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Abstract

Objective: There is strong empirical evidence that a reduction of trauma cognitions lessens PTSD symptoms, but there are discrepancies, including evidence that baseline negative post-trauma cognitions are associated with more, less, or are not associated with changes in PTSD symptoms. Discrepancies may be a function of power, sample size, analytic method, or measure.

Methods: The rate of PTSD symptoms change across 16 trauma-focused treatment sessions in a community clinic (*n*=56) was estimated using a Bayesian mixed-effects model with repeated measures nested within participants. Number of treatment sessions was the level-1 predictor variable with baseline levels of trauma-related cognitions (overaccommodation, assimilation, accommodation, and optimism) as time-invariant level-2 predictors. The relations between baseline trauma-related cognitions and PTSD symptoms change across sessions were assessed by cross-level interactions.

Results: PTSD symptoms declined over treatment (b=-1.57, 95% CrI [-1.89, -1.25]). Higher levels of overaccommodation and assimilation were associated with attenuated (b=0.38, 95% CrI [0.03, 0.73]) and greater (b=-0.36, 95% CrI [-0.69, -0.02]) rates of symptom reduction, respectively. The relations between PTSD symptom reduction and accommodation (b=-0.12, 95% CrI [-0.43, 0.20]) and optimism (b=-0.13, 95% CrI [-0.45, 0.20]) were uncertain.

Conclusions: There may be a nuanced role of trauma-related cognitions on PTSD symptoms during treatment. More research is needed to examine theoretically grounded trauma-related cognitions that align with the different treatments for PTSD, particularly in reference to the current diagnostic criteria for PTSD.

Keywords: Bayesian inference, post-trauma cognitions, PTSD treatment

Clinical Impact Statement

We examined the rate of change in PTSD symptoms through a course of time-limited trauma-focused therapy as a function of baseline trauma-related cognitions in a diverse sample presenting to a community mental health clinic soon after criminal victimization. On average, there was a clinically meaningful decrease in PTSD symptoms from baseline to midway, and midway to final session. Higher overaccommodated and assimilated cognitions were associated with less and more symptom reduction, respectively. While the most probable direction of effects were negative, given the current data, there is still uncertainty with regards to accommodated post-trauma cognitions, optimism, and their association with PTSD symptom change in therapy.

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Negative post-trauma cognitions are central in several conceptual models of the development, maintenance, and recovery of Posttraumatic Stress Disorder (PTSD) (Ehlers & Clark, 2000, Foa et al., 2007; Resick & Schnicke, 1992). For example, in social cognitive theories of trauma, three cognitive processes have been implicated in the development and maintenance of PTSD (i.e., overaccommodated and assimilated cognitions), as well as recovery (i.e., accommodated cognitions; Resick & Schnicke, 1992). Further, in a recent review of the literature, positive expectancies like self-efficacy, hope, and optimism were associated with lower levels of PTSD symptoms cross-sectionally and prospectively (Gallagher et al., 2020).

Overaccommodation involves altering post-trauma cognitions to the extreme to feel safe and in control (e.g., "I can't trust anyone"). Assimilation involves altering new information post-trauma to maintain and reinforce pre-existing cognitions (e.g., "It is my fault this happened"). Overaccommodation and assimilation can contribute to ruminative responses that create a sense of current threat and maintain negative emotions and maladaptive behaviors, and reduce the likelihood for corrective experiences that challenge these cognitive distortions. Conversely, accommodation is a balanced alteration of cognitions to incorporate new information post-trauma (e.g., "Some people are dangerous, but not everyone"); it represents realistic thinking that allows for acceptance of the trauma and reduces the likelihood of maladaptive behaviors to cope. Positive expectancies have been conceptualized as cognitive traits that facilitate positive coping and adaptive responses to obstacles, and therefore, can promote resilience in response to traumatic events.

There is an established literature base demonstrating strong empirical support for the role of post-trauma cognitions in posttraumatic stress. A recent review of 65 PTSD treatment studies that included measures of both post-trauma cognitions and posttraumatic stress found mostly strong evidence for concurrent reductions in negative cognitions and PTSD symptoms across controlled and uncontrolled trials, treatment types, cognition measures, and samples (Brown et al., 2019). Specifically, 23 compared to 11 studies showed simultaneous changes in post-trauma cognitions and PTSD symptoms in controlled and uncontrolled studies, suggesting treatments that improve negative post-trauma cognitions also effectively reduce PTSD symptoms (Brown et al., 2019). Further, 11 studies documented that a reduction in negative post-trauma cognitions preceded a reduction of PTSD symptoms, but four studies demonstrated a pattern of mutual influence between these constructs or did not find mediational relations (Brown et al., 2019). Lastly, four studies, compared to two with null findings, showed higher negative post-trauma cognitions at baseline were significantly associated with post-treatment PTSD symptom severity, but the directional effect was not consistent (Brown et al., 2019).

In fact, the most underdeveloped research area with the most discrepant findings is in the examination of baseline negative post-trauma cognitions on PTSD symptom outcomes. For example, Moser et al. (2010) found that higher baseline overaccommodated cognitions but not assimilated cognitions were associated with higher PTSD symptoms outcomes in those receiving PE with cognitive restructuring, but negative post-trauma cognitions were not associated with PTSD symptom outcomes in those who completed PE only. Similarly, Jun et al. (2003) found no relation between negative post-trauma cognitions and PTSD symptoms. Whereas, Clifton et al. (2017) found that higher baseline assimilated cognitions predicted lower PTSD symptoms. For those with higher overaccommodation, they may believe they do not have the abilities to cope

with stressors and confront trauma-related stimuli, which may hinder their progress in trauma treatment. Higher assimilation may impede processing of primary emotions (e.g., fear, sadness), but increased therapeutic focus on assimilated cognitions may lead to reduced avoidance and help to reduce PTSD symptoms.

With regard to positive post-trauma cognitions, higher accommodation may facilitate productive coping and receptiveness to confronting and processing trauma in a way that can enhance reduction of PTSD symptoms, though few studies have investigated baseline levels of accommodation on PTSD treatment outcomes. Also, optimism has been found to consistently predict a decrease in PTSD symptoms from two months up to nine years (Gallagher et al, 2020), but no known studies have examined the role of optimism in trauma treatment outcomes; however, given its nature as a "common factor" suggested to promote recovery across psychotherapy modalities (Wampold, 2015) it may be facilitate recovery in trauma treatment.

Thus, although there is strong evidence to support the theoretical assumptions that a reduction of post-trauma cognitions lessens PTSD symptoms, there are notable discrepancies in the literature, which may be a function of power, sample size, analytic method, or selected measures (Brown et al., 2019). For example, the average sample size was about 78 participants, ranging from 5 to 268; 50% of the studies included less than 34 participants and 75% of the studies included sample sizes below 51 (Brown et al., 2019). Small sample sizes would likely reduce power in these studies, limiting the ability to detect a true effect using conventional frequentist statistics. Also, 12 different measures were used to capture trauma-related cognitions in their review (Brown et al., 2019), some of which are conflated with emotional experiences (e.g., "I usually feel safe when I'm alone," Trauma Stress Institute Belief Scale; Traumatic Stress Institute, 1994) and overt behaviors ("I energetically pursue my goals," Adult Hope Scale;

Snyder et al., 1991). Other measures have theoretical grounding but are unpublished with unknown reliability and validity (e.g., Personal Beliefs and Reaction Scale; Mechanic & Resick, 1993) or use adapted and unvalidated versions of post-trauma cognition measures (e.g., Emotions and Beliefs after Trauma; Livanou et al., 2002). Complicating matters, many measures commingle different types of post-trauma cognitions or only assess one type.

Consequently, the limitations of these studies may contribute to discrepancies in the literature and obscure our understanding of the role of post-trauma cognitions in trauma-focused treatments. The aim of this study was to utilize Bayesian methods that are less sensitive to sample size and other methodological issues inherent in studies of psychological trauma (Yalch, 2016) and clinical research (Matthews, 2001), as well as a comprehensive trauma-related cognitions measure that taps different aspects of cognitive processes post-trauma to clarify the role of negative and positive baseline post-trauma cognitions on the course of PTSD symptoms in trauma-focused therapy.

To this end, we estimated the slope of posttraumatic stress from baseline through final treatment session in time-limited, 16-session, non-specific trauma-focused therapy among a diverse sample of trauma survivors presenting to a community mental health clinic after criminal victimization, as well as the relation between the slope of posttraumatic stress symptoms on baseline levels of post-trauma cognitions and optimism. Clients at this clinic receive individualized treatment that integrates trauma-informed case management and psychotherapy interventions that fall within an established three-stage model of trauma treatment (Herman, 1997). The comprehensive model of care developed at this clinic has been shown to be clinically effective (Kelly et al., 2010). Thus, it was hypothesized that PTSD symptoms will decrease from baseline to final session. Further, given theoretical assumptions on the role of post-trauma

cognitions in the development, maintenance, and recovery of PTSD, it was hypothesized that those with higher overaccommodated and assimilated post-trauma cognitions will experience an attenuated decrease in PTSD symptoms compared to the average rate of change in posttraumatic stress across trauma-focused therapy, whereas, those with higher accommodated post-trauma cognitions and post-trauma optimism will experience an accelerated decrease in PTSD symptoms.

Method

Participants

Participants included 73 recent victims of violent crime who were presenting for trauma-focused therapy from 2015 to 2016 with one of 17 clinicians at a community mental health clinic in a large metropolitan area on the West Coast region of the United States. The average age of participants was 41.28 (*SD* = 13.80), ranging from 21 to 87. The average number of diagnoses was 2.13 (*SD* = 1.43), ranging from zero (two participants did not meet criteria for any disorder) to eight (in the case of multiple substance use disorders). Refer to Table 1 for a summary of demographic characteristics in this sample.

Procedure

This study was approved by the University of California, San Francisco Institutional Review Board as part of a broader study examining trauma-related psychological constructs among victims of crime seeking trauma-focused treatment at a community trauma-focused mental health clinic (Author Reference, 2021). The mental health clinic offers free-of-charge, time-limited trauma-focused treatment, funded by various county, state, and federal grants, thus clients tend to be of lower income. Potential clients are identified and referred for services by community partners, including medical services, victim services (e.g., rape crisis centers,

domestic violence shelters), law enforcement, and other agencies (e.g., homeless shelters, treatment programs, housing programs). Given funding and referral sources, the majority of clients tend to be of low income and publicly health insured or uninsured, though this is not a requirement for services.

During initial engagement with potential clients, an intake evaluation is conducted to determine clinical presentation and eligibility. Eligibility for services includes being a victim of a crime or a family member of a homicide victim within the last 3 years, or a survivor of torture in another country. A diagnosis is not required for services, as some clients may exhibit significant subthreshold distress that demonstrates need and potential for benefiting from engaging in brief, evidence-based, trauma-informed services. Trauma services consist of 16 sessions of trauma-focused therapy with clinicians trained in social work and/or clinical psychology operating from a variety of clinical orientations that are grounded in a strength-based approach and trauma-informed perspective, and in some cases the number of sessions can be extended given the needs and circumstances of the client. All clinical services fall within an established three-stage model of trauma treatment that addresses survivors' differing needs and environment (Herman, 1997). Clinical services are provided by an assigned clinician who co-develops with the client a plan of care for practical issues (e.g., immediate safety, housing, medical care) and/or trauma processing that are aimed at increasing a sense of safety and stabilization and reducing posttraumatic stress symptoms.

The index trauma that precipitated treatment at the clinic was identified for 64 participants during the intake evaluation. Most participants identified sexual assault (32.9%), followed by physical assault (26%); 9.6% were family members of homicide victims, 5.5% were refugees or victims of torture in their home country, 4.1% were victims of vehicular assault,

2.7% were victims of a stabbing, 2.7% were victims of attempted murder, 1.4% were victims of a shooting, and 2.7% of participants reported another type of crime as their index trauma.

Clinicians at the community mental health clinic were encouraged to refer potential clients to the study during an intake evaluation; clinicians used their clinical judgment with respect to who was referred, and those potential clients who expressed interest in participating met with a research assistant to learn more about the study. After providing written informed consent, participants completed a packet of questionnaires before their first therapy session that took approximately 45 minutes to complete, including the TRCS and other measures not relevant to this study. Following the completion of the packet of questionnaires, participants were thanked for their time and debriefed. They were provided a payment of $20 for their time. No adverse events were reported. At the completion of the study, demographic data, trauma history, and psychiatric diagnoses at intake, as well as posttraumatic stress symptoms at intake, session 8, and session 16 were extracted from clinical records.

Measures

Post-Trauma Cognitions

The Trauma-Related Cognitions Scale (TRCS; Valdez et al., 2021) is a 69-item multi-dimensional measure that assesses three theoretical trauma-related cognitive processes, including overaccommodation (25 items: “My life has been destroyed by the trauma”), assimilation (13 items: “I blame myself for what happened”), and accommodation (15 items: “I have made good and bad choices in life”), as well as an additional attitude reflecting a belief of an outcome - optimism (16 items: “The good things that happen in this world far outnumber the bad”). Items from the TRCS were gathered from previously validated open-access trauma-related cognition measures and additional item generation. The TRCS internal structure was developed through

exploratory and confirmatory factor analyses. Items are rated from 1 (Strongly Disagree) to 6 (Strongly Agree). A total score for each subscale is averaged, with higher scores indicating a greater degree of agreement with each statement. The inter-item correlation alpha ranged from .84 (optimism) to .97 (overaccommodation) in the non-clinical developmental sample (Valdez et al., 2021). In this sample, inter-item correlation alpha for each subscale at baseline is: .67 accommodation, .85 for optimism, .91 for assimilation, and .93 for overaccommodation).

PTSD Symptoms

The PTSD Checklist for DSM-5 (PCL-5; Weathers et al., 2013) was used to assess PTSD symptoms. The PCL-5 is a 20-item self-report scale for posttraumatic stress based on DSM-5 criteria. Items are rated from 0 (Not at All) to 4 (Extremely). A total severity score is obtained by summing scores from each of the 20 items. Initial research suggests a PCL-5 cutoff score between 31-33 represents a probable diagnosis of PTSD (Weathers et al., 2013). A 5-point decrease on the PCL-5 indicates treatment response, and a 10-point decrease suggests clinically meaningful improvement (Weathers et al., 2013). Inter-item correlation alpha for the PCL-5 has ranged from .91 (military service member sample seeking treatment; Wortmann et al., 2016) to .94 (college sample; Blevins et al., 2015). The PCL-5 was administered prior to initiating trauma-focused therapy, as well as at the eighth and sixteenth sessions. Inter-item correlation alpha for the PCL-5 total in this sample throughout the study was: .87 at intake, .90 at session 8, and .93 at session 16.

Data Analysis

R version 4.0.5 (R core team, 2021) was used for analyses. Because this study focused on rates of change, only participants with observations for at least two time points (i.e. an observed rate of change) were included in the analysis. The probability of exclusion (having less than two

observations) was assessed with a series of Bayesian logistic regressions (using brms default priors) where exclusion status was predicted by patient characteristics. Patient characteristics that had odds ratio 95% credible intervals that did not include a ratio of 1 were considered to provide support that said characteristic was meaningfully associated with exclusion. Exclusion did not depend on age, race, gender, TRCS scores, or baseline PCL-5 scores (see results section). Most participants completed the targeted 16 sessions of therapy (n = 47, 64.4%), and 62 participants completed at least 8 sessions (84.9%). The final sample size was 56. Remaining missing values were handled with multilevel multiple imputation with chained equations (van Burren, 2018) using the *mice* (van Buuren & Groothuis-Oudshoorn, 2011) and *miceadds* (Robitzsch & Grund, 2021) R packages. A total of 50 imputed datasets were created.

Bayesian statistical approaches allow for previous information (research findings, theory, clinical experience) to be incorporated into parameter estimates through defining prior distributions. Because Bayesian statistics takes a subjective view of probability and treats population parameters as random variables, priors describe existing beliefs as distributions of possible values for statistical parameters (e.g. a regression coefficient), with more narrow distributions indicating more certain beliefs (Wagenmakers, et al., 2008). These prior beliefs are updated with information from new data to produce posterior distributions, which represent refined beliefs about how likely different parameter values are given the new data. Posterior distributions are the basis of Bayesian statistical inference and can be summarized in a number of ways. In addition to point estimates, Bayesian credible intervals directly capture the range of most probable population parameter values from the posterior at a given level of credibility. In stark contrast, frequentist confidence intervals say nothing about whether a specific interval contains the population value, instead they are designed to control error rates in decision making

over a series of hypothetically repeated studies. Another unique metric in Bayesian analyses is the probability of direction (PD). The PD is an index of effect existence and quantifies what percentage of the posterior distribution lies above or below 0. While the PD cannot evaluate the significance or importance of an effect, it can be useful in quantifying uncertainty in developing research areas where there are mixed findings about even the direction of an effect (Makowski et al., 2019).

The relations between trauma-related cognitions (i.e., overaccommodation, assimilation, accommodation, and optimism) at intake and the rate of PTSD symptom (i.e., PCL-5) change over time during a 16-week course of therapy were estimated with a Bayesian multilevel linear model with random intercepts and slopes. The model had 2-levels, repeated measures at level-1 nested within persons at level-2 with the number of treatment sessions over time as a level-1 predictor and each of the TRCS subscales (overaccommodation [OA], assimilation [AS], accommodation [AC], and optimism [OP]) as time-invariant level-2 predictors. The sessions variable was centered such that 0 represented the intake appointment/baseline, thus the intercept indicates the expected PCL-5 score at treatment intake and all TRCS scores were grand mean centered and standardized within each imputation set such that 0 on the transformed score indicates the sample average score on each scale. The multilevel model can be represented as:

$$\text{PCL-5}_{ij} = \beta_{0j} + \beta_{1j}(\text{Sessions}_{ij}) + e_{ij} \quad (1)$$

$$\beta_{0j} = \beta_{00} + \beta_{01}(\text{OA}_j) + \beta_{02}(\text{OP}_j) + \beta_{03}(\text{AS}_j) + \beta_{04}(\text{AC}_j) + u_{0j} \quad (2)$$

$$\beta_{1j} = \beta_{10} + \beta_{11}(\text{OA}_j) + \beta_{12}(\text{OP}_j) + \beta_{13}(\text{AS}_j) + \beta_{14}(\text{AC}_j) + u_{1j} \quad (3)$$

Which can be expanded to:

$$PCL\text{-}5_{ij} = \gamma_{00} + \gamma_{01}(OA_j) + \gamma_{02}(OP_j) + \gamma_{03}(AS_j) + \gamma_{04}(AC_j) + \gamma_{10}(Sessions_{ij}) + \gamma_{11}(Sessions_{ij}*OA_j) + \gamma_{12}(Sessions_{ij}*OP_j) + \gamma_{13}(Sessions_{ij}*AS_j) + \gamma_{14}(Sessions_{ij}*AC_j) + u_{0j} + u_{1j}(Sessions_{ij}) + e_{ij} \quad (4)$$

The moderating relation between trauma-related cognitions and the rate of PTSD symptom change across treatment sessions was estimated by the cross-level interactions between session number and TRCS subscales (i.e., γ_{11}, γ_{12}, γ_{13}, and γ_{14} in (4)). These relations were assessed with estimated posterior means, 95% credible intervals (95% CrI), and probability of direction (PD). Estimates were interpreted as clinically relevant if the 95% CrIs did not contain zero, and the probabilities of direction were greater than 97.5%. This would indicate that there is some statistical support to believe that these baseline variables are related to differences in PCL-5 scores over time in a particular direction. Interaction terms were also plotted and subjected to simple slopes analysis. Simple slopes estimate the slope of interest at several values of the moderator (e.g. assimilated post-trauma cognitions), presenting how the moderator affects the slope of interest (e.g. rate of PTSD symptom change over time in treatment) (Darlington & Hayes, 2017).

Priors for each parameter in (4) were informed by cumulative information in the current literature on the course of PTSD symptoms in trauma-focused treatments and the role of negative post-trauma cognitions on the course of treatment, intended to add prior information without leading or constraining the parameter estimates. Final prior values were chosen by using prior predictive checks to tune the values such that the beliefs implied by the set of priors were in the range of possible PCL-5 values (0-80) and were plausible in the context of existing knowledge.

The prior for the intercept term (□00) was a normal distribution with a mean of 35, the median of PCL-5 scores across all timepoints in the current sample, and a standard deviation of 10 such that 99.8% of implied intercept values fell between 4 and 66. The □01 term prior used a normal distribution with a mean of 1 to reflect the positive theoretical (Resick & Schnicke, 1992) and empirical (Moser et al, 2010) relationships between overaccommodation and PTSD symptoms, while respecting remaining uncertainty and new data with a standard deviation of 5. This logic was applied to the Gaussian priors for □02 (OP; M = -1, SD = 5; Gallagher et al., 2020), □03 (AS; M = 1, SD = 5; Clifton et al., 2017), □04 (AC; M = - 1, SD = 5). The relationship between the number of treatment sessions attended and PCL-5 scores ($□_{10}$) had a Gaussian prior with a mean of -1 and a standard deviation of 1, informed by rates of PCL-5 score changes in clinical research of trauma-focused therapies (Byllesby et al., 2019; Resick et al., 2015). The session by TRCS subscale interaction terms were given priors with means that reflected their theoretical and empirical relationships (Resick & Schnicke, 1992) to the rate of symptom change in therapy, while their standard deviations reflect wide but plausible boundaries around the effects ($□_{11}$ [Sessions * OA; M = 0.25, SD = 0.5], $□_{12}$ [Sessions * OP; M = -0.25, SD = 0.5], $□_{13}$ [Sessions * AS; M = 0.25, SD = 0.5], $□_{14}$ [Sessions * AC; M = -0.25, SD = 0.5]. Variance terms u_0 and e received priors constructed from half-normal distributions bounded at 0 with a scale parameter of 10, while the random effects of session number (u) used a mean of 0 and scale parameter of 1.25 , the short tail of the half-normal distribution respects the limits to variance imposed by the possible range of PCL-5 scores. The prior distributions for each parameter are summarized in Table 2. A duplicate model using uninformative priors was estimated to check the sensitivity of the main model results (Table 3).

The model was estimated with the *brms* R package (Bürkner, 2017) using a Markov Chain Monte Carlo No U-Turn Sampler, with the 50 imputed data sets. Models used 4 chains, with 6000 iterations and 3000 warm-up samples. Each model (imputed data set) was individually checked for convergence visually with trace plots and with the potential scale reduction factor (Gelman & Rubin, 1992). In total, the pooled model had 600,000 post-warmup samples.

Results

Most participants in the analysis completed the targeted 16 sessions of therapy (n = 45, 80%), and 54 participants completed at least 8 sessions (96.4.%). Bayesian logistic regression with default priors was used to estimate the odds of being excluded from the analysis model (having less than two observations) based on participant characteristics. The odds of exclusion did not depend on age (OR = 0.99, 95% CrI [0.95, 1.03]), race (OR = 0.74, 95% CrI [0.22, 2.71]), gender (OR = 1.10, 95% CrI [0.31, 3.85]), overaccommodation scores (OR = 0.99, 95% CrI [0.48, 2.04]), assimilation scores (OR = 1.06, 95% CrI [0.64, 1.75]), accommodation scores (OR = 2.07, 95% CrI [0.57, 8.54]), optimism scores (OR = 0.72, 95% CrI [0.30, 1.78]) or baseline PCL-5 scores (OR = 0.99 95% CrI [0.95, 1.03]). At intake, trauma-related cognition scale scores were 2.64 (*SD* = 0.89) on overaccommodation, 3.13 (*SD* = 1.17) on assimilation, 4.23 (*SD* = .44) on accommodation, and 4.23 (*SD* = .68) on optimism. PCL-5 scores averaged 47.69 (*SD* = 15.06). Table 2 presents the results of the mixed-effects model detailed in (4). Given that the TRCS subscale scores were standardized in the model, the following relations should be interpreted when all other TRCS subscales are at their sample average. The estimated population average PCL-5 score at treatment intake was estimated as 45.61 (*SD* = 1.91, 95% CrI [41.81, 49.33]. The average change in PCL-5 scores per 1 session of trauma-focused therapy was

estimated as -1.57 (*SD* = 0.16) and found to be clinically relevant, 95% CrI [-1.89, -1.25] (Figure 1). Standard deviations for the random parameters are also reported in Table 2.

A one standard deviation increase in TRCS overaccommodation scores was associated with a clinically relevant 4.08-point increase in baseline PCL-5 scores (b = 4.08, SD = 1.98, 95% CrI [0.19, 7.97]). The cross-level interaction between overaccommodation scores and treatment sessions was estimated at 0.38 (*SD* = 0.18, 95% CrI [0.03, 0.73]) and 98% of the posterior distribution was above 0.[1] This indicated a clinically relevant moderating relation between overaccommodation scores and symptom change in treatment in which higher scores were associated with less symptom reduction during treatment, see Figure 2. With simple slopes we see that one session of trauma-focused therapy was associated with a -1.19 (95% CrI [-1.58, -0.79]) point change on the PCL-5 for high levels of overaccommodation (+1 SD), a -1.57 (95% CrI [-1.84, -1.30]) point change for mean levels, and -1.95 (95% CrI [-2.35, -1.55]) points for low levels (-1 SD). Thus, higher TRCS overaccommodation scores were substantially associated with both higher baseline PCL-5 levels and with attenuated rates of PCL-5 score reduction over treatment.

Assimilation was not meaningfully associated with PCL-5 scores at intake (b = -0.08, SD = 2.03, 95% CrI [-4.14, 3.83]). The cross-level interaction between assimilation scores and treatment sessions was estimated at -0.36 (*SD* = 0.17, 95% CrI [-0.69, -0.02]) and 98% of the posterior distribution was below 0. This indicated a clinically relevant moderating relation between assimilation scores and the rate of symptom change in treatment such that higher assimilation was associated with greater symptom reduction over the course of treatment, see

[1] When age, gender, race, and comorbid psychiatric diagnosis were included as covariates in a 4th supplementary model, the session by overaccommodation interaction coefficient estimate reduced to 0.30, while the SD remained 0.18. Thus the 95% CrI adjusted to [-0.05, -.85]. No other variables shifted substantially. See supplementary table S1 for complete details of this model with covariates.

Figure 3. The simple slopes show that one session of trauma-focused therapy was associated with a -1.93 (95% CrI [-2.32, -1.53]) point change on the PCL-5 for high levels of assimilation (+1 SD), a -1.57 (95% CrI [-1.84, -1.30]) point change for mean levels, and -1.20 (95% CrI [-1.59, -0.82]) points for low levels (-1 SD). Therefore, while TRCS assimilation scores did not affect baseline PCL-5 levels, they were associated with a faster rate of PCL-5 score reductions over treatment.

A one standard deviation increase in TRCS accommodation scores was associated with a higher PCL-5 score at intake (b = 3.12, SD = 1.81, 95% CrI [-0.48, 6.64]), though this should not be interpreted as a certain clinically relevant relation as 4% of the posterior distribution was below 0. The cross-level interaction between accommodation scores and treatment sessions was estimated at -0.12 (*SD* = 0.16, 95% CrI [-0.43, 0.20]) and 77% of the posterior distribution was below 0. Though this association is not certain to be clinically relevant as both null and positive effects are credible values, given the data. With simple slopes we see that one session of trauma-focused therapy was associated with a -1.68 (95% CrI [-2.05, -1.31]) point change on the PCL-5 for high levels of accommodation (+1 SD) , a -1.57 (95% CrI [-1.84, -1.30]) point change for mean levels, and -1.45 (95% CrI [-1.83, -1.07]) points for low levels (-1 SD). Neither baseline PCL-5 levels nor the rate of PCL-5 score change over the course of treatment were associated with TRCS accommodation scores.

A one standard deviation increase in TRCS optimism scores was associated with a 3.06 less points on the PCL-5 at intake (b = -3.06, SD = 2.47, 95% CrI [-7.88, 1.82]), though this should not be interpreted as a certain clinically relevant relation as 11% of posterior values suggested increased PCL-5 scores were also probable given the data. The cross-level interaction between optimism scores and treatment sessions was estimated as -0.17 (*SD* = 0.22, 95% CrI [-

0.61, 0.27]) and 78% of the posterior distribution was below 0. Though this association is not certain to be clinically relevant as both null and positive effects are credible values, given the data. Using simple slopes it was estimated that one session of trauma-focused therapy was associated with a -1.68 (95% CrI [-2.05, -1.31]) point change on the PCL-5 for high levels of optimism (+1 SD), a -1.57 (95% CrI [-1.84, -1.30]) point change for mean levels, and -1.45 (95% CrI [-1.83, -1.07]) points for low levels (-1 SD). Therefore, TRCS optimism scores were not meaningfully related to neither baseline PCL-5 scores, nor the rate of symptom change over the course of treatment.

Two alternative models, one using uninformative default brms priors (flat model), and one using Gaussian priors with mean of 0 and standard deviations of 10 (weakly informative model), were fit to assess the sensitivity of estimates to prior specification, see Table 3 for the flat model summary. The posterior point estimates were similar across the three models, however, both the alternative models had larger standard deviations and wider 95% CrIs. In both the alternative models, the 95% CrI of the overaccommodation parameter expanded to include 0, whereas it does not contain 0 in the main model. In both the alternative models, the accommodation parameter estimate and its standard deviation are both higher than in the main model. With regard to the interaction terms, each maintained its direction and relative magnitude across all three models. The 95% CrI for the interactions between sessions and assimilation excluded 0 in all three models, while the 95% CrI for overaccommodation excluded 0 in the main model and the weakly informative model, but included 0 in the flat model. Thus, the chosen priors reduce uncertainty in the model.

Discussion

The purpose of this study was to estimate the slope of PTSD symptoms over the course of time-limited, 16-session, non-specific trauma-focused therapy as a function of post-trauma cognitions in a diverse sample of trauma survivors presenting with posttraumatic stress related to criminal victimization. At baseline, participants reported generally disagreeing with items on the Trauma-Related Cognitions Scale (TRCS) that assessed overaccommodated post-trauma cognitions (i.e., altering beliefs to the extreme to feel safe and in control), were ambivalent in reporting agreement with items that assessed assimilated post-trauma cognitions (i.e., altering new information post-trauma to maintain and reinforce pre-existing beliefs), and generally agreed with items that assessed accommodated post-trauma cognitions (i.e., balanced alteration of beliefs to incorporate new information post-trauma) and optimism (i.e., a cognitive tendency to anticipate positive generalized outcomes and expectancies). Also, at baseline, the average PTSD Checklist (PCL) score was above the cut-off criteria, which suggests the average participant likely had PTSD. On average, PTSD symptoms on the PCL-5 reduced by around one-and-a-half points for every session of therapy when all post-trauma cognitions were at the sample average. This indicates clinically meaningful change in symptoms of PTSD from baseline to midway, and from midway to final treatment session. A reduction of around one score on the PCL-5 at each therapy session has been found across several treatment studies for PTSD (Byllesby et al., 2019; Resick et al., 2015).

Consistent with our hypothesis, greater overaccommodated post-trauma cognitions were related to an attenuated decrease in PTSD symptoms over the course of 16 sessions of trauma-focused therapy. This finding is consistent with a study that found higher baseline overaccommodated cognitions predicted higher PTSD symptoms post-treatment in those receiving a trauma-focused treatment with a cognitive restructuring component (Moser et al.,

2010). Overaccommodated post-trauma cognitions represent global beliefs about the self, others, and the world that may undermine treatment. Also, overaccommodation may more directly relate to comorbid symptoms of anxiety (e.g., triggered by beliefs that "the world is entirely dangerous") and depression (e.g., triggered by beliefs that "I'm a bad person") that are indirectly related to posttraumatic stress, and therefore, may not play a central role in reducing PTSD symptoms, specifically. Thus, it may be beneficial to include adjunctive treatments to treatments for PTSD that target overaccommodation to accelerate PTSD symptoms reduction. For example, a recent review found that interventions based, in part or whole, on self-compassion potentially reduce PTSD symptoms, though the precise mechanism is unknown (Winders et al., 2020). Other research suggests that self-compassion enhances the efficacy of dialectical and balanced beliefs among those with posttraumatic stress (Boyraz et al., 2019) and depression (e.g., Diedrich et al., 2016).

To the contrary and inconsistent with our hypothesis, greater assimilated post-trauma cognitions were associated with a greater reduction in PTSD symptoms over treatment. These findings are consistent with one study that found higher assimilated cognitions predicted lower PTSD symptoms post-treatment (Clifton et al., 2017). However, these findings are inconsistent with a study that found no relation between baseline scores of assimilation and post-treatment PTSD symptoms in female assault survivors, though this may have resulted because the measure of assimilation was assessed with few items, and therefore, not able to capture nuanced beliefs. Yet, other studies have found that qualitatively coded nuanced assimilated beliefs at the beginning of trauma-focused therapy are not associated with PTSD symptoms post-treatment (Dondanville, 2016; Iverson et al., 2015), but in both of these studies there were low levels of assimilated beliefs expressed, which may preclude meaningful findings. The findings from

Clifton et al. (2017) and this study may have found an effect due to the robust assessment of trauma-related assimilated cognitions. It may be that certain types of assimilated post-trauma cognitions are associated with posttraumatic stress and require more formal cognitive intervention (Resick et al., 2002). For example, challenging post-trauma assimilation related to self-guilt, which many trauma-focused treatments do, may help one to reconceptualize the causes and consequences of trauma and reduce internal avoidance. Thus, identifying and challenging nuanced assimilated post-trauma cognitions, especially when individuals present with high assimilated beliefs, may accelerate treatment gains because it directly targets mechanisms related to PTSD maintenance. However, more research on the longitudinal course of assimilated beliefs throughout trauma-focused treatment is needed to explicate their function on PTSD symptoms.

Given the current data, there is still uncertainty with regard to accommodated post-trauma cognitions, optimism, and their association with PTSD symptom change in therapy. Though the most probable direction of the effect was in line with our hypothesis, the current evidence was not strong enough to support a substantial relation between baseline accommodation scores and rates of symptom change in therapy. However, previous studies have found that a greater percentage of accommodated post-trauma cognitions formally expressed in therapy during treatment assignments were associated with less post-treatment PTSD symptoms (Dondanville et al., 2016 Iverson et al., 2015; Sobel et al., 2009), and may suggest that rather than pretreatment levels of accommodated cognitions setting the stage for the course of therapy, the amount of change, regardless of initial levels, is what matters. Looking at optimism, the current data is not strong enough to support a substantial clinically relevant effect on the rate of PTSD symptom change during therapy, though the most probable direction of the effect was negative. As this is the first known study to assess trauma-related optimism as a predictor of

treatment trajectory, our initial findings point toward further investigating the role of trauma-related optimism in treatment outcomes, in line with previous studies that have measured related constructs (Gallagher et al., 2020).

There are important limitations of this study to consider. The study sample was diverse in demographics and comorbidities, and these variables were not controlled for in the primary analyses, as they were not central to the research question of this study. Yet, these variables could represent confounds, and future research may examine them as moderating factors in the relation between post-trauma cognitions and PTSD symptoms. Also, examining the relation between post-trauma cognitions and specific PTSD symptom clusters was beyond the scope of this study. Given the addition of the Negative Alterations in Cognitions and Mood (NACM) cluster to the current PTSD criteria, it will be important for future research to parse out the relation between post-trauma cognitions on specific PTSD symptom clusters. It may be that post-trauma cognitions are more related to the NACM cluster than other clusters, particularly given that the NACM cluster includes symptoms that tap overaccommodated and assimilated beliefs, and this direct relation may drive the effect on overall PTSD symptoms, especially because the NACM cluster is the largest symptom cluster and it accounts for 35% of PTSD symptoms. Also, we only assessed post-trauma cognitions at baseline and not throughout the course of treatment. Therefore, it is important for future research to assess the directionality of the relation between post-trauma cognitions and PTSD symptoms, as there are mixed findings in the literature that mainly suggest a reduction of negative post-trauma cognitions precede a reduction of PTSD symptoms, but research has also found a pattern of mutual influence between negative post-trauma cognitions and PTSD symptoms or no mediational relation (Brown et al., 2019). Future research may also examine the relation between post-trauma cognitions and PTSD symptoms as

a function of trauma type, as research has documented that post-trauma cognitions are more central to interpersonal types of trauma (Lilly & Valdez, 2011), but more research with the current PTSD criteria is needed.

There are also notable strengths of this study. We used a comprehensive post-trauma cognitions measure that assessed theoretically grounded and empirically derived cognitive processes post-trauma, and that parsed trauma-related cognitions from behaviors and emotions, which have been limitations in prior studies. By assessing specific types of post-trauma cognitions, we were able to elucidate their differential impact on the course of PTSD symptoms throughout treatment. Further, given that findings from previous research on the associations between baseline post-trauma cognitions are contradictory and not well established (Brown et al., 2019), Bayesian methods allowed for this cumulative information to be rigorously included through model priors, and for the remaining uncertainty given the newly observed data to be directly quantified in posterior distributions (Matthews, 2001; Yalch, 2016). Bayesian methods also provide more accurate estimates and practically allow more complicated models to be fit when sample sizes are small (Yalch, 2016), and therefore, should continue to be utilized in research areas with discrepant findings. Lastly, as mentioned previously, participants in this sample were demographically diverse and diagnostically complex, which may also represent strengths of this study given that some minority populations are underrepresented in clinical outcomes research in trauma, even though they have high prevalence rates for trauma and PTSD (Benuto et al., 2020). It is also important to consider the role of post-trauma cognitions in complex cases given that PTSD comorbidity is the rule rather than the exception (Brady et al., 2000). However, this sample represented acute victims of crime, and therefore, results may not generalize to individuals seeking trauma-focused therapy who have experienced non-

interpersonal types of trauma (e.g., natural disasters, motor vehicle accidents, etc.) or to those who are presenting to treatment years or decades after trauma.

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Table 1

Demographic Summary Table

Characteristic	N	%	Characteristic	N	%
Gender	73		Psychiatric Diagnoses	63	
Female	44	60.3	PTSD	36	57.1
Male	20	27.4	Any TS Dx	59	93.6
Decline to respond	9	12.3	Depressive Dx	25	39.7
Ethnicity	73		Substance Use Dx	12	19.0
Hispanic	25	34.2	Anxiety Dx	12	19.0
White	18	24.7	Bipolar Dx	3	4.8
Black	10	13.7	Psychotic Dx	2	3.2
Asian/Pacific Islander	7	9.6	Eating-related Dx	2	3.2
Multiracial	1	1.4	Gender Dysphoria	1	1.6
Other	11	15.1			
Decline to respond	1	1.4			
Sexual Orientation	73				
Heterosexual	43	58.9			
Homosexual	10	13.7			
Bisexual	4	5.5			
Declined to respond	16	21.9			

Note. Demographic summary table. TS = trauma and stressor-related. Dx = Diagnosis

Table 2

Results of Mixed-effects Model

Model	Prior	Estimate	SD	95%CrI	PD < 0
Intercept	~N(35,10)	45.61	1.91	[41.81, 49.33]	0%
Sessions	~N(-1,1)	-1.57	0.16	[-1.89, -1.25]	100%
OA	~N(1,5)	4.08	1.98	[0.19, 7.97]	2%
OP	~N(-1,5)	-2.20	1.81	[-5.74, 1.37]	89%
AS	~N(1,5)	-0.08	2.03	[-4.14, 3.83]	51%
AC	~N(-1,5)	3.12	1.81	[-0.48, 6.64]	4%
Ses * OA	~N(0.25, 0.5)	0.38	0.18	[0.03, 0.73]	2%
Ses * OP	~N(-0.25, 0.5)	-0.13	0.16	[-0.45, 0.20]	78%
Ses * AS	~N(0.25, 0.5)	-0.36	0.17	[-0.69, -0.02]	98%
Ses * AC	~N(-0.25, 0.5)	-0.12	0.16	[-0.43,0.20]	77%
Sigma	~Half-N(0,10)	9.23	1.23	[7.15, 11.88]	-
SD-Intercept	~Half-N(0,10)	10.66	2.48	[5.55, 15.33]	-
SD-Sessions	~Half-N(0,1.25)	0.73	0.28	[0.09,1.20]	-

Note. Structure, priors, and results of the Bayesian mixed-effect model. SD = standard deviation. ~N = normally distributed. ~Half-N = half-normally distributed. OA = overaccommodation. OP = optimism. AS = assimilation. AC = accommodation. CrI = credible interval. PD < 0 = probability of negative direction of relation.

Table 3

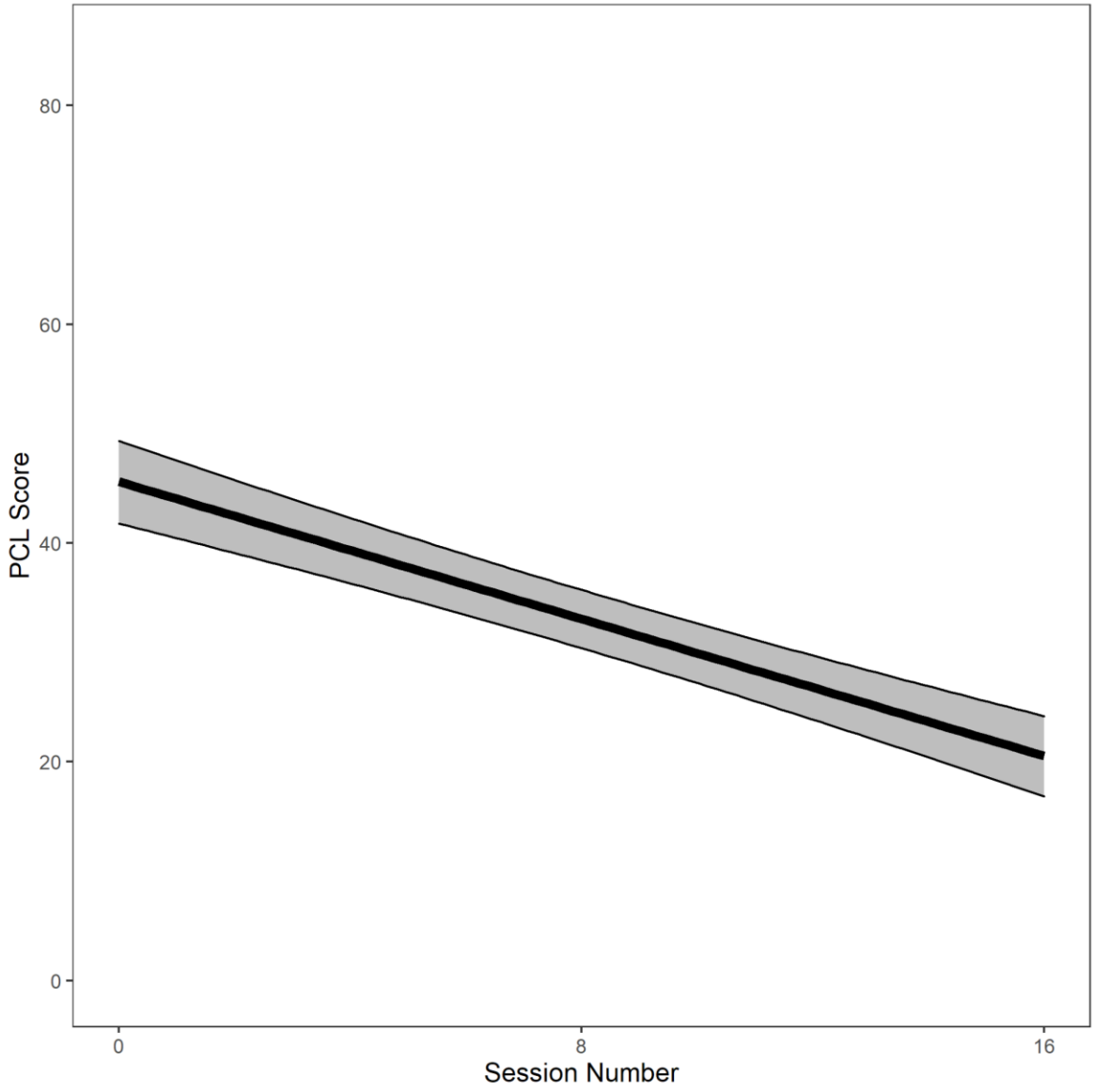
Results of Mixed-effects Model Using Uninformative Default Priors

Model	Prior	Estimate	SD	95%CrI	PD < 0
Intercept	~st(3, 0, 20.8)	45.72	1.98	[41.79, 49.58]	0%
Sessions	Flat	-1.58	0.17	[-1.92, -1.25]	100%
OA	Flat	4.10	2.40	[-.61, 8.86]	4%
OP	Flat	-2.33	2.09	[-6.42, 1.82]	87%
AS	Flat	0.23	2.41	[-4.63, 4.87]	46%
AC	Flat	3.55	2.07	[-0.57, 7.59]	4%
Ses * OA	Flat	0.41	0.21	[-0.01, 0.83]	3%
Ses * OP	Flat	-0.11	0.19	[-0.47, 0.27]	72%
Ses * AS	Flat	-0.43	0.20	[-0.81, -0.03]	98%
Ses * AC	Flat	-0.14	0.18	[-0.50, 0.22]	78%
Sigma	~st(3, 0, 20.8)	9.16	1.22	[7.11, 11.83]	-
SD-Intercept	~st(3, 0, 20.8)	11.19	2.57	[5.90, 16.09]	-
SD-Sessions	~st(3, 0, 20.8)	0.78	0.25	[0.13, 1.26]	-

Note. Structure, priors, and results of the alternative Bayesian mixed-effect model using brms uninformative default priors. SD = standard deviation. ~st() = Student t distributed with degrees of freedom, mean, standard deviation. OA = overaccommodation. OP = optimism. AS = assimilation. AC = accommodation. CrI = credible interval. PD < 0 = probability of negative direction of relation.

Figure 1

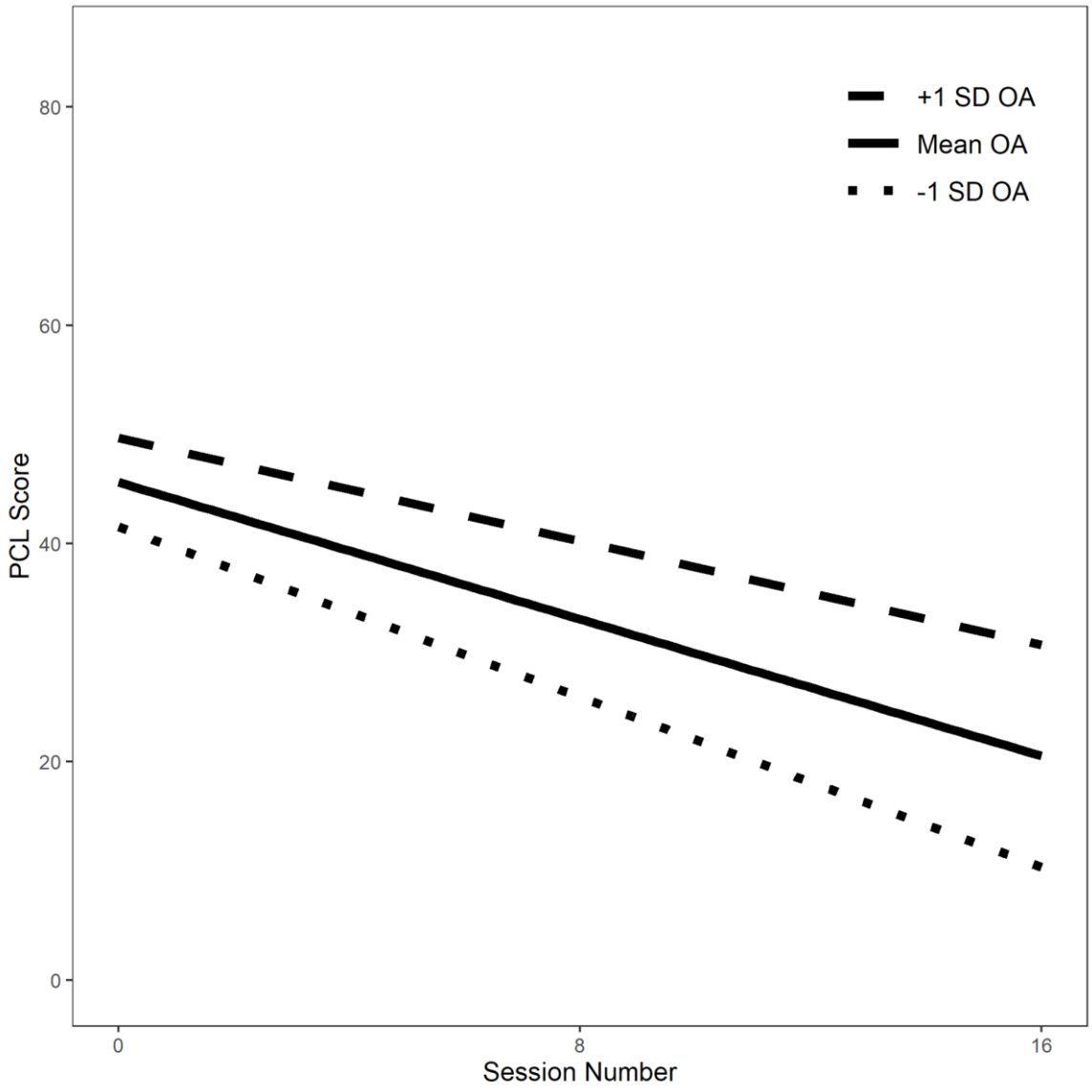
The Estimated Relation between PTSD Symptoms and the Number of Treatment Sessions, when All Other Predictors Are at their Average



Note. This figure displays the estimated population-level relation between PTSD symptoms and the number of trauma-focused treatment sessions over the course of treatment. PCL = PTSD Checklist 5.

Figure 2

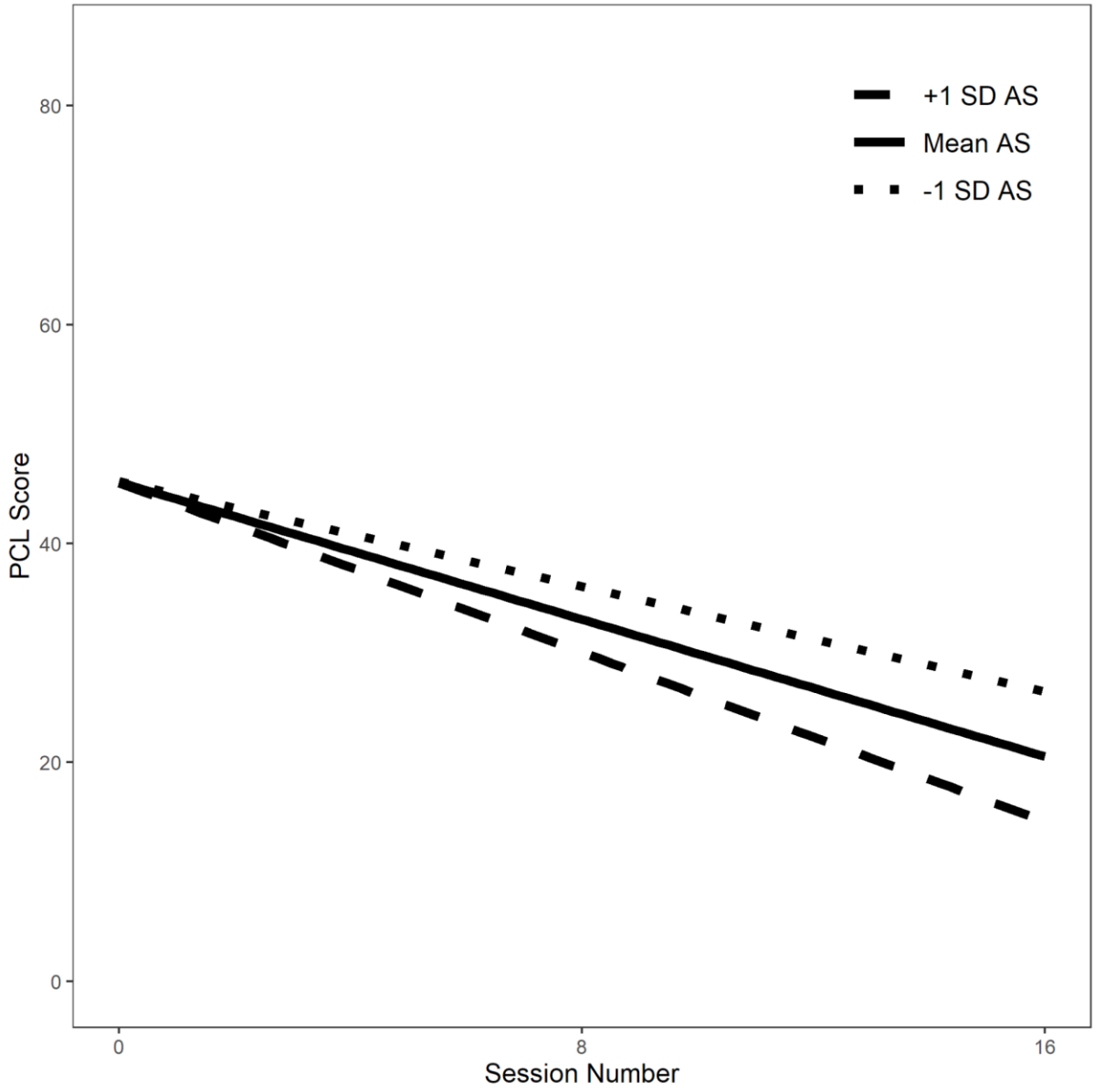
Simple slopes for the cross-level moderation of Overaccommodation on the Rate of Symptom Change During Treatment



Note. This figure displays the predicted values of PTSD symptoms over 16 sessions conditional on overaccommodation scores at mean and +/- 1 SD levels. PCL = PTSD Checklist 5. OA = overaccommodation.

Figure 3

Simple slopes for the cross-level moderation of Assimilation on the Rate of Symptom Change During Treatment



Note. This figure displays the predicted values of PTSD symptoms over 16 sessions conditional on assimilation scores at mean and +/- 1 SD levels. PCL = PTSD Checklist 5. AS = assimilation.