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Which came first: the readiness or the change? Longitudinal relationships between readiness to change and drinking among college drinkers

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Abstract

Aims—Although readiness to change (RTC) is cited as a key mechanism underlying drinking behavior change, empirical evidence supporting RTC as a predictor of college drinking has been mixed. Considering methodological limitations of previous studies, the current aim was to conduct a more comprehensive test of longitudinal relationships between readiness to change and college drinking.

Design—In this correlational, longitudinal study, we used a series of cross-lagged path analyses to test associations between RTC and college drinking outcomes over a 2-year period.

Setting—Data collection was conducted via online surveys on a university campus in the US Pacific Northwest.

Participants—Participants ($n = 818$; 58% women) were college students who reported at least one heavy-drinking episode in the past month and participated in a randomized controlled trial of personalized normative feedback interventions.

Measurements—Drinking quantity–frequency items and the Rutgers Alcohol Problem Index assessed drinking outcomes. The Readiness to Change Questionnaire assessed RTC.

Findings—For drinking-related problems, the best-fitting model included cross-lagged paths between RTC and subsequent drinking-related problems. For drinking quantity–frequency, best-fitting models also included the cross-lagged paths between drinking quantity–frequency and subsequent RTC. Higher RTC almost uniformly predicted higher subsequent levels of drinking and greater experience of drinking-related problems, and drinking quantity–frequency variables were primarily positive predictors of subsequent RTC.

Conclusions—Contrary to previous assumptions, ‘the Readiness to Change Questionnaire’ does not appear to be predictive of lower levels of subsequent drinking.

Keywords

alcohol use; college drinking; motivation; path analysis; readiness to change

Declarations of interest

All authors declare that they have no conflicts of interest pertaining to this manuscript.

INTRODUCTION

Readiness to change (RTC), defined as a person's readiness to enter into a positive behavior change strategy, is widely cited as a promising predictor of drinking behavior change [1–3]. The operationalization of RTC as a measurable construct for empirical and clinical applications developed out of research on stages of change. The stages of change represent a linear, potentially recursive model that describe a person's progression through discrete stages leading from substance abuse through sustained, positive behavior change [4,5]. Recent methods of measuring RTC have developed out of a new, continuous conceptualization of the construct [6] and have provided alternatives to stage measures, which have shown both psychometric [7,8] and conceptual [9,10] limitations.

In the college drinking literature, the most frequently used and well-validated RTC measure is the 12-item Readiness to Change Questionnaire (RTCQ) [11]. Further measures include the 19-item Stages of Change Readiness and Treatment Eagerness Scale (SOCRATES) [12], the 32-item University of Rhode Island Change Assessment (URICA) [13] and single-item 'readiness rulers' [6,14]. The RTCQ is an amalgam of modified URICA items and additional items that provided face valid representations of the stages of change [11], with items assessing problem recognition, ambivalence and active attempts to change drinking.

A number of cross-sectional studies have demonstrated positive concurrent correlations between RTC and college drinking [14–16]. The clinical utility for theoretically based constructs, however, is in their ability to predict subsequent outcomes [17]. Accordingly, RTC has been characterized as a 'critical condition of change' ([18], p. 49), and the college intervention literature has been dominated by brief motivational interventions built upon the theoretical assumption that enhancing RTC will promote drinking behavior change [19–21].

Longitudinal studies have, however, evinced mixed findings regarding RTC as a predictor of subsequent drinking among college students. Kaysen *et al.* [22] found that higher RTC was associated with lower intention to drink and future drinking behavior. Carey and colleagues [23] found that baseline RTC predicted drinking outcomes at 1-month follow-up. Fromme & Corbin [24] showed that baseline RTC moderated a motivational enhancement intervention, such that higher RTC predicted reduced drinking outcomes for the intervention group. Conversely, a recent review of three studies involving college students reported a positive association between brief interventions and RTC, but not between RTC and drinking after controlling for treatment effects [1]. Further, Collins and colleagues [25] found that change in RTC from baseline to 1 month post-test did not predict subsequent drinking during a 12-month follow-up.

One interpretation of these mixed findings is that the RTC construct and/or measures, which were developed originally for more severely affected populations [11,13], may be less relevant for lower-severity, non-treatment-seeking populations such as college drinkers. However, unlike readiness for treatment, RTC should theoretically be applicable to drinkers of all levels. It is also possible that RTC is a valid construct for this population but is not captured adequately by traditional RTC measures [26].

Limitations of the statistical methods used in prior studies should also be considered. Analytical methods in these studies assumed normally distributed data; however, drinking outcomes in college populations often comprise integer/count data that evince positive skew and/or overdispersion [27]. Statistical methods involving alternate distributional assumptions are recommended for use with such data (e.g. generalized linear models using the Poisson or negative binomial distributions; [28,29]), but have not yet been incorporated widely into studies of college drinking.

Study design issues also complicate interpretation of these findings. Longitudinal analyses involving multiple time-points provide a more dynamic understanding of the transactional nature of psychological correlates and drinking [30,31]; however, most 'longitudinal' studies to date measured drinking at only two time-points. Next, many studies cited above involved a delayed measurement of RTC which may not best reflect real-time changes in RTC and may obscure significant RTC effects on later drinking. Finally, positive, 'concurrent' correlations of RTC and drinking outcomes are often reported; however, drinking data are typically collected retrospectively (e.g. typical drinking over the past month), whereas RTC is assessed concurrently (e.g. '... how you personally feel about your drinking right now'). Thus, such positive, 'concurrent' findings may actually indicate that higher levels of drinking and drinking-related problems predict higher subsequent RTC. This 'hangover effect' may reflect students' retrospective report of heavy drinking paired with the subsequent recognition of its negative consequences. Although items assessing recognition of problem drinking are included in some RTC measures, recognition may not necessarily be accompanied by movement towards behavior change. Further, in the presence of immediate alcohol cues, prior negative consequences may prove less salient and important than positive aspects of drinking, and students may continue drinking despite them.

CURRENT STUDY

Although cross-sectional studies have demonstrated positive, concurrent associations between RTC and self-reported drinking and drinking-related problems [14–16], findings are mixed regarding RTC as a predictor of subsequent drinking outcomes [1]. Further, although theory posits that RTC is a fluid and dynamic construct [6], most studies have failed to measure and model longitudinal developments of RTC and drinking outcomes in a transactional way. This study sought to improve upon the methodology used in previous studies by (i) assessing RTC and various drinking outcomes at multiple points over a longer time-frame (24 months), (ii) incorporating analyses better suited to accommodate skewed count data and (iii) utilizing a larger sample ($n = 818$) to ensure adequate power to test hypotheses. Thus, this study is positioned to provide a more methodologically sound test of the potentially transactional, longitudinal relationships between RTC and drinking outcomes.

Path analyses were used to capture the autoregressive and cross-lagged effects between RTC and drinking over a 24-month period. It was hypothesized that both RTC and drinking would evince significant, positive autoregressive effects over the follow-up period. Further, it was predicted that repeatedly assessed RTC would consistently inversely predict subsequent drinking. Finally, an additional exploratory model was planned, which allowed for a test of drinking as a predictor of subsequent RTC to capture potential 'hangover' effects.

METHOD

Participants

Participants consisted of 818 (58% women) freshmen students at a public, 4-year university in the US Pacific Northwest who had participated in a randomized clinical trial of personalized normative feedback interventions [32]. Inclusion criteria included consumption of at least four or five drinks (for women and men, respectively) on at least one occasion in the past month; 43% of the screened students met this criterion. Participants reported a mean age of 18.14 (standard deviation = 0.46) years, and 65.3% self-identified as Caucasian/white, 24.2% as Asian/Pacific Islander, 4.2% as Hispanic/Latino/a, 1.5% as African American/black, 0.5% as Native American/American Indian and 4.4% as another racial/

ethnicity group. Most participants reported living in on-campus residence halls (65.8%), with 22% living in a fraternity/sorority house, 6.5% in off-campus housing and 5.6% with their parents/guardians.

Measures

Single-item measures assessed participants' socio-demographic characteristics. The 12-item Readiness to Change Questionnaire (RTCQ) is an amalgam of modified URICA items and additional items that provided face valid representations of the stages of change [11]. Individual items appear to assess problem recognition, ambivalence and active attempts to change drinking, and the measure consists of three validated scales: precontemplation, contemplation and action. Precontemplation items were reverse-coded and added to the contemplation and action summary scores to form a continuous RTCQ scale score [7], which served as a predictor and outcome variable in primary analyses. Internal consistency of the baseline RTCQ was adequate ($\alpha = 0.81$).

A quantity–frequency questionnaire [33], consisting of single items, assessed participants' drinking frequency ('How many days of the week did you drink alcohol during the past month?') and typical ('On a typical occasion during the past month, how much alcohol did you typically drink?') and peak ('Think of the occasion you drank the most this past month. How much did you drink?') drinking quantities during the past month.

The Alcohol Consumption Index (ACI) [34] consists of eight, seven-point Likert-type items that capture behavioral counts ranging from 0 (no occurrences) to 6 (*k* or more occurrences, depending on the behavior). One of these questions (i.e. 'During the past month, how many times did you have five or more drinks at one sitting?') was used to assess self-reported frequency of heavy drinking episodes (HDE) in the past month.

Alcohol-related problems were assessed using the Rutgers Alcohol Problems Index (RAPI) [35], which asked participants how often they had experienced 23 drinking-related consequences over the previous 3 months. Item responses capture behavioral counts using ordinal categories ranging from 0 (never) to 4 (more than 10 times). The summary score of the 23 items was used as a drinking outcome in the main analyses and showed acceptable internal consistency ($\alpha = 0.89$).

Procedure

In fall 2005, incoming freshman students not involved in other, similar studies ($n = 4103$) were invited to participate in an online survey examining relationships among college students' social norms, motivation and drinking as well as the impact of normative information on perceived norms and drinking behavior. Students were e-mailed invitations for the screening survey, and 2095 (51.1%) provided online, informed consent and completed the screening survey. Students who did not meet the drinking eligibility criteria were thanked for their participation and received a \$10 check in the mail.

Students ($n = 898$; 57% women) who met eligibility criteria were invited to complete the online baseline assessment. Of these students, 818 (91.1%) completed the baseline survey and were assigned randomly to one of five conditions: (i) single exposure to gender-non-specific personalized normative feedback (PNF); (ii) repeated exposure to gender-non-specific PNF; (iii) single exposure to gender-specific PNF; (iv) repeated exposure to gender-specific PNF; or (v) attention control. At 6-, 12-, 18- and 24-month follow-ups, participants completed the same online questionnaires and/or intervention boosters. Incentives for participation were \$10 for the screening and \$25 for the baseline and each follow-up.

Further information about the interventions and other procedures may be found in the parent study [32].

Data analysis plan

Three sets of path analysis models tested associations between RTC and drinking variables. The autoregressive model served as the reduced comparison model and consisted of autoregressive effects and associations between drinking outcomes and RTC within a given assessment period. As is the case in most alcohol studies, drinking variables were assessed retrospectively, whereas RTC was assessed ‘in the moment’. Because recent drinking may have influenced participants’ RTC at any given time-point, RTC was regressed on drinking outcomes for more accurate modeling. The hypothesized model included cross-lagged paths testing the hypothesis that RTC would predict subsequent drinking. The reciprocal model added cross-lagged paths testing the effects of drinking on subsequent RTC. This model established the relative strength of the hypothesized effects (i.e. drinking regressed on RTC) versus ‘hangover’ effects (i.e. RTC regressed on drinking). Although not of primary interest in this study, intervention groups from the parent study were controlled for at all time-points using four dummy-coded variables (the attention–control condition served as the reference group).

Wald tests and model constraints assessed the equality of coefficient paths over the 24-month follow-up, including autoregressive effects for drinking and RTC, within-time-point correlations between RTC and drinking, RTC effects on drinking and drinking effects on RTC. In the case of non-significant Wald tests, constrained models were used to establish ‘average’ longitudinal effects of RTC on drinking and vice versa.

Mplus 5.1, which allows for modeling combinations of count, continuous and binary outcome variables, was used for the primary analyses [36]. Anticipating skewed count data in this study, we used maximum likelihood estimation with robust standard errors and Monte Carlo integration. The Satorra–Bentler corrected χ^2 test (TRd) was used to compare the nested models mentioned above [37]. Because each subsequent model test was less restrictive than the previous, significant χ^2 tests would indicate that the larger model improved significantly upon the more restrictive model. Although they were not derived from the models, standardized coefficient estimates were hand-calculated using widely accepted formulas and sample statistics [36], and were reported in the figures to facilitate interpretation of path effect sizes.

Drinking outcomes included drinking frequency in the past month, drinking quantity during peak and typical drinking occasions in the past month, HDE and RAPI score. Because drinking outcome variables were mainly positively skewed count/integer responses, Poisson distributions were specified [27]. Because RAPI scores evinced a preponderance of zeros, zero-inflated Poisson (ZIP) models were used for this variable [28].

When using ZIP models, there are two potential data-generation processes for each participant, and the result of a Bernoulli trial determines which process is used. The ‘zero-inflated’ process generates zero counts, and the second process generates counts from a Poisson distribution [29]. The Poisson process was of greatest interest in this study; the zero-inflation process accounted primarily for the large proportion of the sample that never experienced problems across the course of the study. Because the zero-inflated portion of the model was not highly predictive of RAPI outcomes and for clarity of presentation, only Poisson coefficients are presented in the figures, and zero-inflation coefficients are reported in the figure captions.

RESULTS

Distributions of explanatory and outcome variables were examined for univariate outliers and deviation from expected distributions. All drinking outcomes were positively skewed count/integer variables. RTC variables were distributed normally. As suggested in the literature [38], analyses were conducted to examine missingness on the outcome variables (see Table 1 for completeness by variable and time-point) and its relationship to both outcome and predictor values. Missingness occurring completely at random (MCAR) cannot usually be tested directly, because the probability of missingness on the outcome variable is assessed as a function of the values of both predictors and outcome variables. Because we had repeated measures, however, we were able to impute the closest previously measured data point to approximate outcome variable values. After applying Bonferroni corrections to control for number of family-wise tests, no outcome or predictor values were significant correlates of missingness ($p > 0.05$). The data missingness mechanism was therefore deemed ‘ignorable’ for analyses [38]. The use of maximum likelihood estimation also served to minimize bias that may otherwise be introduced if using methods resulting in list-wise data deletion [38].

Autoregressive models

Across all drinking outcomes, the autoregressive models were statistically superior to the independence models (see ‘Independence model TRd’ in Table 2). After controlling for intervention effects at each time-point, we found expected positive, significant autoregressive effects for both RTC and drinking. Specifically, higher levels of RTC and drinking predicted higher subsequent levels of RTC and drinking, respectively. Further, expected positive and significant temporal effects were shown, such that higher levels of drinking at a given time-point were associated with higher RTC at the same time-point (see Fig. 1 for a representation of the autoregressive model across all drinking outcomes).

Hypothesized models

The next set of models tested the hypothesis that the effects of RTC on subsequent drinking outcomes (i.e. cross-lagged effects) would improve model fit significantly above and beyond the autoregressive effects included in the previous set of models. With the exception of the drinking frequency model, all hypothesized models were statistically superior to the autoregressive models (see Table 2, ‘Model comparison TRd’). As shown in Fig. 2, statistically superior models evinced some significant cross-lagged effects. When significant, these effects showed that higher levels of RTC predicted higher rather than lower subsequent drinking outcomes (see Fig. 2 for significant hypothesized models). As shown in Table 3, the typical and peak drinking quantity models showed statistically stable RTC effects on alcohol across the 24-month follow-up. For these two models, we constrained parameters to produce ‘average’ RTC effects on drinking. Average effects for peak [incident rate ratio (IRR) = 1.04, $P = 0.04$] and typical drinking quantity (IRR = 1.10, $P < 0.001$) indicated that each one-point increase in RTC was associated with 4% and 10% higher drinking rates for peak and typical occasions, respectively.

Reciprocal models

Reverse, cross-lagged paths of drinking on subsequent RTC were added to previous models to account for bidirectional, reciprocal effects of both RTC on subsequent drinking and drinking on subsequent RTC. As shown in Table 2, reciprocal models provided significant improvement upon previous models for all variables, except the RAPI model, for which the hypothesized model fit the data most effectively. Even after controlling for autoregressive, temporal and hypothesized cross-lagged paths, we observed some significant and positive associations between drinking and subsequent RTC. Thus, higher levels of drinking often

predicted higher subsequent RTC (see Fig. 3 for significant reciprocal models) and vice versa, with one exception. There was one significant, inverse effect of time 1 RTC on time 2 drinking frequency (see the top panel of Fig. 3). Examination of equality tests (see Table 3) indicated that this single effect was not strong enough to create significant heterogeneity in overall RTC effects on drinking frequency over time.

As shown in Table 3, there were no significant longitudinal differences in paths representing drinking effects on subsequent RTC. We therefore constrained these parameters to produce an 'average' drinking effect on RTC over the 24-month follow-up for frequency ($B = 0.04$, $\beta = 0.12$, $P < 0.001$), typical drinking quantity ($B = 0.01$, $\beta = 0.08$, $P < 0.001$), peak drinking quantity ($B = 0.01$, $\beta = 0.08$, $P < 0.001$) and heavy-drinking episodes ($B = 0.03$, $\beta = 0.09$, $P < 0.001$).

DISCUSSION

This study explored transactional relationships between repeatedly assessed RTCQ and college drinking outcomes over a 24-month period. Three sets of path analysis models were conducted: (a) a baseline autoregressive model, which accounted for autoregressive effects and concurrent associations between RTC and drinking; (b) the hypothesized model testing the popular hypothesis that RTC would be associated with reduced subsequent drinking outcomes; and (c) a reciprocal model, which added the 'hangover effect' accounting for effects of drinking on subsequent RTC.

The first set of models showed significant, positive, autoregressive correlations for RTC and all drinking outcomes. Thus, higher levels of RTC and drinking predicted higher subsequent levels of RTC and drinking, respectively. As shown in prior studies [14–16], higher levels of drinking were also associated with higher RTC within the same assessment period. As is usually the case with alcohol studies, however, drinking outcomes were assessed retrospectively, whereas RTC was assessed concurrently. Thus, this finding should be interpreted such that drinking variables over the past month positively predicted RTC at the time of the assessment.

After taking into account this baseline model, relative fit of the hypothesized versus reciprocal models was tested. The hypothesized model, which tested RTC prediction of subsequent drinking, provided the best model fit for drinking-related problems. Path effects, however, were contrary to hypotheses: higher RTC was associated with greater experience of subsequent drinking-related problems. The reciprocal model provided the best fit for the remaining four quantity–frequency drinking outcomes. Also contrary to hypotheses, findings showed positive drinking effects on subsequent RTC in addition to primarily positive RTC effects on subsequent drinking. The superiority of the reciprocal models provided evidence that, contrary to theoretical assumptions, relationships between drinking quantity–frequency and RTC are not unidirectional but are transactional and predominantly positive.

Only one path of 20 (i.e. the effect of time 1 RTC on time 2 drinking frequency in the past month) reflected the hypothesized, inverse relationship of RTC on subsequent drinking. One explanation for this finding is that higher RTC might correspond to more black-and-white, definitive action, such as avoiding drinking situations altogether. On the other hand, subtler gradations of drinking intensity [e.g. heavy-episodic drinking, blood alcohol concentration (BAC), drinking-related problems] may be influenced more heavily by pervasive, stable and/or immediately salient behavioral [39], personality [40], biological [41] or contextual [42] variables. This would signal a limitation of the ability of RTC to predict different aspects of drinking behavior. On the other hand, considering the large number of path estimates per model, this effect resulted more probably from Type I error. It was not strong

enough to create significant heterogeneity in the overall drinking frequency model and was not sustained for any of the subsequent time-points.

The overall findings, which generally contradict hypotheses about the relationship between RTC and drinking outcomes, suggest that higher RTC may reflect a ‘hangover effect’ and thus serve as a proxy for college drinkers’ recognition or awareness of their alcohol-related problems and heavy drinking. Problem recognition has been acknowledged as an early step in movement towards behavior change [12], and is included in most RTC measures. It does not, however, necessarily follow that a person who recognizes their own drinking-related problems will actually engage in subsequent behavior change. Further, it has been posited that RTC may be necessary for initiation of behavior change, but is not sufficient and must also occur in the presence of people’s belief that change is important and possible [3,18]. Findings, however, suggest that elevated RTC is not only insufficient for initiation of behavior change, but that it is associated with continued, heavy drinking and drinking-related problems.

LIMITATIONS AND FUTURE DIRECTIONS

Current findings are consistent with previous studies in which RTC did not predict future drinking [cf. 1, 25]. On the other hand, they contradict commonly held theoretical assumptions [18] and findings from other empirical studies [22–24]. To the authors’ knowledge, this study represents the largest and most comprehensive test of longitudinal relationships between RTC and drinking to date. That said, further replication of these findings is necessary: most studies have involved treatment conditions that may confound findings and have substantial methodological and analytical differences that make direct, cross-study comparison difficult.

Although RTC was associated positively with subsequent drinking outcomes, it is also possible that RTC is moderated by other motivational constructs, and thereby instigates behavior change only in the presence of, for example, elevated self-efficacy or importance of behavior change. Similarly, RTC is not the only factor that plays a role in longitudinal drinking patterns; contextual (e.g. financial cost, availability, sanctions) and psychosocial factors (e.g. sensation-seeking, coping skills, expectancies, perceived norms) may mediate and/or moderate RTC effects, which may explain the observed disconnect between self-reported RTC and drinking [43]. Future studies should examine RTC effects in combination with other predictors to understand more clearly its relative role in predicting college drinking.

This study made use of the continuous version of the RTCQ, which has been recommended for college populations [7] and is less affected by the psychometric problems encountered with stage-based versions of the RTCQ [8,44] and other RTC questionnaires [45]. That said, other measures may represent this underlying construct more effectively. Although they come with their own set of psychometric challenges [2], single-item measures such as the contemplation ladder [46] or readiness ruler [3] may avoid potential conflation with problem recognition inherent in the RTCQ. Further, a recent study indicated that an open-ended measure designed to assess more personally salient, individual-level elements of motivational states was more predictive of longitudinal drinking outcomes than the RTCQ [25]. Because the RTCQ is the most frequently used measure of RTC in the college population, it was a relevant starting-point in this study. However, future studies can incorporate other RTC measures to compare their predictive validity and resolve whether the current findings may have resulted from measurement issues or the clinical relevance of the RTC construct in this population.

Finally, the current analysis plan allowed for larger-scale, longitudinal modeling of associations between RTC and drinking and included distributional assumptions that fit the data. The strengths of this analysis plan made it a logical starting-point for a critical examination of the predictive validity of the RTC construct. Its limitations, however, highlight future research directions that can further explicate the dynamic and transactional relationships between RTC and drinking. First, models included both Poisson and Gaussian distributional assumptions, and therefore the mean, variance and covariance structures were not sufficient to produce traditional tests of model fit that are familiar to readers and facilitate model interpretation. Hopefully, this study will provide impetus for the development of new statistical fit indices that are appropriate for these analyses and enhance interpretation of the findings. Next, RTC and drinking scores at a given time-point were used to predict subsequent RTC and drinking in a sequential path analysis model. Future studies may feature statistical designs that capture other nuances in these relationships, including embedding them within a larger, theoretically based model, examining the parallel growth curves of RTC and drinking, testing RTC as a longitudinal mediator and moderator of intervention effects on drinking, and using difference scores to explicitly test associations between RTC and drinking change.

SUMMARY

This study has provided the first large-scale, long-term, longitudinal test of associations between RTC and drinking outcomes among at-risk college drinkers. Most findings contradicted hypotheses that higher RTC would predict lower subsequent drinking (i.e. only one of 20 possible paths fit the hypothesized relationship). Not only did higher RTC generally predict higher levels of subsequent drinking and drinking-related problems; higher levels of drinking often predicted higher subsequent RTC as well. These findings suggest that high RTC may reflect a ‘hangover effect’ and thus serve as a proxy for college drinkers’ recognition or awareness of their alcohol-related problems and heavy drinking. Further research is necessary to replicate these findings in different populations, with different measures of RTC, and within the context of more comprehensive theoretical models of motivation to change. We hope this study will instigate further critical examination of the clinical relevance of the RTC construct and the adequacy of instruments designed to measure it.

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Figure 1.

The reduced model showing autoregressive and temporal stability effects of readiness to change (RTC) and drinking variables at each time-point provided the base model for all analyses. Statistically significant, positive paths are denoted with a '+' sign. Time-point 1: baseline; time-point 2: 6-month follow-up; time-point 3: 12-month follow-up; time-point 4: 18-month follow-up; time-point 5: 24-month follow-up; E: measurement error

Figure 2.

Significant hypothesized model adding the cross-lagged paths from readiness to change (RTC) to subsequent drinking outcome variables to the autoregressive model. Because the model included both count and continuous outcomes, path coefficients in the white boxes represent standardized beta coefficients, whereas path coefficients in the gray boxes represent incident rate ratios (IRRs). Time-point 1: baseline; time-point 2: 6-month follow-up; time-point 3: 12-month follow-up; time-point 4: 18-month follow-up; time-point 5: 24-month follow-up; E: measurement error. PEAK: drinking quantity on peak drinking occasion in past month; TYP: drinking quantity on typical drinking occasion in past month; RAPI: Rutgers' Alcohol Problem Index; HDE: frequency of heavy drinking episodes in past month. There were no significant zero-inflated effects for the RAPI model (all P s > 0.05).

* $P < 0.05$; ** $P < 0.01$

Figure 3.

Significant hypothesized model adding reciprocal paths [i.e. from drinking outcome variables to subsequent readiness to change (RTC)] to the previous hypothesized models. Because the model included both count and continuous outcomes, path coefficients in the white boxes represent standardized beta coefficients, whereas path coefficients in the gray boxes represent incident rate ratios (IRRs). Time-point 1: baseline; time-point 2: 6-month follow-up; time-point 3: 12-month follow-up; time-point 4: 18-month follow-up; time-point 5: 24-month follow-up; E: measurement error. PEAK: drinking quantity on peak drinking occasion in past month; TYP: drinking quantity on typical drinking occasion in past month; HDE: frequency of heavy drinking episodes in past month; FREQ: drinking frequency in past month. * $P < 0.05$; ** $P < 0.01$. Significant zero-inflated coefficients were found for the autoregressive RAPI effects between time-points 2 and 3 (IRR = 0.75, $P < 0.001$), time-points 3 and 4 (IRR = 0.80, $P = 0.01$) and time-points 4 and 5 (IRR = 0.81, $P = 0.002$), such that greater experience of previous alcohol problems predicted lower likelihood of a self-report of zero problems at the later time-points

Table 1

Descriptive statistics for primary variables.

Variables	Baseline Mean (SD) n	24-month F-U Mean (SD) n	2-month F-U Mean (SD) n	9-month F-U Mean (SD) n	16-month F-U Mean (SD) n
Drinking frequency	22.76 (6.89) n = 815	22.26 (25.2) n = 751	22.55 (25.26) n = 706	22.30 (25.16) n = 685	22.51 (25.12) n = 665
Quantity: typical	23.76 (22.18) n = 817	23.06 (22.07) n = 755	23.12 (22.43) n = 709	22.79 (1.88) n = 688	22.69 (1.75) n = 665
Quantity: peak	34.75 (22.7) n = 818	32.94 (23.00) n = 755	32.74 (22.88) n = 709	32.65 (23.01) n = 688	32.70 (22.99) n = 665
HDE frequency	25.18 (6.69) n = 818	25.06 (6.76) n = 757	25.12 (6.84) n = 708	n = 690	25.04 (6.73) n = 666
RAPi score	24.41 (24.97) n = 792	24.08 (32.70) n = 733	23.60 (34.74) n = 680	23.96 (35.85) n = 665	23.17 (35.26) n = 632
RTC	25.50 (0.62) n = 818	25.54 (0.68) n = 742	25.55 (0.68) n = 698	25.51 (0.73) n = 679	25.45 (0.72) n = 653

F-U: follow-up; HDE: heavy drinking episodes; RAPi: Rutgers's Alcohol Problem Index; RTC: readiness to change; SD: standard deviation.

Table 2

Model comparison statistics.

Models	Independence model (TRd) ^a	Models compared	Nested model comparison (TRd)
Drinking frequency in past month			
Autoregressive	2423.36 [*]		
Hypothesized	2452.35 [*]	M2, M1	32.43
Reciprocal	2428.2[*]	M3, M1	43.55[*]
Quantity on typical drinking occasion in past month			
Autoregressive	1394.15 [*]		
Hypothesized	1389.15 [*]	M2, M1	8.98 [*]
Reciprocal	1451.58[*]	M3, M2	14.49[*]
Quantity on peak drinking occasion in past month			
Autoregressive	2303.37 [*]		
Hypothesized	2233.74 [*]	M2, M1	35.67 [*]
Reciprocal	2295.7[*]	M3, M2	8.04[*]
Frequency of heavy episodic drinking in past month			
Autoregressive	2553.44 [*]		
Hypothesized	2581.64 [*]	M2, M1	3.88 [*]
Reciprocal	2566.78[*]	M3, M2	9.77[*]
RAPI score			
Autoregressive	2255.7 [*]		
Hypothesized	2281.13[*]	M2, M1	74.65[*]
Reciprocal	2366.06 [*]	M3, M2	22.01

Bold text denotes most predictive model based on fit statistics reported in the table.

^{*} $P < 0.05$.

TRd: χ^2 difference test corrected for use with scaled robust log-likelihood statistics [37]; M1: autoregressive, baseline model; M2: hypothesized model building on M1 by adding cross-lagged relationships between readiness to change (RTC) and subsequent drinking; M3: reciprocal model, building on M2 by adding cross-lagged relationships between drinking variables and subsequent RTC.

^aThe independence model TRd represents the differences between the scaled log-likelihoods of the independence (i.e. all paths constrained to zero) and comparison models. Because these tests are corrected for scaling factors, they are not directly comparable across comparison models in the table. To compare the fit of the models, see the 'Model comparison TRd.' RAPI: Rutgers' Alcohol Problem Index.

Table 3

Wald tests of equality constraints on path coefficients across time.

	M1		M2		M3	
	Autoregressive effects: alcohol (df = 3)		Autoregressive effects: RTC (df = 3)		Alcohol effects on RTC (df = 3)	
Drinking frequency	6.24	14.15 ^a	4.50	7.77 ^a	2.49	
Quantity: typical	11.78 ^a	14.53 ^a	2.89	1.50	5.61	
Quantity: peak	7.47	14.33 ^a	6.22	4.99	1.46	
HDE frequency	14.16 ^a	13.15 ^a	1.73	10.42 ^a	2.56	
RAPi score	27.54 ^a	17.45 ^a	16.29 ^a	11.68 ^a	4.26	

M1: autoregressive, baseline model; M2: hypothesized model building on M1 by adding cross-lagged relationships between readiness to change (RTC) and subsequent drinking; M3: reciprocal model, building on M2 by adding cross-lagged relationships between drinking variables and subsequent RTC. HDE: heavy drinking episodes; RAPi: Rutgers' Alcohol Problem Index.

^a*p* 0.05.