COGNITIVE BIAS MODIFICATION OF ALCOHOL APPROACH TENDENCIES: A RASCH MODEL-BASED EVALUATION OF A LONGITUDINAL STUDY

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The present study explores the applicability of the Many-Facet Rasch Measurement model to an Approach Avoidance Task assessing automatic approach tendencies toward alcohol. The MFRM was applied to 54 alcohol dependent outpatients who completed a combined Cognitive Bias Modification (CBM) training, targeting alcohol approach and attentional bias. Main objectives were to examine a) occurrence of change; effect of b) experimental conditions and c) gender; d) measurement status of the measure. Main results included a) no main effect of time, which only modulates effects of experimental condition on approach/avoid tendencies; b) double CBM, and to a lower degree double placebo, outperformed the other conditions, while approach bias placebo/attentional CBM had a negative effect; c) no gender differences; d) the measure taps into general and drink-specific approach/avoid tendencies, is stable in time, and is slightly sensitive to stimuli context. Methodological and clinical implications of study results are further discussed.

Key words: Rasch modeling; Many-Facet Rasch measurement model; Approach Avoidance Task; Approach bias; Cognitive Bias Modification.

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In experimental clinical psychology measurement of change represents a difficult challenge. We expect patients to change from Time 1 to Time 2 as a consequence of a treatment intervention administered between the two assessment sessions. Confusion may arise as the functioning of the assessment measures used (tests, surveys or neuropsychological tasks) may not be stable over time and may also change even when the same data collection protocol is used. Therefore, the challenge consists in measuring people and instrument performance in the same clearly defined reference frame so that measurement of change will have unambiguous numerical representation and substantive meaning.

The correct estimation of targeted psychological attributes on the same continuum along different time points allows for a more accurate evaluation of the rate of change after the experimental intervention. It might happen, though, that a certain manipulation at first sight does not produce a manifest change in the expected direction or that the expected change does not occur at all. However, what is visible does not always concur with what actually happens. For this reason, the use of invariant measures of the crucial underlying attributes is central to monitor change and to detect the effect of other events or variables that can influence the outcome. Experimental conditions, medications, instructions, or individual differences can moderate the desired results.

The Many-Facet Rasch Measurement model (MFRM; Linacre, 1989), which belongs to the family of Rasch models, has demonstrated to be a powerful modeling framework in exploring change processes, both in experimental social psychology (e.g., Vianello & Robusto, 2010) and in applied clinical psychology (e.g., Balottin, Nacinovich, Bomba, & Mannarini, 2014; Mannarini, 2009; Mannarini, Boffo, Bertucci, Andrisani, & Ambrosini, 2013), for its flexibility in the inclusion of several elements that can contribute to the outcome of an evaluation process (i.e., *facets*) and for the transformation of observed scores into scalar-invariant, meaningful and comparable measures. One of the fundamental advantages of constructing psychological measures within a Rasch modeling framework is that estimates derived from a Rasch analysis are located on an interval scale wherein the measurement unit is maintained at all points and for all facets entered in the model.

The use of Rasch models to depict change over time implies restructuring data by appending person measures at Time 2 onto the baseline measures at Time 1, resulting in twice as many persons being measured (i.e., stacking the data; Wright, 2003). Conceptually speaking, this procedure transforms observations at Time 1 and at Time 2 into measures on the same ruler and enables to test the assumption that the targeted psychological attribute or behavior has changed as a result of the experimental intervention or manipulation. As Wright claimed, "[by] stacking the data, we see who has changed" (p. 906).

One of the most traditional experimental designs involves the comparison between the group of participants receiving the targeted intervention and a control group by using traditional statistical methods like between-subjects repeated measures ANOVAs, in order to establish whether a change occurs or not as a result of the experimental intervention. Although robust when the underlying assumptions are not violated, these methods are based on covariance matrices and are typically employed on the assumption that numbers, such as test raw scores, are measurements. Such approaches implicitly endorse Stevens' (1946) definition of measurement, which requires only that numbers be assigned according to some rule. The main research task, then, is generally considered to be the discovery of associations between scores and of factors supposed to underlie such associations. On the other hand, when measurement models such as the Rasch model are employed, numbers are not assigned based on a rule. Instead, specific criteria for measurement are stated, and the objective is to devise a model structure to relate an observable attribute to a theoretical attribute (for more details on the conceptual foundations of measurement, see Haig and Borsboom, 2008; for the debate on philosophy of science and psychometrics, see Borsboom, 2005, 2006, and Michell, 1997).

Following this premise, the present work represents a first endeavor to deploy the MFRM in a clinical experimental context as a tool to investigate the effectiveness of new treatment interventions in alcohol addiction: Cognitive Bias Modification (CBM) paradigms. This new family of interventions has recently been developed to tackle the prepotent, drug-evoked automatic processes involved in the onset and maintenance of addiction problems (for a review, see Wiers, Gladwin, Hofmann, Salemink, & Ridderinkhof, 2013). CBM paradigms are computerized tasks aimed at training alternative responses to a drug-related stimulus and adjusting the biases that underlie the breakdown in more controlled processes over impulsive reactions toward the addictive substance (Hofmann, Friese, & Wiers, 2008; Wiers, Gladwin, Hofmann, et al., 2013). Typically, CBM is a modified version of an assessment task, such as the Approach Avoidance Task (AAT; Rinck & Becker, 2007; Wiers, Rinck, Dictus, & van den Wildenberg, 2009), with a built-in contingency that recasts it to *re-training* paradigm.

The present study focuses on the measurement analysis of an irrelevant-feature AAT as assessment instrument and CBM training paradigm of alcohol-driven behavioral approach bias, or approach tendencies. In this task respondents have to react to a content-irrelevant feature of a stimulus (e.g., landscape or portrait format) with an approach or avoid response and ignore the actual content of the stimulus (e.g., alcohol or soft drink). A visual response feedback of increasing or decreasing stimulus size is incorporated in the task as a function of approach versus avoid reactions (Figure 1). The advantages of an irrelevant-feature version of the AAT are first that the measurement is more indirect (De Houwer, 2003), and second, that you can change from measurement to manipulation without changing the instructions (Wiers, Gladwin, & Rinck, 2013; Wiers, Rinck, Kordts, Houben, & Strack, 2010).

First clinical applications of approach bias CBM training with alcohol dependent inpatients have shown promising results by demonstrating that alcohol approach bias can be re-trained, which was associated with a reduction in relapse one year after (e.g., Eberl et al., 2013; Wiers, Eberl, Rinck, Becker, & Lindenmeyer, 2011). Moderated mediation analyses further identified that CBM intervention mediated the main clinical outcome (i.e., relapse rate) and that patients with stronger approach bias toward alcohol at baseline benefited more from CBM intervention than those with a weaker bias (Eberl et al., 2013). However, there is scant evidence about the measurement validity of the AAT, particularly in the irrelevant-feature variant. This version has indeed been found to present lower reliability estimates and predictive validity when compared to relevant-feature approach/avoidance tasks (relevant-AAT and Stimulus Response Compatibility Task; Field, Caren, Fernie, & De Houwer, 2011; Kersbergen, Woud, & Field, in press), thus putting into question its suitability as an assessment measure of approach bias.

This study is explorative in nature for two main reasons: it is the first to attempt to prove the existence of a latent measurement dimension underlying the (irrelevant-feature) AAT measure, wherein the AAT scores are located and share the same metric. Second, the adaptation of the AAT to CBM paradigm, with the purpose of experimentally manipulating the to-be-measured psychological attribute, provides a breeding ground for exploring the changing process caused by the intervention and for establishing the AAT measurement validity within an experimental research framework (Borsboom, Mellenbergh, & van Heerden, 2004). To this end, the MFRM can potentially provide new insights into the measurement status of the task.

Early work on the use of Rasch models for the analysis of indirect measures of automatic associations, such as the Implicit Association Test (e.g., Anselmi, Vianello, & Robusto, 2011; Mannarini & Boffo, 2014), has already started to pave the ground for the deployment of Rasch models not only in standard self-report measures but also in experimental, computerized tasks. This work takes a step further: the analytical focus here is not on the stimuli used in the AAT (cf. Mannarini & Boffo, 2014), as content of stimuli is not the relevant categorization category. The primary research question involves the *structure* of the task in itself.

OBJECTIVES

The MFRM analysis is conducted here on preliminary AAT data from an ongoing Randomized Clinical Trial (RCT) testing the combination of two computerized CBM modules, one targeting alcohol approach bias and one alcohol attentional bias (Boffo, Pronk, Wiers, & Mannarini, 2014). The main study objectives are the following:

1) Examination of change: did participants' approach bias for alcohol and/or soft drinks change over time?

2) Examination of experimental condition effect: did the CBM intervention impact on participants' approach bias?

3) Examination of any difference related to participants' gender.

4) Examination of the dimensional nature of the approach bias measure: can we consider the AAT as a global measure of approach-avoid tendencies toward an object, which is subspecified within the measure (e.g., alcohol-approach tendencies and soft drinks-approach tendencies)? Or should we distinguish between independent object-specific approach tendencies? The approach bias for alcohol does not necessarily imply an avoidance bias toward soft drinks; rather, approach tendencies could coexist and be simultaneously directed to different appetitive stimuli (Wiers, Gladwin, Hofmann, et al., 2013; Wiers et al., 2009). This examination also implies a closer look at the task structure: is there any difference in the task trial formats? This research question is particularly relevant for a valid measurement of approach tendencies, since if the task presents internal differences in the extent to which the to-be-measured construct is represented by task trial formats, then the final aggregated task scores may include misleading effects (e.g., trials hardly tapping into alcohol-related approach tendencies aggregated with trials that are highly representative of alcohol-related approach tendencies).

METHODS

Study Design

The general study is a Phase-II double blind parallel-group RCT testing the effectiveness of the combination of computerized alcohol approach bias and attentional bias CBM trainings alongside a motivational support intervention supporting the training process. The experimental intervention has a 2 × 2 factorial design, which combines the real and placebo versions of alcohol approach bias and alcohol attentional bias CBM training into four experimental conditions: one double CBM training experimental condition, two experimental groups receiving one active training and one placebo training, and one double-placebo training control group. As previously explained, the approach bias CBM trains the automatic action tendencies away from alcohol, whereas the attentional bias CBM targets the automatic allocation of attention to alcohol-related stimuli. The placebo version of each CBM training module consists of a continuous assessment, in which half of the trials train the cognitive biases toward alcohol and the other half toward soft drinks (i.e., active placebo). Participants complete a total of 14 sessions: two baseline assessment sessions, 11 training sessions, one post-intervention assessment session, and a 3-month follow-up assessment session. At each assessment session, alcohol approach and attentional bias is assessed along with other clinical measures. The RCT was approved by the Ethics Committee of the School of Psychology of the University of Padua (March 2013; Pr. 1242) and registered in the International RCT registry Current Control Trials (ISRCTN01005959; Boffo, Mannarini, & Wiers, 2013). For more details about the study design, materials and methods, see Boffo et al., 2014, or visit the RCT registration webpage: http://www.controlled-trials.com/ISRCTN01005959.

Participants

Participants are adult outpatients with a primary diagnosis of alcohol addiction disorder and abstinent for at least two months, recruited in the public health addiction service of San Donà di Piave (Venice), Italy (Addiction Service, ULSS10) (for a detailed description of recruitment criteria and procedure, see Boffo et al., 2014). The Rasch analysis of the AAT was carried out on data of participants who fully completed baseline, post-intervention and follow-up assessment sessions (N = 54, 59.26% male; mean age = 53, SD = 10.99; 69.32% of total enrolled participants so far). Fifty per cent of analyzed participants has a low education level (primary school/lower secondary school degree), 35.18% a medium education level (higher secondary school degree), and 14.81% high education (university degree).

The Approach-Avoidance Task

Alcohol automatic approach tendencies are assessed and trained with the modified Approach-Avoidance Task (AAT; Rinck & Becker, 2007; Wiers et al., 2009, 2010, 2011). The AAT is a computerized speeded reaction-time task in which participants are asked to react to stimulus presentation format and ignore stimulus content (i.e., irrelevant-feature task).

In this task, a picture of an alcoholic or non-alcoholic beverage is presented in the center of the screen. The picture is three degrees tilted to the left or to the right. Participants are instructed to respond to the tilt direction of the picture, by pushing pictures tilted to the left away from them and pulling pictures tilted to the right toward them by pressing and holding two keys (U and N) on the keyboard.[1] The combination of the format of the picture and the response (left = push and right = pull, versus left = pull and right = push) is counterbalanced across participants. Participants' responses are accompanied by a zooming effect, which increases picture size in the pulling closer response and decreases it in the pushing away response, mimicking actual approach/avoidance (for an example of trial, see Figure 1).

In the AAT assessment versions, the pictures of alcoholic and soft drinks are presented equally often in both formats. In CBM training, participants in the experimental condition are trained to avoid alcohol by exposing them mostly or only to alcohol/push and soft drink/pull trials, whereas for participants in the placebo training condition alcohol and soft drink pictures are presented equally often in both formats (continued assessment).

Stimuli are pairs of matched pictures of alcohol and soft drinks photographed in both passive (beverage only) and active (presence of a human in interaction with the drink) contexts (for a detailed description of stimuli see Boffo et al., 2014). Stimuli stay on screen for a maximum of 3000ms; in case of no response the trial is restarted after repeating the instructions. Stimuli are randomized with 50/50 proportion of passive and active pictures in each task session. At pre- and post-intervention assessment session the AAT uses different untrained stimuli. Follow-up measurement session is equal to post-intervention, that is, the same stimuli are used.

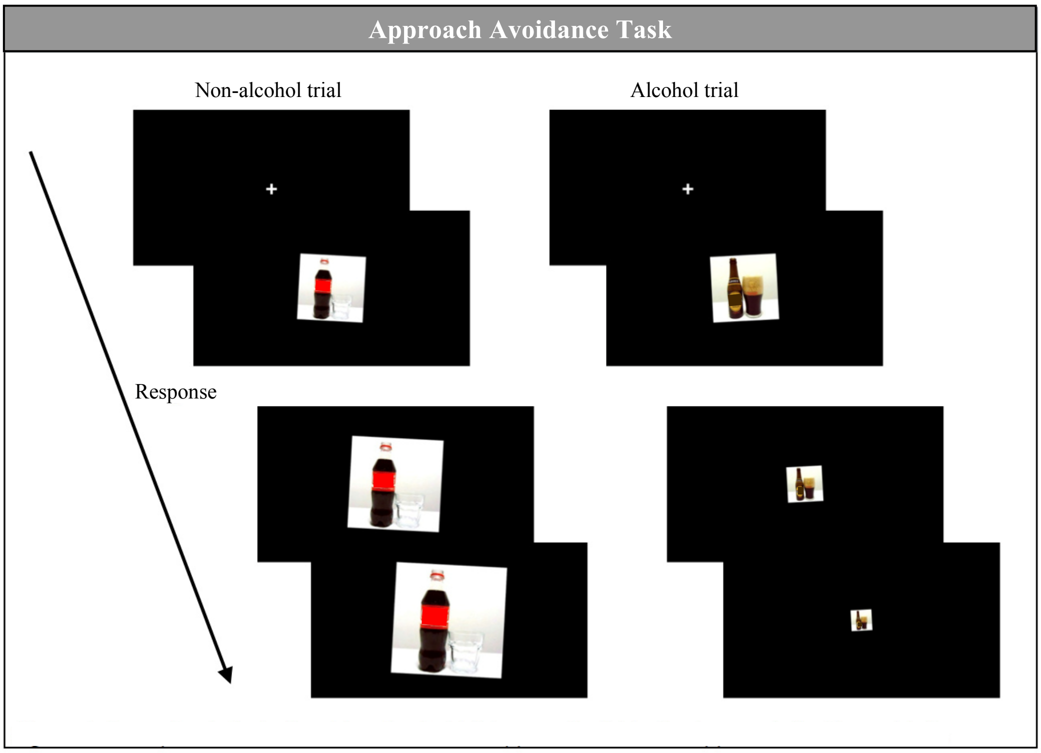

FIGURE 1
Example of alcohol/avoid and soft drink/approach trial in the Approach Avoidance Task.

Data Analysis

Data Pre-Processing

The AAT scoring algorithm follows an adapted version of the standard D-score designed for the Implicit Association Test. The improved D-algorithm standardizes the difference in response latencies by dividing an individual's difference in RTs by a personalized standard deviation (*SD*) of these latencies (Greenwald, Nosek, & Banaji, 2003). The advantage of such standardized scores over simple median difference scores is that they are less vulnerable to biases due to differences in average reaction time. In recent studies with the AAT (Eberl et al., 2013; Wiers et al., 2011) the algorithm performed better than the original scoring algorithm. The algorithm yields an approach bias score for each drink type (alcoholic, soft drinks) and stimuli contexts (active and passive). Positive scores indicate an approach tendency, negative scores an avoidance tendency. Higher scores correspond to stronger approach tendencies.

The AAT data scoring and preparation for the MFRM analysis were done as follows:

1) Practice trials and latencies lower than 300ms were removed;

2) Incorrect responses were replaced by the mean of correct responses in the same trial

format (e.g., mean alcohol/push/passive trials) plus a penalty of twice the standard deviation of the same correct responses;

3) The D-score was computed for alcohol trials, (mean alcohol/pull — mean alcohol/push)/ SD(alcohol), and soft drinks trials, (mean soft drinks/pull — mean soft drinks/push)/SD(soft drinks), separately for trials using active and passive pictures, for a total of four D-scores indicating the approach tendencies toward alcohol and soft drinks;

4) Each D-score was successively discretized into five categories according to the quintiles computed at each time point on the score distribution of each drink to index: 1 = *strong avoid bias*, 2 = *mild avoid bias*, 3 = *no bias*, 4 = *mild approach bias*, 5 = *strong approach bias*;

5) A two-dimensional matrix $P \times (T, C, G, I)$ included stacked data for the four approach bias indices at baseline, post-intervention, and follow-up data for each participant. P identifies participant v, T identifies time-point t, C lists the experimental condition c, G codes for participant's gender g, and I identifies the approach bias index i;

6) Two two-dimensional matrices $P \times (T, C, G, A)$ and $P \times (T, C, G, S)$ included stacked data for the approach bias indices per drink type (alcoholic and soft drinks): P identifies participant v, T identifies time-point t, C lists the experimental condition c, G codes for participant's gender g, and A and S identifies the alcohol approach bias index a and the soft drinks approach bias index s, respectively.

The Model

In the MFRM, each observation is considered to be the outcome of an interaction of elements, such as individual ability, the difficulty of the item, the condition the item is presented in, and so on. These interacting facets are modeled in the MFRM independently one to each other, so that their parameter estimates can be additively combined on the latent trait. The MFRM is an extension of Rasch's seminal Simple Logistic Model (SLM; Rasch, 1960/1980; for a detailed description see Cristante & Mannarini, 2004), in which two main facets determine the response to an item: the person's ability and the item difficulty. According to a logistic distribution, the probability of a response x to a test, which can be correct (1) or incorrect (0), is a function of the ability of respondent v and difficulty of the item i, expressed on the *logit* scale ($\beta_v - \delta_i$) (Rasch, 1960/1980).

While retaining the mathematical properties of Rasch models (specific objectivity, local independence, monodimensionality, monotonicity; for details, see Bond & Fox, 2007; Sijtsma, 2012), the MFRM extends the analysis to more complex situations by including other sources of systematic variability (*facets*) that can impact on the probability of a response (e.g., Mannarini, Boffo, & Balottin, 2013). In the present study, several facets were specified in the attempt to first model the likelihood of a certain approach bias score: respondents' ability, that is, the individual global or specific approach tendency (facet 1); task indices representativeness, that is, the extent to which each index taps into the underlying construct and the degree of approach/avoid responses they trigger (facet 2); measurement time-point (facet 3); participants' gender (facet 4); the experimental condition participants were assigned to (facet 5). An additional parameter accounting for the approach bias score $k = \{1,...,m\}$, provided by the discretization of the score distribution of the approach bias indices in the AAT, was embedded in the model. The general MFRM model equation is then formally expressed as follows:

$$ln\frac{P(X_{vibcdk})}{P(X_{vibcdk(k-1)})} = \beta_v - \delta_i - \lambda_b - \gamma_c - \eta_d - \tau_k \quad (1)$$

Equation (1) describes the *logit* (i.e., the log-likelihood) of a certain response *k* as the dependent variable, whereas the various factors entered in the model act as independent variables that influence (or control) the response. Equation (1) specifies the probability that a respondent *v* would respond to index *i* at time point *b* in experimental condition *c*, given gender *d*, with a score *k* rather than *k* – 1; β_v is the parameter describing person *v* automatic approach tendency, δ_i is the index *i* representativeness of the approach tendency on the latent trait, λ_b identifies the time point *b*, γ_c lists the four experimental conditions, η_d identifies participants' gender, and τ_k is the parameter for the step up to category *k* rather than *k* – 1 of the index score.

Equation (1) was applied to all of the three matrices including the four AAT task indices, alcohol indices or soft drink indices. The analytical approach strategically entailed running parallel model estimations on the general approach-avoid dimension, which does not focus on any specific object to avoid or to approach, and on the subdimensions of alcohol approach/avoid tendencies and soft drinks approach/avoid tendencies. All parameter estimates were positively scaled in the analyses, so that positive values indicate a stronger alcohol approach bias, whereas negative measures indicate the opposite.

To evaluate the goodness-of-fit of the parameter estimates, the MFRM presents two fit indices that show how much the data for each parameter adhere to the model requirements: mean square Infit and mean square Outfit. These statistics are calculated for each participant, each index, and any other facet parameter, and express the relationship between observed and model-derived expected scores, ranging from zero to infinity. Statistics equal to or near 1 indicate perfect correspondence between observed and expected values; statistics above 1 indicate the presence of greater variance than that modeled (underfit); and statistics below 1 indicate the existence of lower variance in the data than that predicted by the model (overfit). A range of .50 – 2 indicates a satisfactory fit of the observed data to the model requirements (Bond & Fox, 2007; Linacre, 2010).

A chi-square statistics — the fixed (all same) χ^2 — is also provided for each facet, and tests the hypothesis that the elements of the facet have the same *logit* in relation to the measurement error (SE). The chi-square statistics plays a pivotal role in the context of the present study, since it traditionally helps to reject the null hypothesis that there is no group-level difference in the different elements composing a facet (e.g., the four indices in the task index facet). However, it is hereby expected that Facet 2 (i.e., AAT task indices) shall present a fixed (all same) χ^2 with an associated probability > .05, which means that the indices have a similar functioning and similarly tap into the approach tendencies toward a target object. In other words, the hypothesis is that active and passive alcohol approach indices and active and passive soft drinks approach indices equally trigger approach/avoid response tendencies. Conversely, for all other model facets it is expected a fixed (all same) χ^2 with an associated probability < .05.

After estimating the model parameters, the MFRM gives the possibility to carry out bias/interaction analyses, that is, the analysis of interactions between elements of different facets (for details, see Linacre, 2010). A bias can be due to any kind of interaction, such as differential index functioning, differential person functioning or differential functioning of any other facet, and is estimated from the residuals left over after estimating the parameters in the main analysis (Linacre, 2010), and tested for statistical significance by means of *t* statistic. This feature allows to identify possible factors causing any systematic deviation from the model expectations in the data, such as the experimental condition participants have been assigned to. For the purpose of the present study, a differential *condition* functioning (DCF) analysis is of particular interest since it examines the interaction between the elements of the facet Experimental Condition and elements of other facets, such as Time. The bias index involves introducing an interaction parameter into the model between the facets (e.g., Condition × Time). The logit of condition *c* at time *b* is computed by adding a bias measure to the overall approach/avoid measure of the same condition *c* if this involves more approach tendencies at time *b* than overall or by subtracting it if the approach tendencies decrease. The same is done for condition *c* at time *b* – 1. The two biased measures are then subtracted. To test for the interaction significance, such difference is transformed into a *t*-value used to run pairwise contrasts between the two biased condition measures at Time *b* and *b* – 1, divided by their joint standard error $SE_{ij} = \sqrt{SE_i^2 + SE_j^2}$ (Linacre, 2010). The degrees of freedom of the *t* value for the difference between the logits of two elements is the number of "free" observations for each element ($df = N_i - 1 + N_j - 1$). Planned bias/interaction analyses in the present study covered potential interactions between facet Time and facet Experimental Condition, Gender and Task Indices.

RESULTS

Objective 1

The application of Equation (1) to AAT stacked data did not evidence any statistically significant difference across the three time points (facet Time) in any of the hypothesized approach/avoid measurement dimensions (*p*s > .05). That means that there is no main effect of time on participants' AAT score probabilities and on the underlying measurement dimension. Participants' parameter values (β_v) at baseline, post-intervention and follow-up were then separately estimated in order to compare their average value on the same logit metric over the three time points. Equation (1) was applied to data for each time point by dropping facet Time parameter out of the equation. At baseline, although being different in their general approach/avoid tendencies, participants showed similar approach estimates toward both alcohol and soft drinks (see Table 1), which means that, at the group level, participants were pretty much similar in their drink-specific approach tendencies. At post-intervention and follow-up, the recovered approach bias estimates were instead more varying for both drink types, which means that, after the experimental intervention, participants were more variable in the degree of approach/avoid tendencies toward alcohol and soft-drinks.

Objective 2

Facet Experimental Condition showed a statistically significant main effect independently of time in all of the three measurement dimensions (.78 ≤ Infit ≤ 1.18, .78 ≤ Outfit ≤ 1.14; see Table 2). Double CBM intervention systematically triggered more avoidance responses, followed by the double placebo condition. Conversely, the mixed treatment module with approach bias placebo and attentional bias real CBM training systematically brought about more approach tendencies.

TABLE 1
Participants' parameter mean estimates $(\overline{\beta}_v)$ at each time point and measurement dimension: standard error $(\overline{SE})$, standard deviation (*SD*), range, and χ^2 statistics

Time point	Approach/ Avoid	$\overline{\beta}_v$	$\overline{SE}$	*SD*	Range	Fixed (all same) χ^2
Baseline	General	.04	.50	0.82	–1.87 – 3.08	$\chi^2_{(53)} = 78.6, p = .01$
	Alcohol	–.03	.88	1.30	–3.14 – 2.76	$\chi^2_{(53)} = 65.9, p = .11$
	Soft drinks	.02	.82	1.11	–2.82 – 2.70	$\chi^2_{(53)} = 57, p = .33$
Post-intervention	General	–.01	.67	1.39	–3.05 – 4.17	$\chi^2_{(53)} = 114.3, p < .001$
	Alcohol	.04	1.12	2.11	–4.05 – 4.21	$\chi^2_{(53)} = 118.3, p < .001$
	Soft drinks	–.07	1.04	1.76	–3.05 – 4.17	$\chi^2_{(53)} = 81.5, p = .01$
Follow-up	General	.10	.57	1.04	–2.48 – 2.58	$\chi^2_{(53)} = 132.8, p < .001$
	Alcohol	.16	.95	1.52	–2.41 – 4.43	$\chi^2_{(53)} = 94.3, p < .001$
	Soft drinks	.13	1.04	1.77	–3.69 – 4.18	$\chi^2_{(53)} = 93.6, p < .001$

TABLE 2
Parameter estimates for facet Experimental Condition for each measurement dimension: parameter values (γ_c) and standard error (*SE*)

	Approach/Avoid dimension					
	General		Alcohol		Soft drinks	
Experimental Condition	γ_c	*SE*	γ_c	*SE*	γ_c	*SE*
Double CBM	–.19	.06	–.21	.09	–.18	.08
Approach CBM/Attention placebo	.01	.06	–.06	.10	.07	.09
Approach placebo/Attention CBM	.34	.07	.40	.11	.32	.10
Double placebo	–.16	.06	–.12	.09	–.22	.08
Statistics	$\chi^2_{(3)} = 38, p < .001$		$\chi^2_{(3)} = 20.8, p < .001$		$\chi^2_{(3)} = 20.8, p < .001$	

A bias/interaction analysis recovered an interaction effect between Time and Experimental Condition (see Figure 2) on drink-specific measurement dimensions. When compared to baseline, the group receiving the double CBM condition showed an increase in approach responses toward alcohol at post-test ($t_{(62)} = –2.96$, $p = .004$), which reverted to strong avoid responses to alcohol at follow-up ($t_{(62)} = 3.27$, $p = .002$). The group receiving the double placebo intervention showed a decrease in alcohol approach tendencies from baseline to post-intervention ($t_{(62)} = 2.68$, $p = .01$), which remained stable at follow-up ($t_{(62)} = –1.51$, $p = .136$). The combination of approach bias CBM and attentional bias placebo resulted in a shift of action tendencies toward soft drinks from baseline to follow-up ($t_{(50)} = –2.54$, $p = .014$), moving from avoidance to approach responses. A similar albeit not statistically significant shift occurred also toward alcohol from post-intervention to follow-up ($t_{(50)} = -1.89$, $p = .065$).

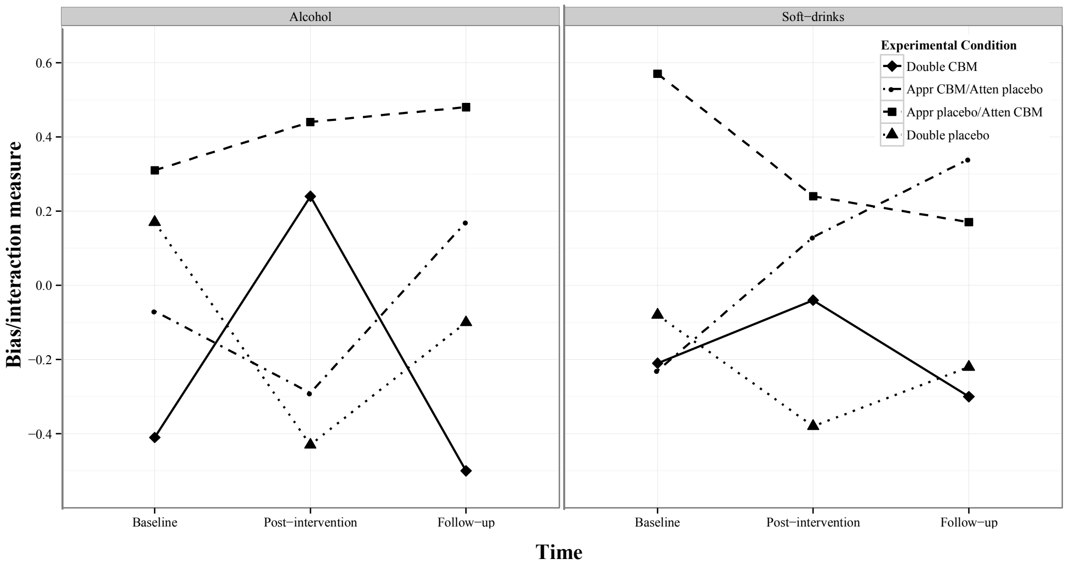

FIGURE 2
Results of bias/interaction analysis for Facet Time by Facet Experimental Condition on drink-specific measurement dimensions.

Objective 3

A main effect of facet Gender was retrieved for approach/avoid responses only toward soft drinks, independently of time and any other model facet ($\chi^2_{(1)} = 4.6$, $p = .03$; $.99 \leq$ Infit $\leq$ 1.01, $.97 \leq$ Outfit $\leq .99$). Males resulted to be generally more inclined to approach soft drinks than women. The bias/interaction analysis for Gender × Time did not evidence any statistically significant gender difference in the approach/avoid responses toward alcohol and soft drinks over the three time points.

Objective 4

The hypothesis about the measurement status of the four approach indices entailed the idea that the approach-avoid tendencies could be an overarching dimension that may be subframed into drink-specific approach/avoid measurement subdimensions. The MFRM parameter estimates of the four AAT indices (δ_i) did not differ in the degree of approach/avoid automatic responses they evoke and presented satisfactory fit indices in both the general approach/avoid latent dimension and in the drink-specific subdimensions, independently of time and any other model facet (i.e., bias-free measure; $\chi^2_{(3)}$s = [.1, .2], *p*s > .05; $.90 \leq$ Infit ≤ 1.10, $.87 \leq$ Outfit ≤ 1.10). A bias/interaction analysis did not retrieve any residual interaction effect between facet Time and Task Index, which results to be stable over time.

To further examine the impact of active and passive pictures on the functioning of each index, six MFRM model estimations were conducted on baseline, post-intervention and follow-up data by applying Equation (1) without the facet Time parameter. In Table 3 are presented the MFRM parameter estimates for task indices on the drink-specific measurement dimensions (alcohol and soft drinks approach/avoid tendencies) and over the three time points. All parameter estimates presented satisfactory Infit and Outfit statistics (.50 ≤ Infit ≤ 1.43, .49 ≤ Outfit ≤ 1.32).

TABLE 3
Parameter estimates (standard error between brackets) for facet Task Index (δ_i) at each time point and drink-specific measurement dimension

	Time point					
	Baseline		Post-intervention		Follow-up	
Task index	Alcohol approach	Soft drinks approach	Alcohol approach	Soft drinks approach	Alcohol approach	Soft drinks approach
Soft drinks A	–	**–.20 (.14)**	–	.21 (.17)	–	.03 (.18)
Soft drinks P	–	**.20 (.14)**	–	–.21 (.17)	–	–.03 (.18)
Alcohol A	.18 (.15)	–	**–.38 (.20)**	–	–.05 (.16)	–
Alcohol P	–.18 (.15)	–	**.38 (.20)**	–	.05 (.16)	–
Statistics	$\chi^2_{(1)} = 2.8$ $p = .09$	$\chi^2_{(1)} = 4$ $p = .04$	$\chi^2_{(3)} = 7.6$ $p = .01$	$\chi^2_{(3)} = 2.9$ $p = .09$	$\chi^2_{(1)} = .2$ $p = ns$	$\chi^2_{(1)} = .1$ $p = ns$

Note. Statistically significant different parameter estimates are evidenced in bold ($p < .05$). A = active; P = passive.

DISCUSSION

The present study explored the applicability of a Rasch modeling approach in the context of assessment and experimental manipulation of automatic approach tendencies and/or attentional bias toward alcohol with a clinical sample of alcohol dependent outpatients. The MFRM analysis of longitudinal AAT data collected before and after the experimental intervention tried to answer four main research questions, which will be discussed further on. A final discussion on the use of MFRM model in the field of CBM research will follow the comment on the study results.

Objective 1

Primary target of this analysis and of the ongoing RCT is to discover whether the experimental intervention does induce a change in participants. The MFRM did not find a main effect of Time on participants' AAT score probabilities. Furthermore, participants' parameter estimates, which in Rasch models describe the underlying psychological feature required to respond to questionnaire items or task trials, did not significantly change from baseline to follow-up.

The absence of a main effect of time, neither as model facet nor as independent changing factor, does not mean that time does not play a role in affecting the measure. When aggregated at group level and inspected at each time point, participants' estimates of alcohol approach/avoid tendencies resulted to be similar one to each other at baseline. That could be considered an expected result given the recruitment inclusion criterion of presenting a main diagnosis of alcohol dependence disorder. Persistent substance abuse has been found to further strengthen impulsive reactions to drug-related cues and to weaken control processes over impulses (e.g., Wiers, Gladwin, Hofmann, et al., 2013). When looking at participants' estimates at post-intervention and follow-up, the model signaled that participants' parameter estimates were substantially more diversified for alcohol and soft drinks approach/avoid tendencies at post-intervention and follow-up. This greater diversification after the experimental intervention does point to the occurrence of a changing effect, which is not solely ascribable to the effect of time. The bias/interaction analysis indeed revealed the effect of Time only in interaction with facet Experimental Condition, which brings us to the discussion of the next study objective.

Objective 2

Second objective of this study is closely linked to the first one and involves the impact of experimental conditions on AAT score probabilities over time. The model detected a general main effect of the four conditions, which embodied different degrees of approach/avoid automatic responses toward alcohol and soft drinks independently of any other model facet (i.e., time, participants, task indices, and gender). If we locate the four conditions on a "success" continuum we will find the double CBM intervention at the "very successful" pole of the continuum, surprisingly followed by the double placebo, which did moderately well in reducing the approach bias toward alcohol. On the "very unsuccessful" pole we will find the mixed intervention with approach bias CBM training and attentional bias placebo. In between, located on the "neither successful/nor unsuccessful" point, is the combination of approach bias placebo and attentional bias CBM. A closer look at the functioning of the four conditions over time showed an interaction effect on alcohol approach bias of the double CBM condition and, to a lower extent, the double placebo condition. Both conditions successfully decreased the approach tendencies from baseline to follow-up. This result partially mirrors findings obtained with traditional analysis (i.e., repeated measures ANOVAs) of the same data (cf. Boffo, Pronk, Cerantola, Mannarini, & Wiers, 2014). Besides the positive result for the double CBM intervention, the beneficial effect of the double placebo condition in decreasing dysfunctional action tendencies toward alcohol needs to be further explored and replicated at the conclusion of the RCT. Given that both placebos are active, with half of the task trials training the cognitive bias away from alcohol, their combination is indeed likely to moderately positively impact on the targeted automatic responses to alcohol.

Unexpectedly, the combination of approach bias real CBM training and attentional bias placebo seems to be counterproductive since, when compared to baseline, it elicited more approach responses at follow-up. The factorial experimental design of the study makes it difficult to disentangle at this stage which of the two modules caused this result. A more careful scrutiny of the combined effect of training modules would break down the facet Experimental Condition into two separate facets with two levels each (real vs. placebo), one for the approach bias training module and one for the attentional bias training module. It would also be interesting to check for the order of presentation of the two treatment modules, which are counterbalanced between participants, to control for carry over and/or crossover effects and see whether completing the attentional bias placebo intervention first hampers the active effects of the approach bias real training.

Objective 3

Measurement of automatic approach tendencies toward alcohol resulted to be gender-independent, whereas males resulted to be more inclined to approach soft drinks than women. In this stage the MFRM analysis was limited to the introduction of facet Gender as a individual difference variable hypothesized to affect the approach/avoid measure. Other facets can also be included in the model insofar as they are expected to be clinically relevant for the study and have a differential effect on alcohol approach bias, such as drinking history or previous detoxifications.

Objective 4

The fourth and last objective of the present study called into question a) the measurement status of the (irrelevant-feature) AAT measure used to assess approach/avoid tendencies toward alcohol and b) the ability of the measure to detect a change in the task scores as a consequence of the experimental intervention targeting the very same to-be-measured construct. The analytical approach followed the hypothesis that the approach bias measure should tap into a general domain that can be framed into specific subcomponents, analyzable separately and with an own "ontological status" (Borsboom et al., 2004). The theoretical assumption is that the four AAT indices lie on a common latent dimension representing general automatic approach/avoid tendencies toward an object. Depending on stimuli presented during the task, which define the target of each approach/avoid index, the measurement dimension specifies into object-specific approach/ avoid tendencies. It follows that alcohol and soft drinks indices are also part of two separate, drink- specific measurement dimensions and can be affected differently by the training intervention.

In data collected so far, the four task indices resulted to be satisfactorily located on a common latent dimension measuring general approach/avoid tendencies. As expected, the four indices do not differentiate one to each other and all similarly measure approach/avoid tendencies toward stimuli presented in the task. When the four indices were split in pairs according to the targeted drink type, they also resulted to satisfy the monodimension requirement of Rasch models, thus suggesting that drink-specific measurement dimensions have their own "ontological status" and that different approach/avoid tendencies toward different objects can coexist. Domain-specific approach tendencies can be simultaneously considered in parallel.

According to the inherent properties of Rasch models, indices parameter estimates are sample-, condition-, and gender-free and can be checked for any differential functioning related to other independent variables. The four indices stood the test of time and did not show any significant differential functioning over the three time points. A further source of information on the measure structure came from the inspection of differences related to the use of active and passive stimuli in the task. Although not presenting any bias/interaction with facet Time, at post-intervention alcohol indices resulted to differ in the degree of approach/avoid responses they trigger according to stimulus context. Contrary to baseline, active alcohol pictures elicited stronger avoid responses. This difference disappeared at follow-up, when active and passive alcohol pictures similarly elicited approach/avoid responses. This difference could be due to the fact that the same task is used for assessment and training of approach tendencies, thus inducing a potential strong learning effect at post-intervention that could have inflated differences in automatic responses for some stimuli. This issue is also likely to impact on the sensitivity of the measure, since the absence of a main effect of Time but the presence of time-related differences possibly suggest the influence of practice effects on the ability of the measure to detect even subtle changes in approach/avoid tendencies after the experimental manipulation (post-intervention assessment takes place before the last training session).

From a measurement perspective the present study highlighted some of the possibilities that a Rasch model has to offer for diving into the structure of an irrelevant-feature, indirect measure such as this version of the AAT. Contrary to other probabilistic models, Rasch models are prescriptive in nature, which means that data need to fit the model requirements and not the opposite. To do so, AAT continuous scores needed to be transformed in discrete values at the price of flattening big portions of information. Scores were then discretized over distribution quintiles to preserve as much information as possible. When fitting data to the MFRM the main question was: do data fit the model adequately? Rasch models define measurement and misfitting data could suggest the presence of random or guessing values, noise, poor measures, or absence of enough variability, and so on. Fit indices indicated that AAT (discrete) data adhered sufficiently to the model requirements.

An innovative use of Rasch models in this context involved the reconceptualization of the Model (fixed) χ^2, which is normally used to reject the null hypothesis that all elements of a facet have the same logit in the population, in relation to the measurement error. Traditionally, the rejection of the null hypothesis is expected to support the hypothesis that an instrument is measuring diverse aspects of the to-be-measured construct. In this instance that was not desired. AAT trial formats are built in such a way that they should all measure approach/avoid tendencies in the same manner. The only thing that differs is the type of stimulus presented; yet it is not the salient categorization category. In other words, given the irrelevant-feature of the task, the four indices were expected to easily trigger similar approach/avoid responses, thus not creating measure-related biasing effects on participants' responses, such as the use of active and passive stimuli.

Task indices resulted to be pretty similar and stable over time, except for an effect of active and passive stimuli context on alcohol indices at post-intervention. This isolated effect should not refrain from the use of active and passive pictures, which are used to introduce variability within the task while keeping stimulus complexity minimal and to present as ecological pictures as possible. The difference between active and passive pics was not significantly present at baseline and the presence of the previously mentioned practice effect. To avoid any possible bias, it would probably be optimal to use different approach/avoid tasks for assessment and for training, such as the approach-avoid IAT (e.g., Wiers et al., 2010, 2011) or the Stimulus Response Compatibility task (although relevant-feature SRC and irrelevant-feature AAT appear to be unrelated; Wiers, Gladwin, & Rinck, 2013).

The MFRM model was here proposed as a formal model for the analysis of the AAT within an experimental context and provided an analytical strategy that could be beneficial to the validity of the AAT for several reasons: a) the model resolves the issue of metric arbitrariness (Blanton & Jaccard, 2006), since parameter estimates are centered by construction around a rational zero point (e.g., their mean); b) Infit and Outfit goodness-of-fit statistics not only allows to evaluate the comprehensive and general fit of data to the model as usually provided by internal consistency statistics, but also allows to examine the fit of each single index, participant, experimental condition, and any other facet element; c) Rasch-based individual measures of drink-specific approach/avoid tendencies are, by definition, independent from participants' gender and experimental condition; hence, beyond giving the possibility of comparing all parameter estimates on the same metric, they prevent the measure from being affected by potential confounds and could provide a potential alternative to traditional task scoring techniques; d) once the actual measurement validity of the measure is confirmed by the model, an additional MFRM feature is the computation of individual probabilities of presenting a certain approach/avoid bias score given all model facets, thus shifting the analytical focus from the group-level to the individual one (cf. Mannarini, 2009).

Yet, some more formal research has to be conducted to refine the application of the MFRM model to this kind of latency-based measures and, last but not least, Rasch models are one of the possible strategies to get a better representation of what is going on (e.g., Mannarini & Boffo, in press; Klauer, Voss, & Teige-Mocigemba, 2007; Zvielli, Bernstein, & Koster, in press).

CONCLUSION

It is a compelling enterprise, and somewhat premature, to draw definite conclusions about changing processes from the corpus of results obtained so far, for two main reasons: first, the explorative nature of the current study limits its generalizability to an all or nothing conclusion. The current group of participants is only a part of the targeted sample for the completion of the RCT, which is still on going. Also, only participants who fully completed the three assessment sessions were analyzed, thus disregarding information for those participants who dropped out from the study. Upon completion of data collection, the study protocol entails the handling of missing data points via multiple imputation (Boffo et al., 2014), which will allow the final test of research hypotheses. Results found so far should then be considered as a work-in-progress that may let the reader and the researcher foresee what is actually occurring and what possible directions and forms the final outcome can take.

NOTE

1. Original AAT used the joystick as response device but later keyboard versions of the task (including the zoom-feature) have also found an approach bias toward alcohol (Peeters et al., 2012, 2013).

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