The associations between interoceptive awareness, emotion regulation, acceptance, and well-being in patients receiving multicomponent treatment: a dynamic panel network model

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ABSTRACT

Mechanisms of change represent the cornerstone of the therapeutic process. This study aimed to investigate how network models could be used to test mechanisms of change at a group level. A secondary aim was to investigate which of the several hypothesized mechanisms (emotion regulation, interoceptive awareness, and acceptance) are related to changes in psychological well-being. The sample comprised adult patients suffering from psychological disorders (*N*=444; 70% women) from 7 clinical sites in the Czech Republic who were undergoing group-based multicomponent treatment composed mainly of psychodynamic psychotherapy (lasting from 4 to 12 weeks depending on the clinical site). Data were collected weekly using the multidimensional assessment of interoceptive awareness, emotion regulation skills questionnaire, chronic pain acceptance questionnaire-symptoms and outcome rating scale. A lag-1 longitudinal network model was employed for exploratory analysis of the panel data. The pruned final model demonstrated a satisfactory fit. Three networks were computed, *i.e.*, temporal, contemporaneous, and between-person networks. The most central node was the modification of negative emotions. Mechanisms that were positively associated with well-being included modification, readiness to confront negative emotions, activity engagement, and trust in bodily signals. Acceptance of negative emotions showed a negative association with well-being. Moreover, noticing bodily sensations, not worrying, and self-regulation contributed indirectly to changes in well-being. In conclusion, the use of network methodology to model panel data helped generate novel hypotheses for future research and practice; for instance, well-being could be actively contributing to other mechanisms, not just a passive outcome.

Key words: psychotherapy, well-being, emotion regulation, interoceptive awareness, acceptance.

Introduction

Well-being is understood to be a protective factor against recurrent psychopathological disorders (Keyes *et al.*, 2010; Lamers *et al.*, 2015). In this study, we define well-being broadly according to Wampold's (2013) contextual model. According to the contextual model of psychotherapy, an increase in overall quality of life is more meaningful than the reduction of a specific symptom, which is frequently the main outcome of interest in the medical model (Wampold, 2013). Therefore, well-being is defined as a

unitary construct related to the overall quality of life (including hedonic and eudaimonic well-being).

Recently, the research focus on psychotherapy interventions targeting well-being has moved from simple effectiveness tested with a pretest-posttest design toward a more complex investigation, assessing whether the intervention effects can be attributed to the influence of specific mechanisms of change (Falkenström *et al*., 2020; Hayes *et al*., 2007). Regardless of the therapeutic approach, interventions often induce change through several mechanisms. These mechanisms could be understood as transdiagnostic and transtheoretical (*cf*. the common factors perspective; Prochaska & DiClemente, 2005). Therapeutic interventions are often characterized as multicomponent treatment incorporating aspects of individual and group therapy, inspired by the integration of interventions from several therapeutic approaches and complementary treatment, such as art therapy or occupational therapy. Under common praxis conditions, the therapeutic work is often not manualized. Therefore, for pragmatic reasons, it is not useful to solely focus on mechanisms derived from only one specific therapeutic approach.

Interoceptive awareness is a transdiagnostic mechanism associated with well-being. When defined as part of mindfulness or measured as a self-reported appraisal of bodily sensations, interoceptive awareness had an overall positive association with well-being among general populations (Brani *et al*., 2014; Tihanyi *et al*., 2016) or collected *via* the MTurks platform (Amazon, USA) (Hanley *et al*., 2017). Usually, when defined as the pure perception of bodily sensations, such interoceptive awareness is maladaptive and does not behave differently from anxiety symptoms or somatization, which have been reported to be negatively related to well-being in adults with mindfulness therapy experience (Mehling *et al*., 2012), unrelated to well-being in the general population of university students (Pennanen, 2017), or inconclusively related to well-being in the general population of young adults (Ferentzi *et al*., 2019). Nearly all multidimensional assessment of interoceptive awareness (MAIA) subscales (excluding *not distracting*) were related to psychological well-being based on bivariate correlations with the small (body listening, noticing, attention regulation, emotional awareness) to moderate (not worrying, self-regulation, and trusting) effect sizes (Hanley *et al*., 2017). Moreover, a meta-analysis of mindfulness meditation programs (*e.g*., mindfulness-based stress reduction, mindfulness-based cognitive therapy, mindfulness meditation) by Goyal *et al*. (2014) identified mindfulness as a moderately large predictor of psychological distress reduction (*e.g*., anxiety, depression).

Several studies have examined the association of emotional regulation with well-being, as we will now discuss. Emotion regulation is a multidimensional construct that can be defined as a set of strategies useful to understand and adjust emotions (especially negative ones). After being noticed and appraised, an emotional response can be further modified using emotion regulation strategies (Gross & John, 2003). According to the adaptive coping with emotions model as embodied in the emotion regulation skills questionnaire [(ERSQ) Berking & Znoj, 2008], emotion regulation strategies could be explained as an increase in the ability to symbolize and express emotional experience manifesting at the bodily level divided into 9 strategies: emotional awareness, interpretation of bodily sensations, clarification, understanding of emotions, self-support in emotional distress, acceptance and tolerance of negative emotions that cannot be changed or modified, modification, and readiness to confront rather than avoid one's emotions.

There is also research supporting emotion regulation as an important mechanism in the reduction of psychological distress (Cisler & Olatunji, 2012; Joormann & Gotlib, 2010). Kraiss *et al*. (2020) conducted a meta-analysis of 35 cross-sectional studies focused on the association between emotion regulation strategies and mental well-being in patients with various diagnoses (*e.g*., over 30% of depressive, 20% of anxiety, 8% of personality disorder). The overall results suggested that various strategies had small to moderate effects on well-being. Additionally, when multiple positive emotion regulation strategies were employed together, they had a cumulative effect on the adult general population (Quoidbach *et al*., 2010). Reappraisal was positively related to well-being, whereas suppression was related negatively in the adult general population of university students (Gross & John, 2003). Reappraisal and refocusing on planning were positively associated with subjective and psychological well-being in a sample of 470 general population participants (Balzarotti *et al*., 2016). Overall, the results of Saxena *et al*. (2011) suggested that the lack of identification of emotions was the strongest predictor of reductions in subjective well-being in the adult general population. Furthermore, the lack of emotional clarification was the strongest predictor of reductions in positive affect. Finally, limited access to emotion regulation strategies was the strongest predictor of increases in negative affect and poor mental health.

Acceptance can be defined as "the active non-judgmental embracing of experience in the here and now" (Hayes, 2004, p. 656) or as psychological flexibility and a willingness to experience negative events or sensations, the opposite of avoidance, engagement in valued activities (McCracken *et al*., 2010; Mutch *et al*., 2021). Several studies have examined the association between acceptance and well-being. A meta-analysis supporting the effectiveness of acceptance as a predictor of reduced psychological distress in various psychological or somatic disorders (*e.g*. depression, anxiety, addiction, somatic health problems) was provided by A-Tjak *et al*. (2015). Acceptance is one of the mechanisms most closely associated with reduced interference of distress with daily life both immediately after intervention and after a follow-up period in various clinical populations, mainly patients suffering medically unexplained physical symptoms (Pourová *et al*., 2020). Acceptance was an important predictor of psychotherapeutic outcomes such as reduced psychological distress and increased general mental health in the population of adult psychotherapy clients dealing with work-site stress (Bond & Bunce, 2000; Flaxman & Bond, 2010). A study by Mutch *et al*. (2021) found a significant indirect effect in which acceptance mediated the association between mindfulness and well-being in 52 nonclinical participants undergoing an eight-week-long mindfulness-based stress reduction intervention. Moreover, the increases in acceptance and well-being were moderated by the baseline level of acceptance. A reverse direction of causality, with mindfulness mediating the association between acceptance and well-being, was not supported. Dan-Glauser and Gross (2015) showed that acceptance might even predict emotion regulation strategies in the sample of university students.

A study by Kotsou *et al*. (2018) assessed the unique contributions of emotional regulation, mindfulness, emotional competence, and acceptance to psychological well-being and distress (conceptualized as the standalone opposite of well-being) in the general population using a cross-sectional sample of 228 participants. The results of a series of regression analyses demonstrated that acceptance explained the variance in psychological distress and positive affect several times more than the other measured mechanisms of change. When discussing the limitations of their

study, Kotsou *et al*. (2018) called for confirmation of their results in longitudinal or randomized controlled studies and for data collection from clinical samples.

The present study is a secondary analysis (*i.e*., usage of the existing dataset to investigate a different research question than the previously published study) of inpatient or daily outpatient data collected in a naturalistic multisite study (Řiháček *et al.*, 2022). The majority of the previous research literature drafted conclusions based on the general population of adult participants using more conventional analytical methods. However, the present study brings original investigation serving as a pilot study of the exploratory use of longitudinal network analysis to reveal potential associations between selected multidimensional mechanisms of change (*i.e*., interoceptive awareness, emotion regulation strategies, and acceptance) and the outcome of psychological well-being in the clinical sample. In the current study, we hypothesized that increases in multidimensional mechanisms of change throughout therapy in adult patients suffering predominantly anxiety or depression disorders and receiving multicomponent treatment (predominantly group psychodynamic therapy, see the *Methods* section for other components) would be significantly associated with a subsequent increase in well-being. Based on the results of Kotsou *et al*. (2018), we hypothesize that acceptance will be the most central node in a network of mechanisms of change and will be most strongly connected to well-being (regardless of diagnosis). This premise is also supported by other research literature (Hayes *et al*., 2006; Kashdan *et al*., 2006).

Methods

Design, participants, and setting

The patients included in the sample were recruited by local staff from January 2018 to December 2019 at 7 clinical sites in the Czech Republic and participated in multicomponent treatment whose main component was group psychodynamic therapy, supplemented by art, music, occupational therapy, physiotherapy, relaxations, and community meetings (depending on the site). Informed consent was collected from all participants. Both the original data collection and the secondary analysis of the data were approved by the Research Ethics Committee of Masaryk University (ref. no. EKV-2017-029-R1 and EKV-2020-122). The intervention was either an inpatient program (at four sites) or a daily outpatient program (three sites). Patients attended 90-minute (75-minute at one site) therapeutic sessions 3 to 5 times a week. The median length of the program across the sites was 6 weeks (ranging from 4 to 12 weeks depending on the site). The therapeutic groups were open and fluid (*i.e*., consisted of patients at the beginning of their intervention as well as patients at the end of their intervention simultaneously). The therapists (N=25; 64% women; mean $(M)_{age}$=44.13; standard deviation $(SD)_{age}$=10.29; range, 25 to 59 years old) had different levels of experience (length of practice from 1 to 25 years, M=12.21; SD=7.30) and had psychoanalytic (N=9), psychodynamic (N=6), gestalt (N=4), person-centered (N=3), integrative (N=2), and daseinsanalysis (N=1) theoretical orientations.

A total of 444 patients were included at baseline. The instruments were administered in group paper-pencil form, and instructions for the questionnaires covered the period of one previous week within the psychotherapy. The measurement was conducted every week during the treatment, starting at baseline and ending after the treatment was complete. Unfortunately, the treatment length was not constant across clinical sites. Although several cases were assessed up to week 12, this study only included data collected from baseline to week 7 of treatment. Data from weeks 9 to 12 were omitted because the sample size dropped under 100 cases (power issues). Furthermore, data from week 8 were omitted because the selected confirmatory factor solution of the ERSQ measure demonstrated collinearity issues and a non-positively definite matrix in this week.

Instruments

Internal consistency of all extracted factors across all 4 questionnaires and all measurement waves was estimated using McDonald´s ω total and ω hierarchical coefficients (McDonald, 1999), and is reported in *Supplement A* together with details regarding factorial validity (*e.g*., specifications of confirmatory factor analyses, model fit).

Multidimensional assessment of interoceptive awareness

The MAIA (Mehling *et al*., 2012) contains 32 items scored on a 6-point Likert scale from 0 (strongly disagree) to 5 (strongly agree). Items 5, 6, 7, 8, and 9 are reverse-coded. The MAIA is divided into 8 subscales (4 items per subscale): noticing, not distracting, not worrying, attention regulation, emotional awareness, self-regulation, body listening, and trusting. MAIA was validated in the Czech sample using confirmatory factor analysis (CFA) to confirm the original 8-dimensional structure with an allowed residual correlation between items 13 and 14 (Klocek *et al.*, n.d.).

Emotion regulation skills questionnaire

The ERSQ (Berking & Znoj, 2008) is composed of 27 items rated on a 5-point Likert scale from 0 (not at all) to 4 (almost always). The original scale consists of 9 domains representing various emotion regulation strategies. The ERSQ was validated in the Czech sample using CFA. ERSQ measures 7 distinct emotion regulation skills after 2 were consolidated with other strategies: emotional awareness (perception in general), interpretation of bodily sensations, understanding merged with clarification of emotions, self-support (self-encouragement in emotional distress), acceptance merged with tolerance of negative emotions that cannot be changed or modified, modification of negative emotions, and readiness to confront negative emotions (*i.e*., the opposite of avoidance). Moreover, in the Czech version, item 23 was omitted (as suggested by the validation study of Klocek *et al*. (2022) for being deviated from the other items measuring the same subdomain and increasing the model fit, respectively).

Chronic pain acceptance questionnaire-symptoms

The chronic pain acceptance questionnaire-symptoms [(CPAQ-S) Klocek *et al*., 2023]. The 20 items of the CPAQ-S are scored on a 7-point Likert scale from 0 (never true) to 6 (always true). The scale is based on the CPAQ. All items were reworded to *my difficulties* instead of *pain* to measure symptoms in general. The scale is most often treated as 2-dimensional, with the activity engagement and symptom willingness subscales (McCracken *et al*., 2010; Vowles & McCracken, 2008). All symptom willingness items are reverse coded. In this study, we used a brief form of the CPAQ-S-8, consisting of 4 items on the activity engagement subscale and 4 items on the symptom willingness subscale (Klocek *et al.*, 2023).

Outcome rating scale

The outcome rating scale [(ORS) Miller *et al*., 2003]. The ORS is a measure of subjective well-being. This scale consists of 4 10-cm-long visual analog scales. Patients were instructed to place a mark on a corresponding line, with low estimates to the left and high to the right. The Czech validation study confirmed the good psychometric properties and unidimensional nature of the instrument (Juhová *et al*., 2021).

Data analysis

R version 4.0.3 (R Core team, 2020) was used to conduct statistical analyses. The anonymized open data were made available through the Open Science Framework (Řiháček, 2019).

A dynamic lag-1 latent variable model for panel data [dlvm1, psychometrics package, version 0.7.2; (Epskamp *et al*., 2020)] was estimated to investigate unique associations between mechanisms and well-being during therapy. The model can be also defined as a multi-level graphical vector-autoregression model with random effects on the mean structure (Epskamp, 2020). The model consisted of 13 nodes measured across 7 measurement time points. The differing intervention duration between clinical sites has not been controlled. The nlminb optimizer was used and missing values were handled using the full information maximum likelihood estimator. Given the overall number of items (70), we could not input individual items in the network model. Instead, it was necessary to use factor scores as nodes to reduce the number of estimated parameters. Factor scores were extracted based on a series of CFAs (the procedure has been described in Klocek *et al.*, 2022, Klocek *et al.*, 2023, Klocek *et al.*, n.d.). Information on the CFAs, internal consistencies of the factor scores at each measurement timepoint, and reasoning related to the selection of nodes into the network are reported in *Supplement A*. Eventually, 13 nodes were selected: MAIA (not worrying, trusting, self-regulation, emotional awareness, body listening, attention regulation, and noticing), ERSQ (modification, acceptance/tolerance, readiness for confrontation, and bodily sensations), CPAQ-S-8 (activity engagement), and ORS (well-being).

The factor scores were detrended (*i.e*., all factor scores were centered at 0) before the network analysis. After identifying a saturated model using a Cholesky decomposition (Krishnamoorthy & Menon, 2013), we pruned all nonsignificant edges (α=.01) from the model. The fit of the model was interpreted using the same criteria as for CFA (*Supplement A*). Additionally, the saturated model and the pruned model were compared to determine whether the potential decrease in fit was still acceptable. The panel dlvm1 model was used to separate within- and between-person variances into 3 matrices representing different types of associations among nodes. Each matrix was visually displayed in a separate graph.

Firstly, the temporal matrix included both vector autoregressive effects [(VAR) van der Krieke *et al*., 2015) and cross-lagged effects using a prediction-based approach and partial weighted directed correlations (Epskamp, 2020), representing prediction over time (Selig & Little, 2012). The directed temporal network can contain 3 types of nodes: source nodes (predictors of other nodes), transitional nodes (nodes that are predictors of some nodes but are predicted by other nodes), and sink nodes (predicted by other nodes).

Secondly, the contemporaneous matrix incorporated the residuals of the VAR model. Effects could be interpreted as associations remaining among nodes in the average patient after controlling for all temporal effects from the previous measurement time and all associations with other nodes at the current measurement time (Epskamp *et al*., 2018). The colorblind theme was used to color the associations – blue edges represent positive and red edges negative partial correlations.

Lastly, the between-person matrix included individual difference effects (mean structure across patients) at the average measurement time after controlling for all other nodes in the network. The 90% confidence intervals of the edge weights are reported in *Supplement B*. Additionally, the out-degree (edge strength), closeness, and betweenness centrality indices for all 3 networks (the temporal, contemporaneous, and between-person networks) were computed.

The rationale for the usage of panel longitudinal network computed among factor scores might be i) to reveal unique associations between a larger number of variables (mechanisms and outcomes) together in a single model (complexity of all items is reduced to theoretically driven and empirically fitting latent factors); ii) to handle reliability by incorporating only reliable factor scores into the network model: if the network input was based on items, the reliability of such indicators is completely unknown; iii) to explore the temporal relations and suggest new mediation hypotheses or potential causal pathways to inform future conceptual models; iv) to explore the contemporaneous relations and suggest which variables might play a significant role (regarding exploration aim) even though their influence was not detected in the temporal network; v) to explore the between-subject relations and suggest new moderation hypotheses to inform future conceptual models; vi) to reduce the complexity of change in time (dynamic change is divided into 3 layers) and to provide understandable interpretation framework separating within- and between-subject effects.

Results

Descriptive statistics

The demographic variables of the overall sample are reported in Table 1. The total sample included 444 patients (72.75% women), aged from 18 to 74 years (M=39.24, SD=11.18). The most common psychiatric diagnoses, as specified according to international classification of diseases-10 (World Health Organization, 2004), included neurotic, stress-related, and somatoform (F4x; *N*=312), mood (F3x, affective; *N*=84), personality and behavior disorders (F6x; *N*=68), behavioral syndromes associated with physiological disturbances (F5x; *N*=9), and disorders related to the substance abuse (F1x; *N*=8). Some patients received multiple diagnoses (*N*=41), which included combinations of F4x and F6x (*N*=18), F3x and F4x (*N*=12), and F3x and F6x (*N*=10).

Network models

In this study, there were 13 variables and they were followed for a maximum of 7 weeks. The fit of the saturated model was good to excellent: $\chi^2(3913)=7465.36$, p<.001, Tucker–Lewis index (TLI)=.905, comparative fit index (CFI)=.909, root mean square error of approximation (RMSEA)=.045 (.044; .047), Akaike information criterion (AIC)=46529.91, Bayesian information criterion (BIC)=48020.79. The model triggered an error message according to which there was at least one non-positive definite matrix. This error message may have occurred because of the small sample size (power issues) relative to the number of parameters being measured. After nonsignificant edges were

pruned, the fit of the model was slightly reduced: $\chi^2(4148)=8273.02$, p<.001, TLI=.895, CFI=.894, RMSEA=.047 [.046; .049], AIC=46867.57, BIC=47395.93. The model was identified and converged normally, probably because it was more parsimonious (235 parameters were cleared). Although the saturated model was significantly better than the pruned model, $\chi^2(235)=807.66$, p<.0001, we decided to use the pruned model as the final model because it converged successfully without any non-positive definite matrix, it was more parsimonious, and its fit was still satisfactory.

Table 1. Demographic variables.

Variable	Categories (N; %)
Gender	Male (323; 24.55) Female (109; 72.75) Missing data (12; 2.70)
Education	Primary school (20; 4.50) Secondary school, incomplete (70; 15.77) Secondary school, complete (156; 35.14) Higher technical education (22; 4.95) University (161; 36.26) Missing data (15; 3.39)
Marital status	Single (218; 49.10) Married or in a civil partnership (131; 29.50) Divorced (78; 17.57) Widowed (3; 0.68) Missing data (14; 3.15)
Nationality	Czech (414; 93.24) Slovak (8; 1.80) Other (8; 1.80) Missing data (14; 3.15)
Occupation	Employee (184; 41.44) Entrepreneur (30; 6.76) Unemployed (66; 14.86) Maternity leave (8; 1.80) Student (28; 6.31) Retirement (6; 1.35) Disability pension (39; 8.78) Other (25; 5.63) Missing data (58; 13.06)
Household	In partnership (212; 47.75) Single (89; 20.05) With parents (52; 11.71) Other (78; 17.57) Missing data (13; 2.93)

The temporal network (Table 2 and Figure 1A) showed that all nodes (except the ERSQ subscale for acceptance of negative emotions) were uniquely and positively correlated with themselves (VAR), with coefficients ranging from β=.073 (body listening) to β=.257 (not worrying). Well-being was autocorrelated from week to week (β=.245) as well. The cross-lagged effects were relatively sparse after the nonsignificant edges were pruned, and the effect sizes were generally small, ranging from β=.023 to β=.160. Modification of negative emotions was the most central node in the network regarding edge strength and the second most central node regarding betweenness (Table 3 and *Supplement C*). A feedback loop emerged between modification and self-regulation (the node with the highest betweenness centrality), which formed the basis for a positive feedback loop increasing well-being. The loop was as follows self-regulation, modification, well-being, not worrying, and back to self-regulation. When self-regulation led to an increase in attention regulation, such a cycle did not emerge. There were only a few direct predictors of well-being (based on the average patient in the previous week). Modification of negative emotions (β=.094) and readiness to confront negative emotions (β=.045) positively predicted well-being. On the other hand, acceptance of negative emotions predicted well-being negatively (β=-.077).

The contemporaneous network (Table 4 and Figure 1B) shows associations remaining in the residuals after all temporal associations were controlled for. Only 2 nodes were directly associated with well-being in the contemporaneous network: modification of negative emotions (r=.159) and activity engagement (r=.163). Generally, nodes tended to form clusters corresponding to the superordinate constructs (*i.e.*, emotional regulation and interoceptive awareness) with small to medium associations within the clusters and rather small associations between clusters. Mod-

Table 2. Network of temporal associations. The values represent standardized directed and weighted partial correlation coefficients with lag-1. Rows are predictors, columns are outcomes, and the values on the diagonal represent vector autoregressions.

	CPAQ-S 1	ERSQ 1	ERSQ 2	ERSQ 3	ERSQ 4	MAIA 1	MAIA 2	MAIA 3	MAIA 4	MAIA 5	MAIA 6	MAIA 7	ORS
CPAQ-S 1: activity engagement	.191	0	0	0	0	0	0	0	0	0	0	0	0
ERSQ 1: bodily sensations	0	.247	0	0	0	.094	0	0	.072	0	.092	0	0
ERSQ 2: acceptance	0	0	0	0	0	0	0	0	0	0	0	0	-.077
ERSQ 3: modification	.071	0	.160	.155	0	0	0	.046	0	.034	.044	0	.094
ERSQ 4: confrontation	0	0	0	0	.220	0	0	0	0	0	0	0	.045
MAIA 1: noticing	0	0	0	0	0	.227	0	0	.087	.043	.068	0	0
MAIA 2: not worrying	0	0	0	0	0	0	.257	0	0	.031	0	0	0
MAIA 3: attention regulation	0	0	0	0	0	0	0	.155	0	0	0	0	0
MAIA 4: emotional awareness	0	0	0	0	0	0	-.034	0	.142	0	0	0	0
MAIA 5: self-regulation	0	0	0	.024	0	0	0	.037	0	.127	0	0	0
MAIA 6: body listening	0	0	0	0	0	0	0	0	0	0	.073	0	0
MAIA 7: trusting	0	0	0	0	0	0	0	0	0	0	0	.170	0
ORS: wellbeing	0	0	0	0	0	0	.075	0	0	0	0	0	.245

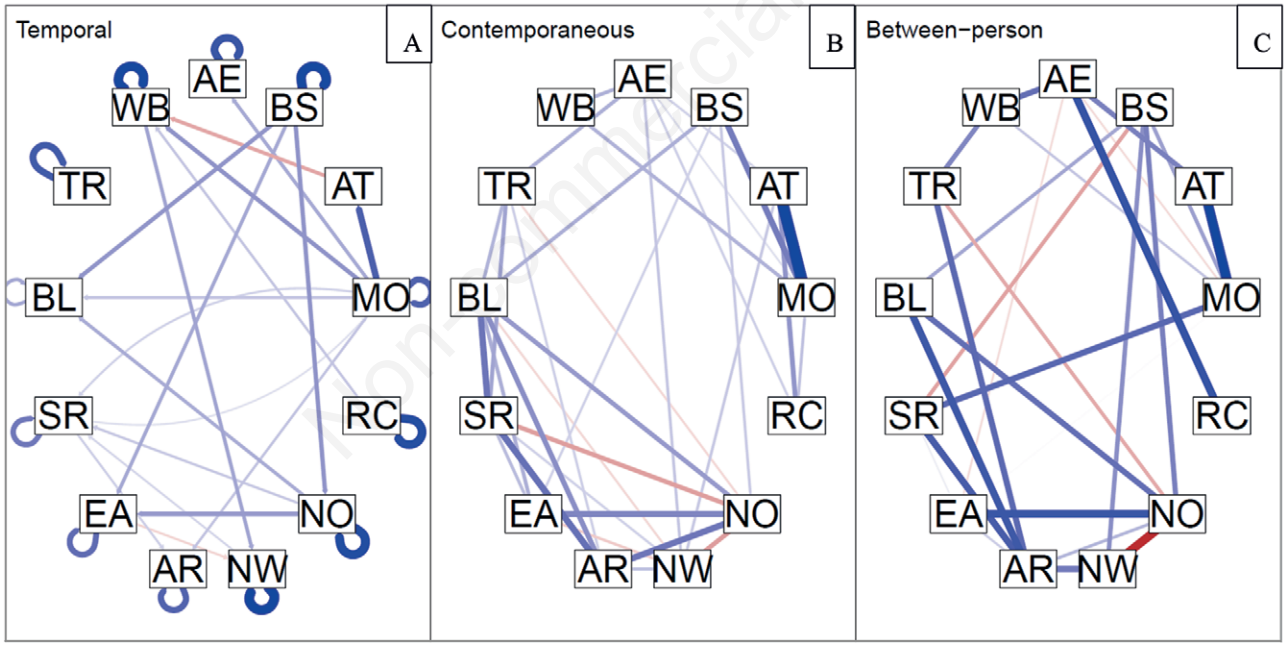
CPAQ-S, chronic pain acceptance questionnaire-symptoms; ERSQ, emotion regulation skills questionnaire; MAIA, multidimensional assessment of interoceptive awareness; ORS, outcome rating scale.

ification remained associated with well-being even after the temporal effects were removed and remained central in the contemporaneous network, especially regarding betweenness. Acceptance/tolerance lost its connection to well-being but was strongly associated with modification. Interestingly, noticing bodily sensations had the largest number of associations with other nodes (N=7) and the highest strength centrality (Table 4 or *Supplement C*). Surprisingly, noticing was negatively associated with

Table 3. Centrality indices for temporal, contemporaneous, and between-person networks.

Network	Centrality	CPAQ-S 1	ERSQ 1	ERSQ 2	ERSQ 3	ERSQ 4	MAIA 1	MAIA 2	MAIA 3	MAIA 4	MAIA 5	MAIA 6	MAIA 7	ORS
Temporal	Out-degree (edge strength)	.000	.258	.077	*.448*	.045	.198	.031	.000	.034	.060	.000	.000	.075
	Closeness	0	0	0	0	0	0	0	0	0	0	0	0	0
	Betweenness	0	0	0	27	0	6	24	0	2	*36*	0	0	15
Contemporaneous	Out-degree (edge strength)	.676	.676	1.090	1.312	.448	*1.469*	.847	1.151	.783	1.318	1.383	.684	.323
	Closeness	.0072	.0087	.0080	.0084	.0061	.0087	.0081	.0082	.0070	.0088	*.0099*	.0073	.0062
	Betweenness	8	38	22	*40*	0	14	8	0	0	8	26	8	4
Between-person	Out-degree (edge strength)	1.312	1.176	.973	1.452	.506	*2.076*	1.161	1.851	.691	1.066	1.012	.856	.761
	Closeness	.0107	.0122	.0122	.0135	.0087	.0127	.0122	*.0150*	.0097	.0142	.0129	.0135	.0113
	Betweenness	26	8	14	24	0	28	10	*40*	0	16	0	34	24

Values in italics represents the node with the highest centrality in its network; the out-degree edge strength centrality was divided by the number of nodes in the network, changing the meaning from the sum of edge strength to the mean. CPAQ-S, chronic pain acceptance questionnaire-symptoms; ERSQ, emotion regulation skills questionnaire; MAIA, multidimensional assessment of interoceptive awareness; ORS, outcome rating scale. CPAQ-S 1, activity engagement; ERSQ 1, bodily sensations; ERSQ 2, acceptance or tolerance of negative emotions; ERSQ 3, modification; ERSQ 4, readiness to confront negative emotions; MAIA 1, noticing; MAIA 2, not worrying; MAIA 3, attention regulation; MAIA 4, emotional awareness; MAIA 5, self-regulation; MAIA 6, body listening; MAIA 7, trusting; ORS, wellbeing.



AE, activity engagement (chronic pain acceptance questionnaire-symptoms); AT, acceptance or tolerance of negative emotions (emotion regulation skills questionnaire); AR, attention regulation (multidimensional assessment of interoceptive awareness); BL, body listening (multidimensional assessment of interoceptive awareness); BS, bodily sensations (emotion regulation skills questionnaire); EA, emotional awareness (multidimensional assessment of interoceptive awareness); MO, modification (emotion regulation skills questionnaire); NO, noticing (multidimensional assessment of interoceptive awareness); NW, not worrying (multidimensional assessment of interoceptive awareness); RC, readiness to confront negative emotions (emotion regulation skills questionnaire); SR, self-regulation (multidimensional assessment of interoceptive awareness); TR, trusting (multidimensional assessment of interoceptive awareness); WB, well-being (outcome rating scale).

Figure 1. Graphical depiction of temporal, contemporaneous, and between-person networks of associations (using shared layers). Blue lines represent significant positive partial correlations; red lines represent significant negative partial correlations; the thickness of each line represents edge strength. The spatial positions of the nodes in the network diagrams are arbitrary – the circle layout was used. In the temporal network, the lines are directed. The significance level was set to α=.01.

self-regulation in the contemporaneous network, whereas the relationship was positive in the temporal network.

The between-person network (Table 3 and Figure 1C) showed between-person effects of the average measurement timepoint across patients. Generally, greater well-being was reported by patients with higher activity engagement (r=.359), trust in bodily sensations (r=.286), and modification of negative emotions (r=.115). Other nodes were unrelated to well-being. Again, noticing was the node with the highest edge strength centrality (Table 4 and *Supplement C*). Attention regulation was an important glue in the between-person network, having the greatest closeness and betweenness centrality. Moreover, the whole between-person network structure tended to be divided into two clusters: i) interoceptive awareness; ii) emotional regulation, symptom acceptance (only activity engagement), and well-being (ORS).

Discussion

This study was a secondary analysis of a multisite naturalistic project incorporating data from patients undergoing multicomponent treatment with dynamic psychotherapy as the main component. This study was also a pilot study testing the possible usage of longitudinal network analysis on panel data to gain insight into associations between several mechanisms of change and the outcome of well-being.

The primary analyses (Řiháček *et al*., 2022) were performed by computing weekly incremental changes in mechanisms and outcomes using a series of regressions only in the subsample of patients suffering medically unexplained symptoms, as dictated by the registered project's aim. The differences between this study and the primary analyses conducted by Řiháček *et al*. (2022) were as follows: i) this study included more detail by using subscales of selected measures; ii) it used the entire sample, not only patients with medically unexplained conditions; iii) it used a different statistical approach to data analysis. The primary analysis results did not provide any evidence that the selected mechanisms of change influenced either the somatic burden or well-being. However, all questionnaires were treated as being unidimensional in the primary analysis (except for CPAQ-S). Thus, this secondary analysis exploratively revealed significant relationships between selected mechanisms of change and outcomes when the multidimensional nature of individual mechanisms was considered.

Within-person effects

Our results suggest that several variables in the network could be causally related to well-being. Modification, readiness for confrontation, and activity engagement predicted well-being positively, while acceptance/tolerance of negative emotions predicted well-being negatively. However, the effect sizes of all directed or undirected predictors (temporal or contemporaneous networks) were too small to establish any strong conclusions.

The temporal network was used to investigate the potential causal pathways between nodes from previous measurement occasions. In the whole temporal network, 10 potential causal pathways could be identified. The causal pathways were identified based on a combination of the Pearl (2009) and Granger (1969) causality approaches. 9 pathways began with the interpretation of bodily sensations as emotions (the ERSQ bodily sensations subscale). The remaining one began with readiness to confront negative emotions. In 7 pathways, the bodily sensations were followed by noticing, which, together with bodily sensations, represented perceptual mechanisms connected to bodily awareness. Their position at the beginning of causal pathways is logical, given that perception of such stimuli should precede any further regulatory activities. The effect of noticing on well-being was found inconclusive (Ferentzi *et al*., 2019) or non-existent (Pennanen, 2017). However, our results suggest that the effect of the combination of bodily sensations and noticing on well-being might be crucial but act indirectly by subsequently activating other relevant nodes in the network.

Four of the pathways ended at attention regulation (all of the passing through self-regulation), 3 ended at body listening, 2 ended at emotional awareness, and 1 ended at activity engagement (being considered sink nodes). Although, conceptually, well-being should represent an outcome in the network (*i.e.*, a sink node), it acted as another change mechanism in the network, predicting a

Table 4. Network of contemporaneous (lower triangle) and between-person (upper triangle) associations. Values below the main diagonal represent contemporaneous effects; values above the main diagonal represent between-person effects.

	CPAQ-S 1	ERSQ 1	ERSQ 2	ERSQ 3	ERSQ 4	MAIA 1	MAIA 2	MAIA 3	MAIA 4	MAIA 5	MAIA 6	MAIA 7	ORS
CPAQ-S 1: activity engagement	0	0	.305	-.070	.506	0	0	0	-.071	0	0	0	.359
ERSQ 1: bodily sensations	0	0	0	.210	0	.306	.258	0	0	-.212	.190	0	0
ERSQ 2: acceptance	.084	0	0	.669	0	0	0	0	0	0	0	0	0
ERSQ 3: modification	.058	.313	.661	0	0	0	0	0	.004	.384	0	0	.115
ERSQ 4: confrontation	.090	0	.236	.122	0	0	0	0	0	0	0	0	0
MAIA 1: noticing	0	.106	0	0	0	0	-.580	.155	.484	0	.357	-.194	0
MAIA 2: not worrying	.114	0	.110	0	0	-.225	0	.322	0	0	0	0	0
MAIA 3: attention regulation	0	0	0	0	0	.332	.124	0	.097	.436	.464	.376	0
MAIA 4: emotional awareness	0	.089	0	0	0	.284	-.108	0	0	.035	0	0	0
MAIA 5: self-regulation	0	0	0	0	0	-.221	.088	.347	.134	0	0	0	0
MAIA 6: body listening	0	.168	0	0	0	.224	-.078	.256	.168	.335	0	0	0
MAIA 7: trusting	.166	0	0	0	0	-.077	0	.093	0	.193	.155	0	.286
ORS: wellbeing	.163	0	0	.159	0	0	0	0	0	0	0	0	0

CPAQ-S, chronic pain acceptance questionnaire-symptoms; ERSQ, emotion regulation skills questionnaire; MAIA, multidimensional assessment of interoceptive awareness; ORS, outcome rating scale.

lack of worry. The association between this lack of worry (*i.e.*, the opposite of negative rumination) and well-being was repeatedly shown in the previous literature (Hanley *et al*., 2017; Kraiss *et al*., 2020; Quoidbach *et al*., 2010). However, it seems that the potential causal effect could be in the opposite direction, with catastrophizing and worrying being reduced after patients experience an improved subjective quality of life and general positive affectivity. Thus, a simplifying categorization of variables into mechanisms and outcomes does not seem to correspond to the real-world complexity of relationships among the variables.

Self-regulation was connected to well-being in the literature (Durand-Bush *et al*., 2015; Hanley *et al*., 2017). However, based on our findings, its contribution to well-being might be more indirect. Owing to the feedback loop between self-regulation and modification, a well-being cycle emerged. Increased well-being in one week predicted an increase in not worrying in the following week, which further positively predicted self-regulation. Self-regulation then positively influenced well-being through modification. However, when modification further influenced well-being indirectly through acceptance/tolerance of negative emotions instead of executing a direct influence, the well-being cycle resulted in a continually decreased well-being. We did not find support for this finding in the literature. The only support close to the negative association was found in a study by Balzarotti *et al*. (2016) where acceptance of emotions was not associated with well-being at all.

The direct positive predictors of well-being, namely modification, and readiness to confront negative emotions, were related to emotion reappraisal. This is in line with previous research, in which cognitive reappraisal was recognized as a significant positive predictor of well-being (Balzarotti *et al*., 2016; Gross & John, 2003; Kraiss *et al*., 2020). Since all 3 direct predictors were emotion regulation strategies, emotion regulation seems to be more important than interoceptive awareness or activity engagement acceptance in increasing well-being during therapy. Moreover, the emotional regulation strategies are not interchangeable, since each of them seems to have a different effect on the whole network.

The contemporaneous network was utilized to investigate the remaining associations between selected nodes in a single measurement occasion after the omission of temporal associations. In the contemporaneous network, we identified an additional mechanism potentially relevant to changes in well-being over time in psychotherapy – activity engagement. Activity engagement may be an effective acceptance strategy to increase well-being. Interestingly, in contrast with the negative temporal effect of accepting negative emotions, the behavioral acceptance that leads to engagement in valued life activities may produce desired effects. However, the association between activity engagement and well-being may only be present during, and not after, therapy (Wersebe *et al*., 2018). Engaging in activities as if the symptoms were not present may influence well-being differently than other directly related mechanisms in the temporal network. It might be too difficult for patients who are already below a certain threshold level of well-being, and a certain level of psychological well-being may be necessary before acceptance can be used as a therapeutic strategy (Trompetter *et al*., 2016). Since the contemporaneous network shows only undirected edges, it might be plausible that the direction of causal influence is reversed and that well-being predicts activity engagement. Possibly, we need to measure the mechanism of activity engagement in different time windows to capture the effects within the temporal network. Furthermore, even though the centrality indices should be interpreted with caution given their potential instability, acceptance (*i.e.*, activity engagement) was not the most central node in any of the networks contrary to expectations. It seems modification of negative emotions, noticing of bodily signals, or attention regulation nodes are more interconnected with the rest of the temporal, contemporaneous, and between-person networks, respectively.

Between-person effects

The between-person network was utilized to investigate the more general averaged relationships between nodes regardless of within-person dynamics. In the between-person network, modification and activity engagement remained associated with well-being. Patients who generally engage in their activities regardless of the presence of symptoms and who generally use a modification of their negative emotions strategy (*e.g.*, the ability to directly cause pleasant feelings) also tend to perceive higher well-being. There may have been 2 different groups of patients in our sample who reported higher well-being: i) those who were able to modify their negative emotions more than others; ii) those who engaged in life activities more extensively than others. Given the negative association between modification and activity engagement, these two groups of patients appear to be mutually exclusive.

Limitations and recommendations for future research

First of all, the sample size in this study may have been too small for the estimation of a network with 13 nodes given the potential of non-positively defined matrices of the saturated not pruned model. Future studies should collect larger clinical samples and compute power analysis before the data collection. The sample was also predominantly female and the findings may thus not generalize equally well to male patients. Also, future studies should confirm the results in less heterogeneous clinical populations, *e.g.* by replicating the analyses in patients suffering from mood disorders solely.

Secondly, the network was computed on previously stored factor scores, not items. This procedure might result in biased estimates, similar to the situation when a common effect is included in the model (Berkson's bias), which could cause errors such as the misidentification of positive edges as negative edges (Epskamp & Fried, 2018). However, if the estimation was performed on the item level, we would have no information about the reliability of such indicators, which might diminish the validity of the presented edges. Either way, edges should be interpreted cautiously. Given the insufficient sample size, a large number of variables, and lack of *a priori* hypotheses, these analyses should be interpreted as purely exploratory. Their main advantage is hypothesis generation for future confirmations.

Lastly, the saturated model was a non-positive definite model, and the pruned model had a significantly worse fit than the saturated one. After pruning, several fit indices were reduced below the threshold of satisfactory fit (Hu & Bentler, 1999). The stability of the model parameters was assessed using confidence intervals based on standard errors in the present dataset. Future studies should perform non-parametric bootstrapping to investigate model stability.

Conclusions

This study answered the call from Kotsou *et al*. (2018) to cross-validate their results concerning the unique contributions of several mechanisms of change to well-being outcomes in

longitudinal and clinical contexts. Our findings highlight the importance of emotion regulation strategies (in particular, modification of negative emotions) for an increase in well-being in multicomponent treatment. In contrast to the findings of Kotsou *et al*. (2018), modification and emotion regulation, in general, were more important mechanisms than acceptance in increasing well-being. The hypothesis that acceptance is the most important node in the network is not consistent with our findings. Nevertheless, acceptance was an important and unique contributor to well-being. This study shows that recognized psychotherapeutic mechanisms of change can be successfully represented as a network. A pilot analysis using longitudinal network methodology resulted in the generation of several solid hypotheses to be tested in future studies. The results of our analysis suggested that the interplay among mechanisms of change and well-being might be more complex. Well-being does not seem to be the ultimate effect of the mechanisms of change, and the associations could be bidirectional, with well-being as an active component of the network. This study suggests that well-being is an actively contributing variable in the network, rather than a passive outcome. This challenges the traditional categorization of variables into either outcomes or mechanisms in psychotherapy.

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Online supplementary material:

Supplement A: Information regarding CFAs, internal consistency, and node selection.

Supplement B. Confidence intervals of edge weights in contemporaneous and between-subjects networks.

Supplement C. Centrality figures for temporal, contemporaneous, and between-subjects networks.