-adjusted average difference between participants who received (1) MI + PF, (2) stand-alone PF, or (3) GMI, respectively, compared to control participants. The covariate BL_MOT_i adjusts for baseline readiness scores and the covariates $\text{WHITE}_i, \text{MALE}_i,$ and FIRSTYEAR_i adjust for the baseline demographic characteristics: sex (1 = man vs. 0 = woman), race (1 = White vs. 0 = non-White), and first-year student status (1 = first-year vs. 0 = non first-year). POST_MOT_i refers to the post-intervention readiness score for participant i . Through obtaining the standardized coefficients $b_1, b_2,$ and b_3 in the above Models 1 and 2 for each study, we essentially estimated the standardized mean difference in readiness between intervention and control groups since intervention has occurred.

In the second step of meta-analysis, we utilized random-effects meta-analysis models to obtain the pooled overall effect size, in which between-study heterogeneity and uneven sample sizes across studies would be taken into account. Meta-regression was conducted to examine

whether the intervention effects on readiness differ across BMI subtypes and whether BMIs present stronger intervention effects on readiness in short-term vs. long-term follow-ups. All meta-analyses and meta-regression were conducted for Models 1 and 2.

Data preparation was conducted using SAS 9.4 (SAS Institute Inc., Cary, NC), IBM SPSS Statistics (Version 26), and Microsoft Excel (Version 16); meta-analyses were conducted using the package ‘metafor’ version 3.0-2 (Viechtbauer, 2010) for R version 4.1.2 (R Core Team, 2021). Statistical significance was set at $p < .05$, and analyses were two-tailed.

Results

Descriptive Analysis

Table 5 shows the means and standard deviations of readiness scores for intervention and control groups for each study at baseline and follow-up and shows the between-study heterogeneity in the outcome of interest across different measures used in primary studies. The comparison of readiness scores at baseline between intervention and control groups indicated that baseline imbalance existed in Study 7.2 (Table 5). Demographic variables were not associated with post-intervention readiness, except for Study 20, in which male participants presented a higher post-intervention readiness than female students.

As a routine check for meta-analysis, Supplemental Figures 1–4 present the regular and contour-enhanced funnel plots for the outcome of interest. A funnel plot can help detect potential publication bias due to the suppression of non-significant findings. In all plots of Supplemental Figures 1–4, effect sizes are distributed in an approximately symmetrical funnel shape but missing studies with small samples. Because none of the primary studies reported readiness in their individual studies, whether effect sizes estimated directly from IPD show publication bias is less relevant for the current study.

Overall BMI on Readiness

Figure 2 shows the overall intervention effect of BMIs on motivation for change in drinking behavior, compared to controls, was not statistically significant, 0.026 in SMD, 95% *CI*: [-0.001, 0.053], $p = .06$, for the model adjusted for baseline motivation level and demographic characteristics, across $k = 19$ comparisons. The I^2 statistic was 28.1%, which indicates a small to moderate level of between-study heterogeneity. Figure 2 presents the different degrees of effectiveness across BMI types and studies, with 13 out of 19 effect sizes in the direction of BMIs increasing readiness, compared to the control groups (see Figure 3 for the result where Model 1 was used as the base model). Table 6 summarizes the effect of BMIs on readiness per study for Models 1 and 2. Supplemental Tables 5–20 present the entire outcomes, including the coefficients for demographic variables (race, sex, and first-year of school) in Model 2.

BMI Subtypes and Readiness

To examine any subtype differences, meta-analysis was analyzed separately for each subtype followed by a meta-regression. Results indicated that among subtypes of BMIs, only GMI statistically significantly increased readiness (SMD = 0.055, 95% *CI*: [0.007, 0.103], $k = 5$, $p = .02$). There was no evidence that MI + PF (SMD = 0.04, 95% *CI*: [-0.02, 0.10], $k = 6$, $p = .20$) or PF increased readiness (SMD = 0.005, 95% *CI*: [-0.028, 0.039], $k = 8$, $p = .75$). A formal meta-regression comparing effect sizes across subtypes also did not show a statistically significant difference across subtypes.

Short-term vs. Long-term Differences

The results from meta-regression indicate that there was no evidence that studies with short-term vs. long-term follow-ups produced different effect sizes, SMD = 0.002, 95% *CI*: [-0.056, 0.059], $k = 19$, $p = .96$. Nonetheless, the results of subsequent subgroup meta-regression

within studies using short-term follow-up schedules indicated that there was a statistically significant decrease in the intervention effects over time within the first 3 months post-intervention, $\beta = -0.05$, 95% *CI*: [-0.08, -0.01], $p = .005$, $k = 14$.

Discussion

This is the first meta-analysis evaluating the intervention effect of BMIs on motivation for change in drinking among college students. Specifically, this study examined the primary hypothesis regarding the overall intervention effect of BMIs on motivation for change in drinking behavior among college students. Two exploratory hypotheses were subsequently examined regarding subtypes of BMIs (i.e., MI+PF, GMI, and stand-alone PF) and intervention effects of BMIs at different follow-up schedules (i.e., short-term less than or equal to 6 months, and long-term more than 6 months). Facilitated by IPD, we were able to check baseline balance and to make appropriate adjustments for variation in participant characteristics across the included studies to ensure that necessary assumptions were met for proper estimation and inference, and that the same interpretation of effect sizes could be made across heterogeneous studies in a meta-analysis.

The findings of this study did not support the first hypothesis regarding the intervention effect of BMIs on motivation for change in drinking. Subsequent subgroup analysis suggested that although the effect size presented by GMI was relatively small, GMI statistically significantly improved motivation compared to control groups. The small effect size may explain the reason for inconsistent findings among the existing studies (Borsari & Carey, 2000; Carey et al., 2006; Murphy et al., 2004; Murphy et al., 2010; Ostafin & Palfai, 2012), with a possibility that even the significant finding may be because of chance, especially among underpowered studies (Kühberger et al., 2014).

Upon carefully examining each intervention, however, the included studies that provided GMI to students tended to cover decisional balance and change discussion for students that were both educational and personalized (Table 2). GMI was also provided in person. Therefore, the current finding suggests that to help motivate students, the discussion should ideally be provided in person.

Given the importance of motivation in behavior change theories (DiClemente & Velasquez, 2002; Miller & Rollnick, 2013) and BMIs (Larimer et al., 2021), the effective components of the BMIs are yet to be further explored. The effect size reflected in the current study's findings may also help determine the essential statistical power for similar interventions in the future. BMIs require considerable funding, time, and human resources for facilitating an individual-level motivational interview and for following up with participants over time to retain beneficial effects or to prevent relapse. Thus, it is important to have the power estimation based on a reasonable effect size assumption at the planning stage and to obtain a sufficient sample size during the implementation stage to ensure a well-powered intervention study. Moreover, this study provides supportive evidence for future GMI studies examining longitudinal mediation hypotheses involving motivation for change as it tested the “a” path of a mediation model, whether the causal variable (i.e., GMI vs. comparison) is associated with change in the theorized mediator (i.e., motivation).

Stand-alone PF interventions require fewer resources for implementation and have relatively better practicality (Cronce et al., 2018), compared to the other two subtypes of BMIs; however, the findings of the current study present the very limited effect of stand-alone PF on motivation for change in drinking behavior, compared to MI + PF and GMI. It may be because with minimal in-person contact, PF focuses more on providing personalized feedback on

drinking norms and other helpful feedback such as protective behavioral strategies rather than addressing motivation, which may require more interaction and processing. There may be an exposure-outcome specificity in the effects of BMIs such that PF is more effective for improving use of protective behavioral strategies, which helps reduce alcohol-related problems (Huh et al., 2022). Because PF can have a better reach than GMI or MI + PF, how to improve motivation when feedback is delivered through the Web or an app may require additional considerations for better engagement and outcome. Recent studies that provided synchronous teleconferencing (i.e., Zoom) or text-based intervention have demonstrated the feasibility and preliminary effectiveness (e.g., Gex et al., 2022). With the Covid-19 pandemic, no-contact in-person meetings have proliferated and have been generally accepted. Therefore, future trials may explore supplementing PF with an additional as-needed exposure to improve motivation for college students.

Although there was no statistically significant evidence that MI + PF improves motivation in the current study, this finding should be interpreted with caution as it may be because of the heterogeneity from the primary studies included in Project INTEGRATE and also the smaller number of studies per each BMI subtype. For example, GMI subgroups had a mandated college student sample (Study 7.1). Additionally, this finding may indicate that for BMIs to improve motivation, behavioral interventions delivered to students in a group setting may yield similar intervention effects compared to individualized behavioral interventions and that GMI may be a reasonable alternative for MI+PF as it usually requires less resources for the delivery of intervention content to participants. This may be helpful for substantive researchers in selecting intervention settings or for practitioners in the determination of related training when resources are limited.

In previous Project INTEGRATE studies, intervention effects on alcohol-related problems (Jiao et al., 2020) and driving after drinking (Mun et al., 2022) presented a generally weakening trend over time post-intervention, which is common among behavioral interventions. Thus, we expected that motivation might present similar decreasing intervention effects over time within the first 12-months post-intervention. However, the findings from the meta-regression indicate that the intervention effects on motivation were similar at longer-term follow-ups, compared to the intervention effects observed at short-term follow-ups. However, this should be cautiously interpreted because the follow-up schedule and study membership were confounded due to the limited sample size at the study level. Nonetheless, there was a significant average decrease of 0.05 in SMD every month in the first three-month post-intervention. Given the overall small effect size, this precipitous drop suggests that the motivation level decreased profoundly and quickly in the short-term, which suggests a sensitive time window in which participants might be still motivated to potentially initiate behavior changes. This “motivated” time window may help intervention researchers determine the implementation timing of potentially additional supports (e.g., booster sessions) for healthy behavior changes.

Limitations

The current study had some limitations. First, the IPD sample of the current study was not sampled systematically or with a probability sampling design. Thus, the generalizability of the IPD sample remains a question for the current study. However, IPD are challenging to obtain, and simple random sampling is rare even in the original studies. Second, the current analyses also retained some of the limitations of the original studies, specifically, the limitation of original measures for motivation for change. Some studies used a single-item measure, while other questionnaires were developed to reflect qualitatively different stages of change, which may not

be ideal as a tool to assess changing motivation quantitatively. Third, the studies included in the current study were published between 2001 and 2010. Thus, future research synthesis may potentially search and update IPD from more current BMIs studies that include more diverse and updated intervention strategies.

Harmonization is an essential preparation step for IPD meta-analysis in which the values from different variables that assess the same concept are recoded for subsequent synthesis (Mun et al., 2015). The purpose of harmonization is to make the measures comparable across different studies or assessment time points if designed differently. In the current study, there is no overlap among the three different measures that assessed motivation for change (i.e., each study used only one of the measures to assess motivation), and none of the measures shared similar response ranges or anchor points, which makes the harmonization of the measures difficult. We overcome this challenge by conducting a two-step IPD meta-analysis. With item overlap across primary studies, it may be possible to conduct item-based, more granular analysis. Compared to traditional scale score-based approaches, novel item-level analysis such as the cognitive diagnosis modeling (CDM) method used in a recent work of Project INTEGRATE (Tan et al., 2022) may be feasible for a simultaneous integrative analysis approach to research synthesis. Finally, some comparisons were nested within the study when primary studies had multiple intervention arms. Though it is a common practice in meta-analysis to analyze the multiple arms from the same study separately, it still violates the independence assumption when the analysis shares the same control group for the multiple arms within the study.

Conclusion

This study did not find evidence that BMIs changed motivation in this group of studies. Future substantive researchers may explore the effective components to improve BMIs using

more advanced modeling and mapping strategies in estimation. However, intervention effects on motivation exist among GMI where intervention content targeted explicitly for motivation is provided. Further, there may be a sensitive time window for behavioral change. It may be helpful for researchers to leverage this time-sensitive period to motivate students to change their drinking and to provide relevant content to help them change.

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Tables

Table 1

Description of the Individual Participant Data at Baseline from the 15 Studies Included in the Current Study (N = 8,067; 35 Randomized Groups and 15 Studies)

Study	Reference	BMI Type	Randomized Group n	Follow-up (Months)	%White	% Male	% First Year
2	White et al. (2008)	PF	111	2	67	71	63
		Control	119				
7.1	Fromme et al. (2004)	GMI	100	1	73	76	57
		Control	24				
7.2	Fromme et al. (2004)	GMI	317	1	58	59	37
		Control	135				
8a	Larimer et al. (2007)	PF	736	12	86	33	49
		Control	750				
8b	Larimer et al. (2007)	PF	1094	12	61	41	47
		Control	1061				
8c	Larimer et al. (2007)	PF	303	12	82	38	36
		Control	297				
9	Lee et al. (2009)	GMI	97	3	72	38	100
		MI + PF	101				
		PF	100				
		Control	101				
10.1	Baer et al. (2001)	MI + PF	174	12	84	46	100
		Control	174				
11	Walters et al. (2007)	PF	185	2	63	59	100
		Control	198				
12	Wood et al. (2007)	MI+PF	84	1	93	47	3
		Control	83				
14	Murphy et al. (2001)	MI+PF	30	3	96	44	38
		Control	25				
15	Labrie et al. (2008)	GMI	155	1	51	0	100
		Control	108				
16	LaBrie et al. (2009)	GMI	161	1	56	0	100
		Control	126				
18	Martens et al. (2010)	PF	102	1	89	25	33
		Control	113				
20	Larimer et al. (2001)	MI + PF	318	12	82	54	74
		Control	369				
21	Walters et al. (2009)	MI + PF	76	3	85	36	42
		PF	68				
		Control	72				

Notes. Study 7 is a single study with two distinct subsamples. Study 8 is a multi-site study (Studies 8a, 8b, 8c). MI + PF = individually delivered in-person motivational interviewing intervention with personalized feedback, GMI = group motivational interviewing intervention, BMI = brief motivational intervention, PF = stand-alone personalized feedback intervention.

Table 2*Intervention Exposure to Motivation-related Content by Group per Study*

Study	BMI type	Decisional balance	Discussion of change
2	PF	0	2
	Control	0	0
7.1	GMI	3	1
	Control	0	0
7.2	GMI	3	1
	Control	0	0
8a	PF	0	1
	Control	0	0
8b	PF	0	1
	Control	0	0
8c	PF	0	1
	Control	0	0
9	PF	0	0
	GMI	1	3
	MI+PF	0	2
	Control	0	0
10.1	MI+PF	0	3
	Control	0	0
11	PF	0	3
	Control	0	0
12	MI+PF	0	2
	Control	0	0
14	MI+PF	0	2
	Control	0	0
15	GMI	3	3
	Control	0	0
16	GMI	3	3
	Control	0	0
18	PF	0	0
	Control	0	0
20	MI+PF	1	3
	Control	0	0
21	PF	0	3
	MI+PF	1	3
	Control	0	0

Notes. Decisional balance: Information on weighing the pros and cons of alcohol use or barriers to change; personal content includes feedback on a participant's pros and cons or barriers to change; general content includes information on general pros and cons or typical barriers that students face. Discussion of change: content that relates to changing one's alcohol use behaviors, including readiness to change or goal-setting; personal content is that which addresses a participant's readiness to change or personal goals about changing; general content includes information such as the importance of goal setting. Coded 0 = no content 1 = general content 2 = personal content 3 = both general & personal.

Table 3*Variation in the Measurement of Readiness to Change in Drinking Behavior Across Studies*

Study	Questionnaire	Number of items	Original response categories (values in original studies)		Possible range of total scale scores
2, 8a, 8b, 8c, 9, 11, 18, 21	Readiness to Change Questionnaire (RCQ)	12	Strongly Disagree Disagree Undecided Agree Strongly Agree	(-2) (Study 18: 1) (-1) (Study 18: 2) (0) (Study 18: 3) (1) (Study 18: 4) (2) (Study 18: 5)	-24–24 (Study 18: 12–60)
7.1, 7.2, 10.1, 14, 20	University of Rhode Island Change Assessment (URICA)	13 (Study 14: 5)	Strongly Disagree Disagree Undecided Agree Strongly Agree	(1) (2) (3) (4) (5)	13–65 (Study 14: 5–25)
12, 15, 16	Contemplation Ladder	1	I've never needed to change my drinking (Study 12: No thought of changing) Sometimes I think about drinking less (Study 12: Think I need to consider someday) I have decided to drink less (Study 12: Think I should change, but not quite ready) I am already trying to cut back on my drinking (Study 12: Start to think about how to change my drinking patterns) My drinking has changed; I now drink less than before (Study 12: Take action to change [e.g., cutting down])	(1) (3) (5) (7) (10)	1–10 (Study 12: 1–5)

Table 4

Cronbach's α of Readiness Score Pre- and Post-Reverse Coding for Precontemplation Items at Baseline and Follow-up

Study	Measure	α of the original coding		α after reverse coding precontemplation items	
		Baseline	Follow-up	Baseline	Follow-up
2	RCQ	0.412	0.490	0.847	0.833
7.1	URICA	0.869	0.890	0.883	0.898
7.2	URICA	0.869	0.881	0.876	0.892
8a	RCQ	0.616	0.649	0.830	0.833
8b	RCQ	0.652	0.670	0.820	0.831
8c	RCQ	0.636	0.659	0.831	0.821
9	RCQ	0.581	0.587	0.825	0.834
10	URICA	0.850	0.909	-	-
11	RCQ	0.656	0.671	0.694	0.772
12	LADDER	-	-	-	-
14	URICA	-0.236	0.151	0.802	0.799
15	LADDER	-	-	-	-
16	LADDER	-	-	-	-
18	URICA	0.623	0.631	0.814	0.831
20	URICA	0.866	0.862	0.817	0.830
21	RCQ	0.450	0.562	0.860	0.870

Notes. Study 7 is a single study with two distinct subsamples. Study 8 is a multi-site study (Studies 8a, 8b, 8c). RCQ = The Readiness to Change Questionnaire, URICA = The University of Rhode Island Change Assessment, LADDER = The Contemplation Ladder. The Contemplation Ladder has only one item; Precontemplation items in Study 10 were reversely coded.

Table 5

Readiness Score in Original Scale by Group per Study at Baseline (N = 7,433) and Follow-up (N = 5,903)

Study	Measure	BMI Type	Baseline			Follow-up		
			<i>n</i>	<i>M</i>	<i>SD</i>	<i>n</i>	<i>M</i>	<i>SD</i>
2	RCQ	PF	111	-6.37	9.00	95	-5.91	8.39
		Control	119	-6.08	8.20	104	-6.83	8.44
7.1	URICA	GMI	100	31.59	9.62	82	31.51	10.13
		Control	24	30.31	9.15	24	30.54	10.41
7.2	URICA	GMI	317	29.21	8.78	220	29.89	9.03
		Control	135	26.45	7.67	111	26.40	8.76
8a	RCQ	PF	629	-8.81	8.65	504	-9.12	8.35
		Control	635	-9.27	8.54	519	-8.71	8.57
8b	RCQ	PF	885	-9.29	8.28	691	-9.19	8.56
		Control	910	-8.58	8.93	743	-9.29	9.00
8c	RCQ	PF	286	-8.45	8.79	133	-7.89	8.43
		Control	278	-8.02	9.15	162	-8.56	8.72
9	RCQ	PF	100	-6.55	7.67	85	-5.34	8.07
		GMI	97	-4.91	7.95	83	-4.72	8.28
		MI+PF	101	-7.54	7.40	84	-6.36	7.40
		Control	101	-6.19	7.73	82	-4.83	7.97
10.1	URICA	MI+PF	173	29.87	8.01	156	28.34	9.95
		Control	173	30.00	7.73	165	25.70	8.66
11	RCQ	PF	185	-9.31	7.16	129	-9.56	7.97
		Control	198	-9.15	7.09	143	-9.34	7.50
12	LADDER	MI+PF	84	2.75	2.33	76	3.55	2.69
		Control	83	3.10	2.47	81	3.26	2.32
14	URICA	MI+PF	30	9.17	2.67	29	9.45	2.90
		Control	25	8.60	2.81	18	8.56	3.40
15	LADDER	GMI	151	3.01	2.98	141	2.71	3.01
		Control	104	2.88	3.04	102	2.15	2.39
16	LADDER	GMI	161	3.16	3.42	159	2.79	2.74
		Control	126	2.71	3.17	125	2.46	2.87
18	RCQ	PF	102	-8.86	7.51	79	-8.05	7.87
		Control	112	-9.89	8.08	89	-10.12	7.72
20	URICA	MI+PF	316	28.27	8.26	228	26.97	8.30
		Control	366	29.35	8.91	261	27.63	9.04
21	RCQ	PF	68	-4.26	8.25	60	-5.82	8.17
		MI+PF	76	-4.84	7.43	73	-4.78	7.91
		Control	72	-4.46	8.37	67	-4.81	8.31

Notes. Study 7 is a single study with two distinct subsamples. Study 8 is a multi-site study (Studies 8a, 8b, 8c). MI + PF = individually delivered in-person motivational interviewing intervention with personalized feedback, GMI = group motivational interviewing intervention, BMI = brief motivational intervention, PF = stand-alone personalized feedback intervention.

RCQ = The Readiness to Change Questionnaire, URICA = The University of Rhode Island Change Assessment, LADDER = The Contemplation Ladder.

Table 6*Linear Models Estimating Intervention Effects on Readiness at First Follow-up*

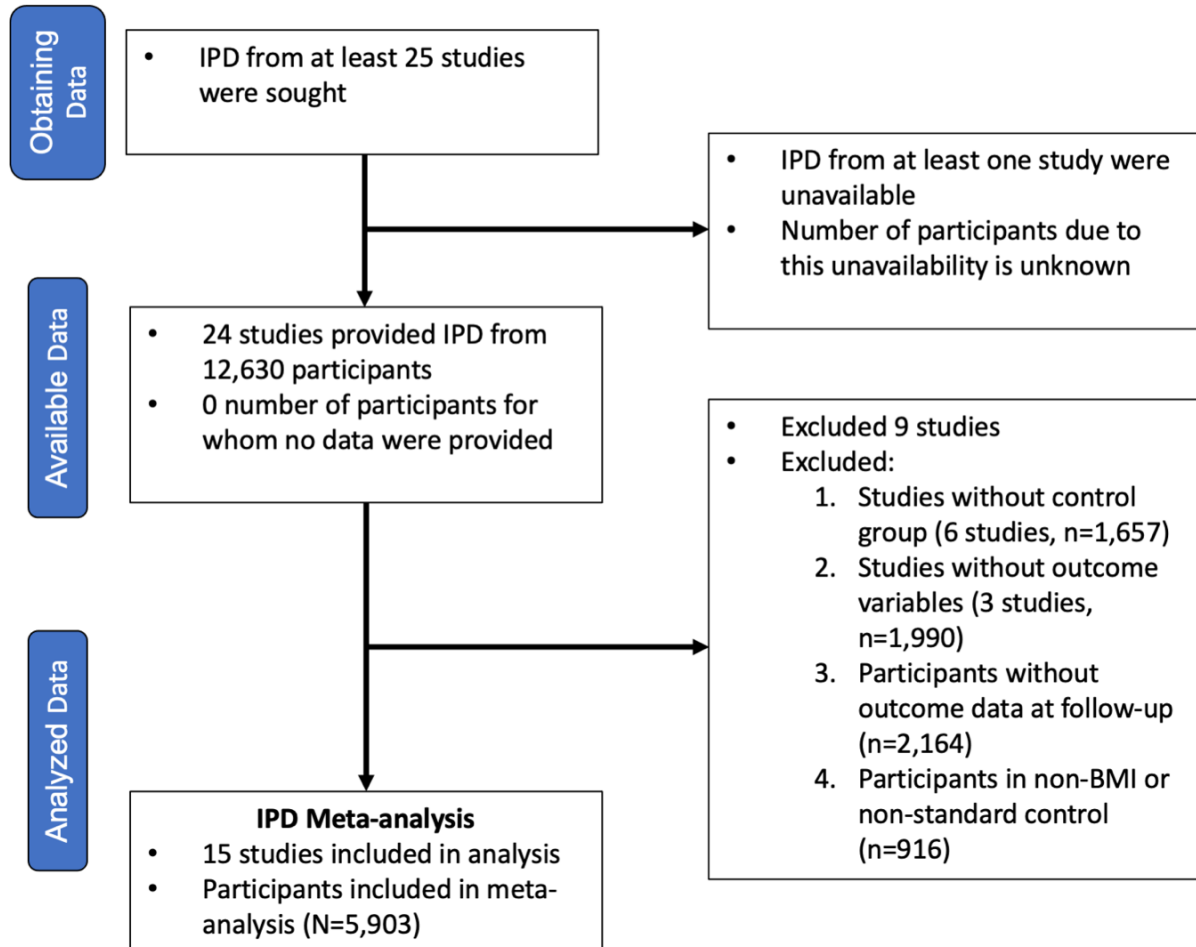
Study	Intervention	Model 1		Model 2	
		Std Beta	SE	Std Beta	SE
2	PF	0.073	0.054	0.075	0.056
7.1	GMI	0.007	0.078	0.028	0.076
7.2	GMI	0.089	0.041	0.089	0.043
8a	PF	-0.040	0.028	-0.038	0.028
8b	PF	0.017	0.025	0.019	0.025
8c	PF	0.067	0.051	0.070	0.051
9	PF	-0.025	0.057	-0.030	0.057
	GMI	-0.012	0.059	-0.014	0.058
	MI+PF	-0.042	0.058	-0.045	0.058
10.1	MI+PF	0.132	0.049	0.134	0.049
11	PF	0.017	0.049	0.015	0.049
12	MI+PF	0.074	0.076	0.078	0.076
14	MI+PF	0.124	0.134	0.100	0.141
15	GMI	0.115	0.060	0.114	0.061
16	GMI	0.029	0.052	0.029	0.053
18	PF	0.043	0.062	0.040	0.062
20	MI+PF	0.019	0.040	0.016	0.038
21	MI+PF	-0.002	0.067	-0.004	0.067
	PF	-0.086	0.062	-0.089	0.062

Notes. MI + PF = individually delivered in-person motivational interviewing intervention with personalized feedback, GMI = group motivational interviewing intervention, PF = stand-alone personalized feedback intervention. Model 1 adjusted for baseline motivation for change; Model 2 adjusted for baseline motivation for change, sex, race, and year of school; Std Beta = standardized beta, SE = standard error.

Figures

Figure 1

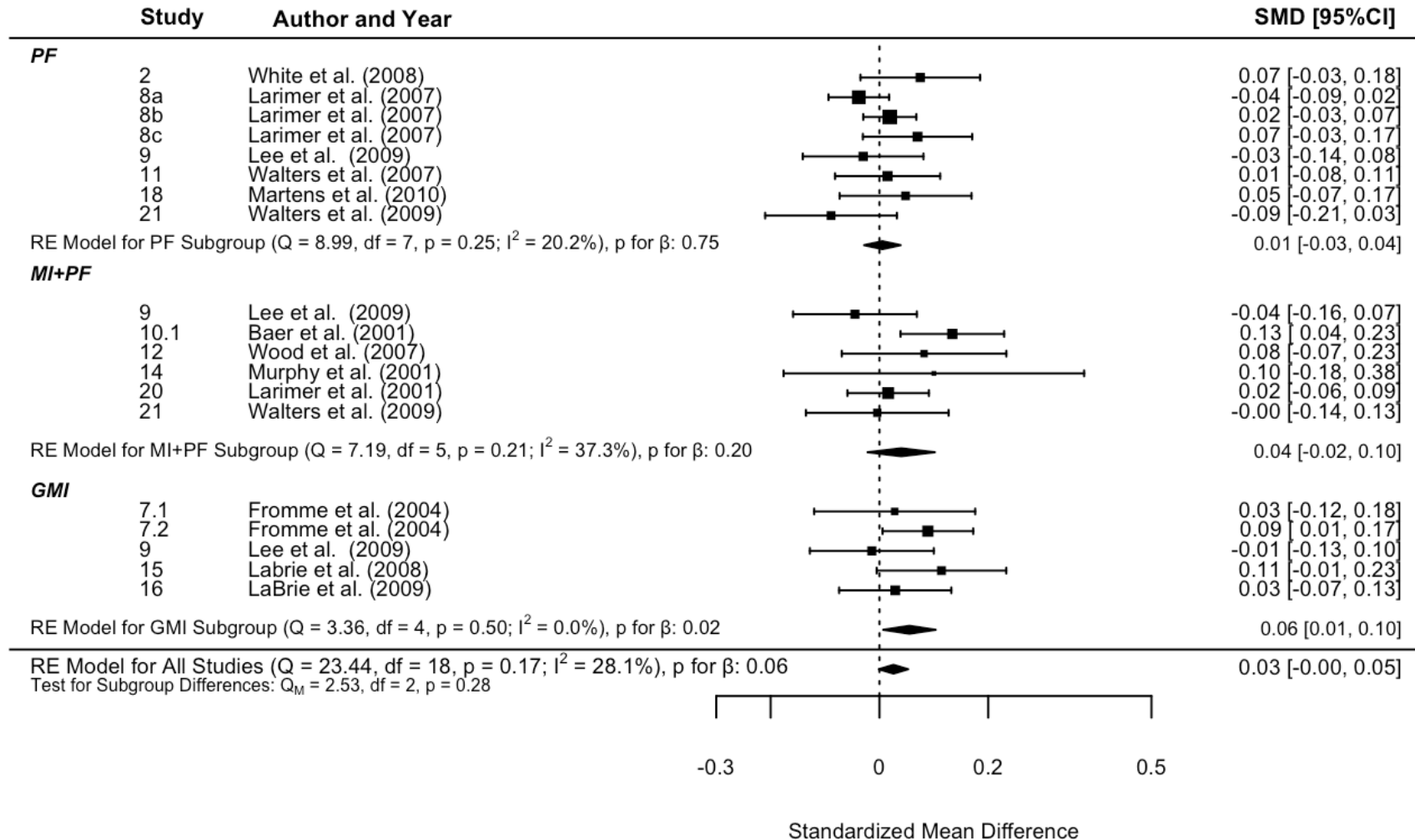
PRISMA IPD Flow Diagram



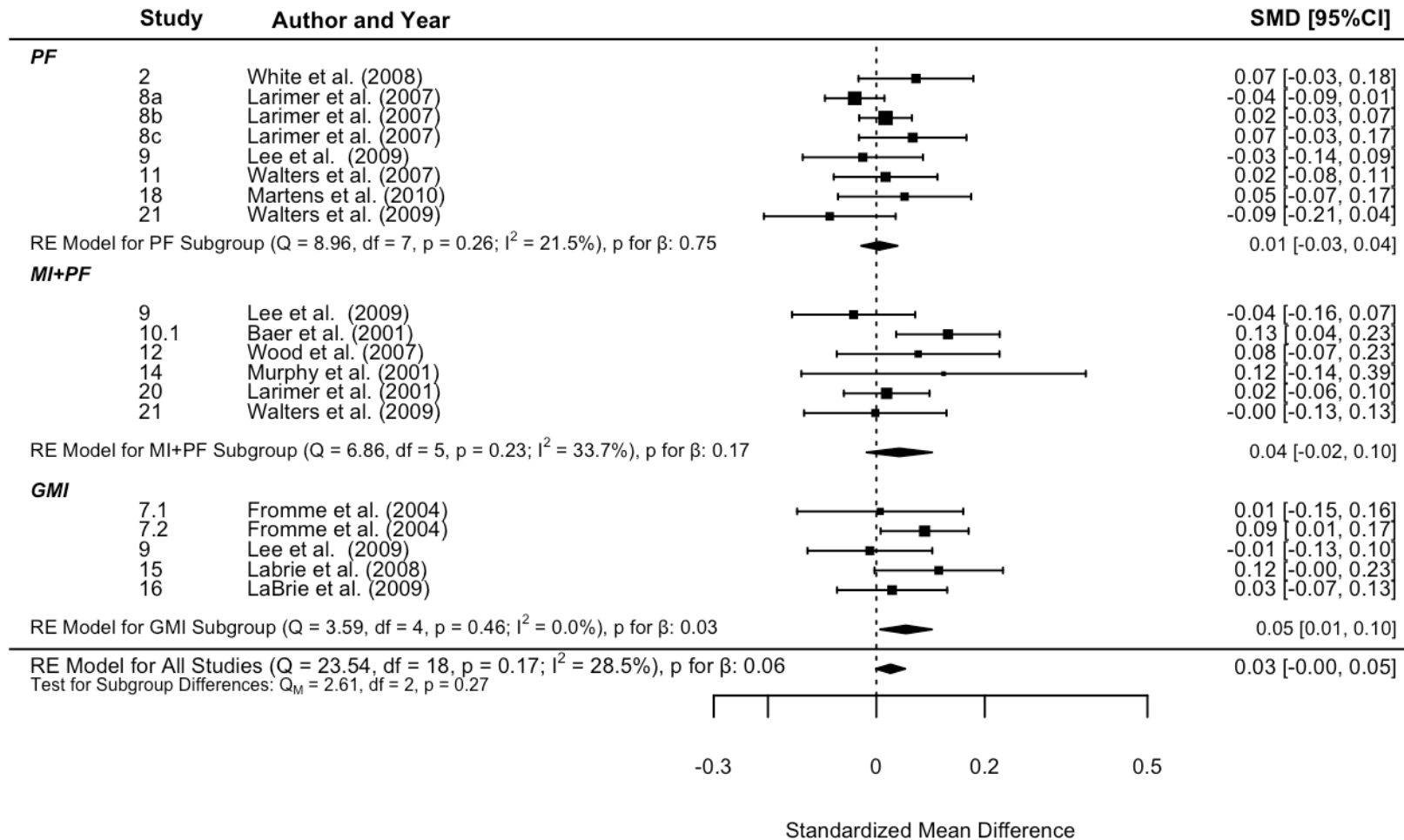
Notes. IPD come from Project INTEGRATE (Mun et al., 2015). Data flow at the identification, screening, and eligibility stages is not applicable.

Figure 2

Forest Plot of Motivation for Change in Drinking from Model Adjusted for Baseline Motivation for Change and Demographic Variables



Note. MI + PF = individually delivered in-person motivational interviewing intervention with personalized feedback, GMI = group motivational interviewing intervention, PF = stand-alone personalized feedback intervention, SMD = standardized mean difference.

Figure 3*Forest Plot of Motivation for Change in Drinking from Model Adjusted for Baseline Motivation for Change*

Note. MI + PF = individually delivered in-person motivational interviewing intervention with personalized feedback, GMI = group motivational interviewing intervention, PF = stand-alone personalized feedback intervention, SMD = standardized mean difference.

Supplemental Table 1

Item Content of the Readiness to Change Questionnaires (RCQ)

Variable Name	Item Content
RCQ01	I don't think I drink too much (Studies 11, 18, 21: My drinking is okay as it is)
RCQ02	I am trying to drink less than I used to
RCQ03	I enjoy my drinking, but sometimes I drink too much
RCQ04	Sometimes I think I should cut down on my drinking (Studies 11, 18, 21: I should cut down on my drinking)
RCQ05	It's a waste of time to think about my drinking
RCQ06	I have just recently changed my drinking habits
RCQ07	Anyone can talk about wanting to do something about drinking, but I am actually doing something about it
RCQ08	I am at the stage where I should think about drinking less alcohol
RCQ09	My drinking is a problem sometimes (Studies 11, 18, 21: My drinking is a problem)
RCQ10	There is no need for me to think about changing my drinking (Study 11, 18, 21: It's alright for me to keep drinking as I do now)
RCQ11	I am actually changing my drinking habits right now
RCQ12	Drinking less alcohol would be pointless for me (Studies 11, 18, 21: My life would be the same even if I drank less)

Notes. Studies 2, 8a, 8b, 8c, and 9 used the wording as shown. Items 1, 5, 10, and 12 are Precontemplation items and hence reverse coded. Items 3, 4, 8, and 9 are Contemplation items, and Items 2, 6, 7, and 11 are Action stage items. RCQ used the stem question, “The following questionnaire is designed to identify how you personally feel about your drinking right now. Please... decide whether you agree or disagree with the statements” for all 12 items.

Supplemental Table 2

Item Content of the University of Rhode Island Change Assessment (URICA)

Variable Name	Item Content
MOT01	As far as I'm concerned, my drinking does not need changing
MOT02	I think I might be ready for some self-improvement around alcohol
MOT03	I've been thinking that I might want to change my drinking habits
MOT04	(I'm hoping this research will help me) OR (This research has helped me) better understand my drinking
MOT05	I am really working hard to change my drinking habits
MOT06	I have had problems with alcohol and I really think I should work on it
MOT07	Even though I am not always successful at changing, I am at least working on changing my drinking habits
MOT08	I wish I had more ideas on how to change my drinking habits
MOT09	(Maybe this research will help me) OR (This research has helped me) in regards to my drinking
MOT10	I may have a drinking problem, but I don't think so
MOT11	(I hope that someone in the research will have some) OR (Someone in the research had some) good advice for me about my alcohol use
MOT12	Anyone can talk about changing, I'm actually doing something about my alcohol use
MOT13	I am actively working on changing my drinking habits

Notes. Items 1 and 10 are precontemplation items and checked for reverse coding. Study 10 had reverse-coded Items 1 and 10. For all other studies, the response values of these two items were reverse-coded in the current study prior to analysis. All studies except Study 14 used the same items and responses. Study 14 used Items 1, 3, 5, 6, and 8. The URICA uses the stem question, "Please indicate the extent to which you tend to agree or disagree with each statement. Make your choice in terms of how you feel right now" for all 13 items.

Supplemental Table 3*Item Description of the Contemplation Ladder*

Variable Name	Item Content
LADDR	Each rung of this ladder represents where various people are in thinking about changing their drinking. Shade the corresponding number that indicates where you are now.

Notes. The Contemplation Ladder uses the question, “Each rung of this ladder represents where various people are in thinking about changing their drinking. Shade the corresponding number that indicates where you are now,” with response categories in the form of a ladder, ranging from 1 to 10 in a figure. All studies except Study 12 used the same item and response option. Study 12 used response values ranging from 1 to 5 and were recoded to 1 to 10 in the analysis (see Table 2).

Supplemental Table 4
Precontemplation Items and Recoding

Study	Measure	Item	Variable name: Baseline/Follow-up	Original value	Recoding
2	RCQ	RCQ01	T1RD1/T2RD1	-2,-1,0,1,2	2,1,0,-1,-2
		RCQ05	T1RD5/T2RD5	-2,-1,0,1,2	2,1,0,-1,-2
		RCQ10	T1RD10/T2RD10	-2,-1,0,1,2	2,1,0,-1,-2
		RCQ12	T1RD12/T2RD12	-2,-1,0,1,2	2,1,0,-1,-2
7	URICA	MOT1	T1URI1A/T2URI1A	1,2,3,4,5	5,4,3,2,1
		MOT10	T1URI10A/ T2URI10A	1,2,3,4,5	5,4,3,2,1
8	RCQ	RCQ01	ABRCQ01/BBRCQ01	-2,-1,0,1,2	2,1,0,-1,-2
		RCQ05	ABRCQ05/BBRCQ05	-2,-1,0,1,2	2,1,0,-1,-2
		RCQ10	ABRCQ10/BBRCQ10	-2,-1,0,1,2	2,1,0,-1,-2
		RCQ12	ABRCQ12/BBRCQ12	-2,-1,0,1,2	2,1,0,-1,-2
9	RCQ	RCQ01	ABRCQ01/BBRCQ01	-2,-1,0,1,2	2,1,0,-1,-2
		RCQ05	ABRCQ05/BBRCQ05	-2,-1,0,1,2	2,1,0,-1,-2
		RCQ10	ABRCQ10/BBRCQ10	-2,-1,0,1,2	2,1,0,-1,-2
		RCQ12	ABRCQ12/BBRCQ12	-2,-1,0,1,2	2,1,0,-1,-2
10	URICA	MOT1	BMOT1/EMOT1		
		MOT10	BMOT11/EMOT10		
11	RCQ	RCQ01	RTC_1_DRINKINGOK/rtc_fu1_1	-2,-1,0,1,2	2,1,0,-1,-2
		RCQ05	RTC_5_WASTEOFTIME/rtc_fu1_5	-2,-1,0,1,2	2,1,0,-1,-2
		RCQ10	RTC_10_ALRIGHT/rtc_fu1_10	-2,-1,0,1,2	2,1,0,-1,-2
		RCQ12	RTC_12_LIFETHESAME/rtc_fu1_12	-2,-1,0,1,2	2,1,0,-1,-2
14	URICA	MOT1	T1MOTIV1/T2MOTIV1	1,2,3,4,5	5,4,3,2,1
18	RCQ	RCQ01	RTC1/YRTC1	1,2,3,4,5	2,1,0,-1,-2
		RCQ05	RTC5/YRTC5	1,2,3,4,5	2,1,0,-1,-2
		RCQ10	RTC10/YRTC10	1,2,3,4,5	2,1,0,-1,-2
		RCQ12	RTC12/YRTC12	1,2,3,4,5	2,1,0,-1,-2
20	URICA	MOT1	AMOT1/BMOT1	1,2,3,4,5	5,4,3,2,1
		MOT10	AMOT10/BMOT10	1,2,3,4,5	5,4,3,2,1
21	RCQ	RCQ01	RTCQ1/RTCQ1_3	-2,-1,0,1,2	2,1,0,-1,-2
		RCQ05	RTCQ5/RTCQ5_3	-2,-1,0,1,2	2,1,0,-1,-2
		RCQ10	RTCQ10/RTCQ10_3	-2,-1,0,1,2	2,1,0,-1,-2
		RCQ12	RTCQ12/RTCQ12_3	-2,-1,0,1,2	2,1,0,-1,-2

Notes. RCQ = The Readiness to Change Questionnaire, URICA = The University of Rhode Island Change Assessment, LADDER = The Contemplation Ladder. Contemplation Ladder has only one item; Precontemplation items in Study 10 had been reverse-coded in the original study.

Supplemental Table 5*Linear Models Estimating Intervention Effects on Readiness at First Follow-up for Study 2*

	Unstandardized Coefficients		Standardized Coefficients		<i>p</i>	<i>R</i> ²	
	<i>b</i>	<i>SE</i>	<i>b</i> *	<i>SE</i>			
Model 1						.4237	<i>F</i> (2, 196) 72.0621
Intercept	-2.9095	0.7089			0.0001		
Intervention	1.2303	0.9103	0.0733	0.0542	0.1781		
Baseline readiness	0.6592	0.0551	0.6489	0.0542	<0.0001		
Model 2						.4214	<i>F</i> (5, 188) 27.3900
Intercept	-3.4323	1.3242			0.0103		
Intervention	1.2561	0.9393	0.0748	0.0559	0.1828		
Baseline readiness	0.6635	0.0578	0.6509	0.0567	<0.0001		
Sex	0.5949	1.0219	0.0329	0.0565	0.5612		
Race	0.1257	1.0394	0.0068	0.0562	0.9039		
Year in school	-0.0927	0.9688	-0.0054	0.0564	0.9239		

Notes. Intervention was coded as 1 = Intervention group vs. 0 = control group; sex was coded as 1 = men vs. 0 = women, race was coded as 1 = White vs. 0 = non-White, and first-year student status was coded as 1 = first-year vs. 0 = non first-year.

Supplemental Table 6*Linear Models Estimating Intervention Effects on Readiness at First Follow-up for Study 7.1*

	Unstandardized Coefficients		Standardized Coefficients		<i>p</i>	<i>R</i> ²	
	<i>b</i>	<i>SE</i>	<i>b</i> *	<i>SE</i>			
Model 1						.4093	<i>F</i> (2, 103) 35.6809
Intercept	10.4486	2.8749			0.0004		
Intervention	0.1640	1.8305	0.0068	0.0759	0.9288		
Baseline readiness	0.6630	0.0786	0.6394	0.0758	<0.0001		
Model 2						.4342	<i>F</i> (5, 98) 15.0387
Intercept	12.1545	3.5798			0.0010		
Intervention	0.6970	1.8803	0.0284	0.0766	0.7117		
Baseline readiness	0.6647	0.0804	0.6383	0.0772	<0.0001		
Sex	-2.5996	1.8142	-0.1120	0.0782	0.1551		
Race	0.5829	1.8603	0.0245	0.0782	0.7547		
Year in school	-1.3621	1.6059	-0.0651	0.0768	0.3984		

Notes. Intervention was coded as 1 = Intervention group vs. 0 = control group; sex was coded as 1 = men vs. 0 = women, race was coded as 1 = White vs. 0 = non-White, and first-year student status was coded as 1 = first-year vs. 0 = non first-year.

Supplemental Table 7*Linear Models Estimating Intervention Effects on Readiness at First Follow-up for Study 7.2*

	Unstandardized Coefficients		Standardized Coefficients		<i>p</i>	<i>R</i> ²	
	<i>b</i>	<i>SE</i>	<i>b</i> *	<i>SE</i>			
Model 1						.4491	<i>F</i> (2, 328) 133.6780
Intercept	7.6047	1.3555			<0.0001		
Intervention	1.7105	0.7947	0.0891	0.0414	0.0321		
Baseline readiness	0.7083	0.0450	0.6517	0.0414	<0.0001		
Model 2						.4479	<i>F</i> (5, 322) 52.2543
Intercept	8.1824	1.4210			<0.0001		
Intervention	1.6980	0.8109	0.0886	0.0423	0.0370		
Baseline readiness	0.7096	0.0461	0.6515	0.0423	<0.0001		
Sex	0.1360	0.8428	0.0074	0.0459	0.8719		
Race	-1.2120	0.7814	-0.0658	0.0424	0.1219		
Year in school	0.0997	0.8323	0.0054	0.0451	0.9047		

Notes. Intervention was coded as 1 = Intervention group vs. 0 = control group; sex was coded as 1 = men vs. 0 = women, race was coded as 1 = White vs. 0 = non-White, and first-year student status was coded as 1 = first-year vs. 0 = non first-year.

Supplemental Table 8*Linear Models Estimating Intervention Effects on Readiness at First Follow-up for Study 8a*

	Unstandardized Coefficients		Standardized Coefficients		<i>p</i>	<i>R</i> ²	
	<i>b</i>	<i>SE</i>	<i>b</i> *	<i>SE</i>			
Model 1						.2707	<i>F</i> (2, 912) 169.2674
Intercept	-3.4510	0.4354			<0.0001		
Intervention	-0.6849	0.4794	-0.0404	0.0283	0.1534		
Baseline readiness	0.5326	0.0290	0.5200	0.0283	<0.0001		
Model 2						.2763	<i>F</i> (5, 894) 68.2472
Intercept	-4.9055	0.8198			<0.0001		
Intervention	-0.6481	0.4843	-0.0382	0.0285	0.1811		
Baseline readiness	0.5307	0.0293	0.5195	0.0287	<0.0001		
Sex	0.8751	0.5315	0.0473	0.0287	0.1000		
Race	1.3750	0.7303	0.0538	0.0286	0.0600		
Year in school	0.0230	0.4859	0.0014	0.0296	0.9623		

Notes. Intervention was coded as 1 = Intervention group vs. 0 = control group; sex was coded as 1 = men vs. 0 = women, race was coded as 1 = White vs. 0 = non-White, and first-year student status was coded as 1 = first-year vs. 0 = non first-year.

Supplemental Table 9*Linear Models Estimating Intervention Effects on Readiness at First Follow-up for Study 8b*

	Unstandardized Coefficients		Standardized Coefficients		<i>p</i>	<i>R</i> ²
	<i>b</i>	<i>SE</i>	<i>b</i> *	<i>SE</i>		
Model 1						.2521 <i>F</i> (2, 1286) 216.7327
Intercept	-4.2564	0.3719			<0.0001	
Intervention	0.2919	0.4263	0.0165	0.0241	0.4937	
Baseline readiness	0.5267	0.0253	0.5020	0.0241	<0.0001	
Model 2						.2586 <i>F</i> (5, 1261) 87.9850
Intercept	-3.9466	0.5564			<0.0001	
Intervention	0.3283	0.4298	0.0186	0.0244	0.4450	
Baseline readiness	0.5359	0.0256	0.5088	0.0243	<0.0001	
Sex	-0.0634	0.4415	-0.0035	0.0244	0.8859	
Race	-0.4089	0.4537	-0.0219	0.0243	0.3676	
Year in school	0.2006	0.4302	0.0113	0.0242	0.6410	

Notes. Intervention was coded as 1 = Intervention group vs. 0 = control group; sex was coded as 1 = men vs. 0 = women, race was coded as 1 = White vs. 0 = non-White, and first-year student status was coded as 1 = first-year vs. 0 = non first-year.

Supplemental Table 10*Linear Models Estimating Intervention Effects on Readiness at First Follow-up for Study 8c*

	Unstandardized Coefficients		Standardized Coefficients		<i>p</i>	<i>R</i> ²	
	<i>b</i>	<i>SE</i>	<i>b</i> *	<i>SE</i>			
Model 1						.2995	<i>F</i> (2, 274) 58.5802
Intercept	-3.4241	0.7352			<0.0001		
Intervention	1.1582	0.8737	0.0672	0.0507	0.1861		
Baseline readiness	0.5516	0.0511	0.5473	0.0507	<0.0001		
Model 2						.3041	<i>F</i> (5, 267) 23.3350
Intercept	-2.2486	1.4752			0.1286		
Intervention	1.2108	0.8867	0.0700	0.0513	0.1732		
Baseline readiness	0.5530	0.0520	0.5457	0.0513	<0.0001		
Sex	0.5531	0.9086	0.0312	0.0513	0.5432		
Race	-1.7091	1.3040	-0.0671	0.0512	0.1911		
Year in school	0.1201	0.9082	0.0068	0.0514	0.8949		

Notes. Intervention was coded as 1 = Intervention group vs. 0 = control group; sex was coded as 1 = men vs. 0 = women, race was coded as 1 = White vs. 0 = non-White, and first-year student status was coded as 1 = first-year vs. 0 = non first-year.

Supplemental Table 11*Linear Models Estimating Intervention Effects on Readiness at First Follow-up for Study 9*

	Unstandardized Coefficients		Standardized Coefficients		<i>p</i>	<i>R</i> ²	
	<i>b</i>	<i>SE</i>	<i>b</i> *	<i>SE</i>			
Model 1						.2883	<i>F</i> (4, 329) 33.3163
Intercept	-1.5828	0.7953			0.0474		
Intervention PF	-0.4597	1.0409	-0.0253	0.0573	0.6590		
Intervention GMI	-0.2142	1.0474	-0.0117	0.0572	0.8381		
Intervention MI+PF	-0.7579	1.0461	-0.0416	0.0574	0.4693		
Baseline readiness	0.5433	0.0476	0.5331	0.0467	<0.0001		
Model 2						.2980	<i>F</i> (6, 327) 23.1366
Intercept	-1.7033	1.0679			0.1117		
Intervention PF	-0.5512	1.0386	-0.0303	0.0571	0.5960		
Intervention GMI	-0.2522	1.0455	-0.0138	0.0572	0.8095		
Intervention MI+PF	-0.8120	1.0469	-0.0445	0.0574	0.4385		
Baseline readiness	0.5331	0.0477	0.5230	0.0468	<0.0001		
Sex	1.5037	0.7637	0.0917	0.0466	0.0498		
Race	-0.6189	0.8289	-0.0348	0.0466	0.4559		

Notes. Intervention were dummy-coded variables that indicate random allocation to MI + PF, PF, or GMI, respectively (each coded 1), compared to controls (all coded 0); sex was coded as 1 = men vs. 0 = women, race was coded as 1 = White vs. 0 = non-White.

Supplemental Table 12*Linear Models Estimating Intervention Effects on Readiness at First Follow-up for Study 10.1*

	Unstandardized Coefficients		Standardized Coefficients		<i>p</i>	<i>R</i> ²	
	<i>b</i>	<i>SE</i>	<i>b</i> *	<i>SE</i>			
Model 1						.2521	<i>F</i> (2, 316) 53.2542
Intercept	8.4101	1.8564			<0.0001		
Intervention	2.4813	0.9145	0.1320	0.0486	0.0070		
Baseline readiness	0.5794	0.0584	0.4824	0.0486	<0.0001		
Model 2						.2624	<i>F</i> (4, 314) 27.9215
Intercept	7.4079	2.2359			0.0010		
Intervention	2.5161	0.9117	0.1339	0.0485	0.0061		
Baseline readiness	0.5540	0.0603	0.4612	0.0502	<0.0001		
Sex	1.7804	0.9462	0.0943	0.0501	0.0608		
Race	1.0975	1.3128	0.0407	0.0487	0.4038		

Notes. Intervention was coded as 1 = Intervention group vs. 0 = control group; sex was coded as 1 = men vs. 0 = women, and race was coded as 1 = White vs. 0 = non-White.

Supplemental Table 13*Linear Models Estimating Intervention Effects on Readiness at First Follow-up for Study 11*

	Unstandardized Coefficients		Standardized Coefficients		<i>p</i>	<i>R</i> ²
	<i>b</i>	<i>SE</i>	<i>b</i> *	<i>SE</i>		
Model 1						.3432 <i>F</i> (2, 269) 70.2865
Intercept	-3.1927	0.7375			<0.0001	
Intervention	0.2661	0.7630	0.0173	0.0496	0.7276	
Baseline readiness	0.6565	0.0554	0.5865	0.0495	<0.0001	
Model 2						.3462 <i>F</i> (4, 262) 34.6814
Intercept	-2.3714	0.9891			0.0172	
Intervention	0.2374	0.7787	0.0153	0.0502	0.7607	
Baseline readiness	0.6487	0.0563	0.5799	0.0503	<0.0001	
Sex	-0.7028	0.7844	-0.0451	0.0503	0.3711	
Race	-0.7322	0.8353	-0.0446	0.0509	0.3815	

Notes. Intervention was coded as 1 = Intervention group vs. 0 = control group; sex was coded as 1 = men vs. 0 = women, race was coded as 1 = White vs. 0 = non-White.

Supplemental Table 14*Linear Models Estimating Intervention Effects on Readiness at First Follow-up for Study 12*

	Unstandardized Coefficients		Standardized Coefficients		<i>p</i>	<i>R</i> ²	
	<i>b</i>	<i>SE</i>	<i>b</i> *	<i>SE</i>			
Model 1						.0943	<i>F</i> (2, 154) 8.0154
Intercept	2.2832	0.3641			<0.0001		
Intervention	0.3854	0.3833	0.0773	0.0769	0.3162		
Baseline readiness	0.3125	0.0795	0.3019	0.0768	0.0001		
Model 2						.1196	<i>F</i> (5, 151) 4.1037
Intercept	1.4857	0.7459			0.0482		
Intervention	0.4074	0.3825	0.0817	0.0767	0.2886		
Baseline readiness	0.2895	0.0806	0.2797	0.0779	0.0004		
Sex	0.7294	0.3954	0.1460	0.0791	0.0671		
Race	0.5940	0.6715	0.0679	0.0768	0.3778		
Year in school	-0.9188	1.1074	-0.0647	0.0780	0.4080		

Notes. Intervention was coded as 1 = Intervention group vs. 0 = control group; sex was coded as 1 = men vs. 0 = women, race was coded as 1 = White vs. 0 = non-White, and first-year student status was coded as 1 = first-year vs. 0 = non first-year.

Supplemental Table 15*Linear Models Estimating Intervention Effects on Readiness at First Follow-up for Study 14*

	Unstandardized Coefficients		Standardized Coefficients		<i>p</i>	<i>R</i> ²
	<i>b</i>	<i>SE</i>	<i>b</i> *	<i>SE</i>		
Model 1						.2155 <i>F</i> (2, 44) 6.0416
Intercept	4.1148	1.4954			0.0086	
Intervention	0.7795	0.8416	0.1238	0.1337	0.3594	
Baseline readiness	0.4965	0.1500	0.4424	0.1337	0.0019	
Model 2						.2373 <i>F</i> (5, 41) 2.5512
Intercept	4.5497	2.5072			0.0769	
Intervention	0.6278	0.8847	0.0997	0.1405	0.4819	
Baseline readiness	0.4594	0.1599	0.4093	0.1425	0.0064	
Sex	0.0044	0.8759	0.0007	0.1393	0.9960	
Race	0.4048	2.1146	0.0267	0.1395	0.8491	
Year in school	-0.9732	0.9084	-0.1560	0.1456	0.2903	

Notes. Intervention was coded as 1 = Intervention group vs. 0 = control group; sex was coded as 1 = men vs. 0 = women, race was coded as 1 = White vs. 0 = non-White, and first-year student status was coded as 1 = first-year vs. 0 = non first-year.

Supplemental Table 16*Linear Models Estimating Intervention Effects on Readiness at First Follow-up for Study 15*

	Unstandardized Coefficients		Standardized Coefficients		<i>p</i>	<i>R</i> ²
	<i>b</i>	<i>SE</i>	<i>b</i> *	<i>SE</i>		
Model 1						.1398 <i>F</i> (2, 233) 18.9302
Intercept	1.1211	0.3034			0.0003	
Intervention	0.6446	0.3395	0.1154	0.0608	0.0588	
Baseline readiness	0.3277	0.0567	0.3514	0.0608	<0.0001	
Model 2						.1425 <i>F</i> (3, 232) 12.8557
Intercept	0.9458	0.3651			0.0102	
Intervention	0.6382	0.3397	0.1143	0.0608	0.0616	
Baseline readiness	0.3338	0.0572	0.3580	0.0613	<0.0001	
Race	0.2930	0.3389	0.0530	0.0613	0.3881	

Notes. Intervention was coded as 1 = Intervention group vs. 0 = control group; race was coded as 1 = White vs. 0 = non-White.

Supplemental Table 17*Linear Models Estimating Intervention Effects on Readiness at First Follow-up for Study 16*

	Unstandardized Coefficients		Standardized Coefficients		<i>p</i>	<i>R</i> ²	
	<i>b</i>	<i>SE</i>	<i>b</i> *	<i>SE</i>			
Model 1						.2382	<i>F</i> (2, 281) 43.9354
Intercept	1.3438	0.2495			<0.0001		
Intervention	0.1640	0.2933	0.0292	0.0522	0.5764		
Baseline readiness	0.4077	0.0438	0.4854	0.0521	<0.0001		
Model 2						.2459	<i>F</i> (3, 280) 30.4385
Intercept	1.6127	0.2951			<0.0001		
Intervention	0.1611	0.2923	0.0287	0.0521	0.5819		
Baseline readiness	0.4123	0.0438	0.4908	0.0521	<0.0001		
Race	-0.4953	0.2928	-0.0880	0.0520	0.0918		

Notes. Intervention was coded as 1 = Intervention group vs. 0 = control group; race was coded as 1 = White vs. 0 = non-White.

Supplemental Table 18*Linear Models Estimating Intervention Effects on Readiness at First Follow-up for Study 18*

	Unstandardized Coefficients		Standardized Coefficients		<i>p</i>	<i>R</i> ²	
	<i>b</i>	<i>SE</i>	<i>b</i> *	<i>SE</i>			
Model 1						.3783	<i>F</i> (2, 164) 49.8922
Intercept	-3.5948	0.9428			0.0002		
Intervention	0.8091	0.9751	0.0515	0.0621	0.4079		
Baseline readiness	0.6046	0.0620	0.6061	0.0622	<0.0001		
Model 2						.3849	<i>F</i> (5, 161) 20.1527
Intercept	-2.5294	1.7364			0.1471		
Intervention	0.7610	0.9810	0.0485	0.0625	0.4390		
Baseline readiness	0.6186	0.0637	0.6202	0.0639	<0.0001		
Sex	-0.2940	1.1980	-0.0156	0.0636	0.8065		
Race	-0.4717	1.4851	-0.0200	0.0630	0.7512		
Year in school	-1.3220	1.0559	-0.0789	0.0630	0.2124		

Notes. Intervention was coded as 1 = Intervention group vs. 0 = control group; sex was coded as 1 = men vs. 0 = women, race was coded as 1 = White vs. 0 = non-White, and first-year student status was coded as 1 = first-year vs. 0 = non first-year.

Supplemental Table 19*Linear Models Estimating Intervention Effects on Readiness at First Follow-up for Study 20*

	Unstandardized Coefficients		Standardized Coefficients		<i>p</i>	<i>R</i> ²	
	<i>b</i>	<i>SE</i>	<i>b</i> *	<i>SE</i>			
Model 1						.1898	<i>F</i> (2, 483) 56.5646
Intercept	14.8151	1.3098			<0.0001		
Intervention	-0.2698	0.7155	-0.0155	0.0411	0.7063		
Baseline readiness	0.4417	0.0417	0.4345	0.0410	<0.0001		
Model 2						.2108	<i>F</i> (5, 480) 25.6482
Intercept	15.3662	1.6950			<0.0001		
Intervention	-0.3222	0.7104	-0.0185	0.0408	0.6504		
Baseline readiness	0.4257	0.0416	0.4187	0.0409	<0.0001		
Sex	2.1957	0.7291	0.1261	0.0419	0.0027		
Race	-0.6867	0.9141	-0.0306	0.0407	0.4529		
Year in school	-0.7949	0.8447	-0.0392	0.0417	0.3472		

Notes. Intervention was coded as 1 = Intervention group vs. 0 = control group; sex was coded as 1 = men vs. 0 = women, race was coded as 1 = White vs. 0 = non-White, and first-year student status was coded as 1 = first-year vs. 0 = non first-year.

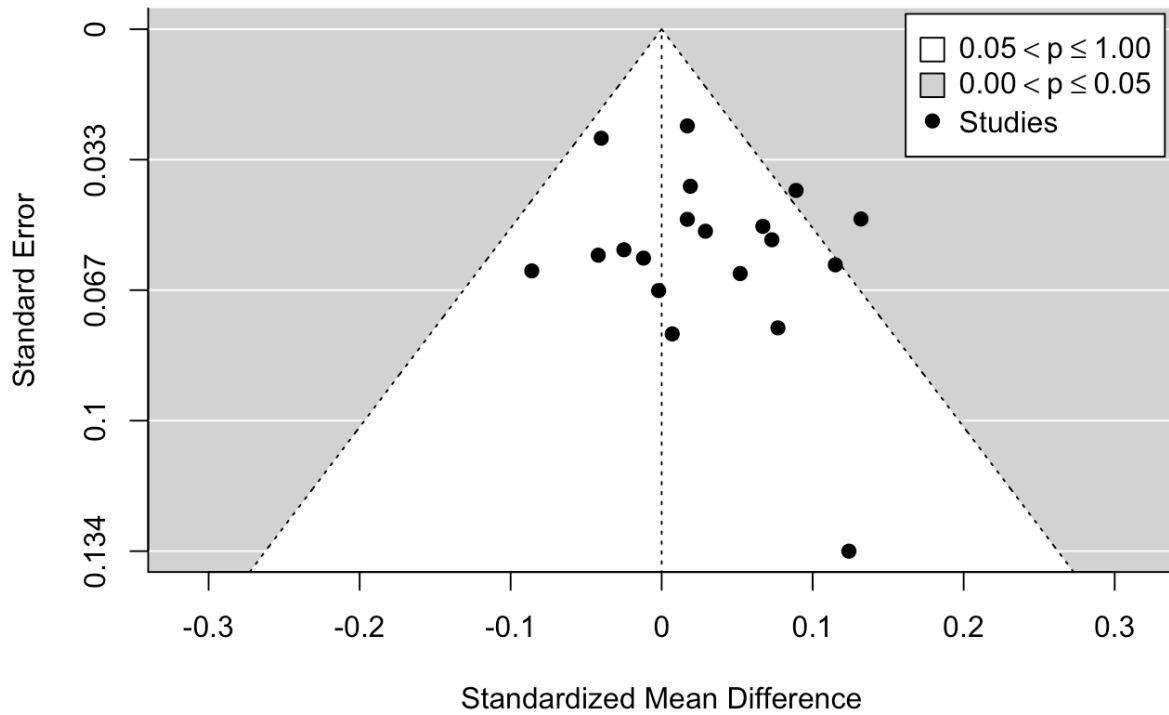
Supplemental Table 20*Linear Models Estimating Intervention Effects on Readiness at First Follow-up for Study 21*

	Unstandardized Coefficients		Standardized Coefficients		<i>p</i>	<i>R</i> ²
	<i>b</i>	<i>SE</i>	<i>b</i> *	<i>SE</i>		
Model 1						<i>F</i> (3, 196) 0.4352 50.3429
Intercept	-1.6024	0.7945			0.0451	
Intervention MI+PF	-0.0307	1.0389	-0.0018	0.0609	0.9764	
Intervention PF	-1.5148	1.0922	-0.0858	0.0619	0.1670	
Baseline readiness	0.6584	0.0538	0.6577	0.0537	<0.0001	
Model 2						<i>F</i> (6, 193) 0.4464 25.9357
Intercept	-3.1127	1.4063			0.0280	
Intervention MI+PF	-0.0622	1.0369	-0.0037	0.0617	0.9522	
Intervention PF	-1.5705	1.0903	-0.0890	0.0618	0.1514	
Baseline readiness	0.6561	0.0543	0.6554	0.0542	<0.0001	
Sex	1.4078	0.9118	0.0833	0.0540	0.1242	
Race	1.5360	1.2520	0.0669	0.0545	0.2214	
Year in school	-0.7220	0.9069	-0.0436	0.0548	0.4270	

Notes. Intervention were dummy-coded variables that indicate random allocation to MI + PF, or PF, respectively (each coded 1), compared to controls (all coded 0); sex was coded as 1 = men vs. 0 = women, race was coded as 1 = White vs. 0 = non-White, and first-year student status was coded as 1 = first-year vs. 0 = non first-year.

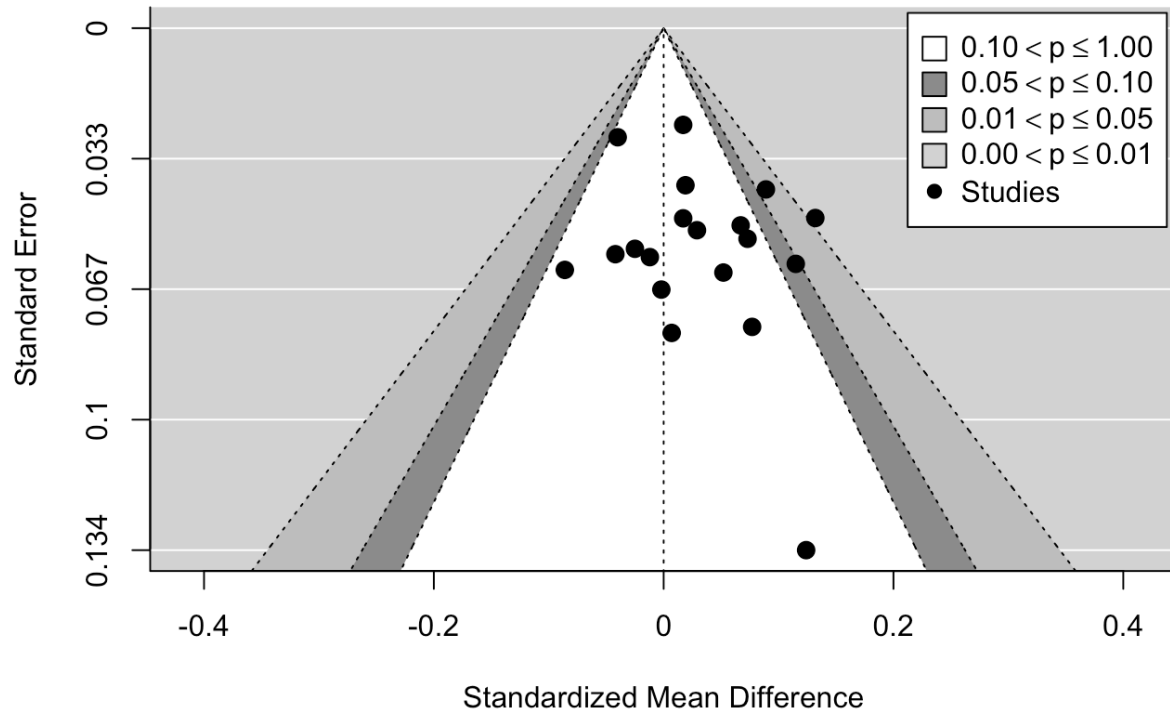
Supplemental Figure 1

Funnel Plot for Intervention Effects Estimated from Model Adjusted for Baseline Readiness



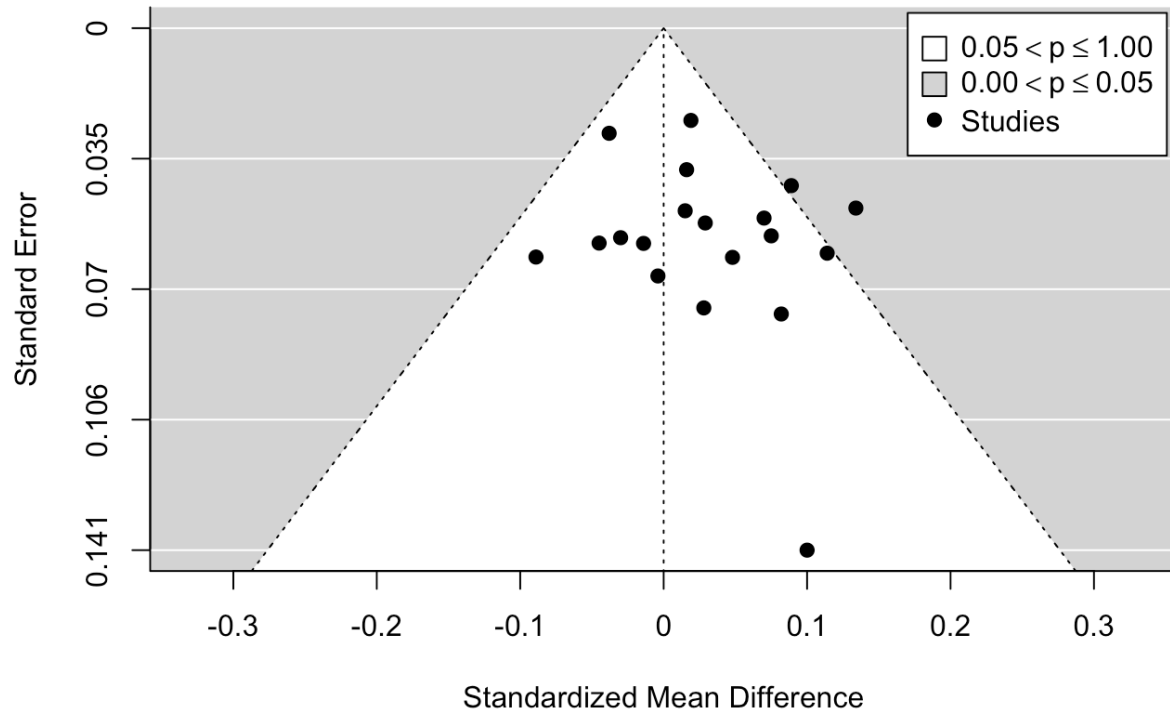
Supplemental Figure 2

Contour-enhanced Funnel Plot for Intervention Effects Estimated from Model Adjusted for Baseline Readiness



Supplemental Figure 3

Funnel Plot for Intervention Effects Estimated from Model Adjusted for Baseline Readiness and Demographic Variables



Supplemental Figure 4

Contour-enhanced Funnel Plot for Intervention Effects Estimated from Model Adjusted for Baseline Readiness and Demographic Variables

