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Supplementary Information for

Linguistic measures of psychological distance track symptom levels and treatment outcomes in a large set of psychotherapy transcripts

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Supplementary Text 1: Testing the Traditional Linguistic Distance Measure

We initially quantified linguistic distance using a traditional approach, following prior research associating this metric with psychological distance and emotion regulation (1–3). Linguistic Inquiry and Word Count (LIWC; Pennebaker, Booth, & Francis, 2007) software was used to compute the percentage of words that fall into each component of the linguistic distance composite (i.e., first-person singular pronouns, present-tense verbs, discrepancy words, articles, and words longer than 6 letters). These percentages were z-scored across participants, and use of first-person singular pronouns, present-tense verbs, and discrepancy words were reverse-scored by multiplying z-scores by -1. Resulting scores were averaged to produce linguistic distance scores for each text message. However, the behavior of this measure was confusing: It was negatively related to internalizing symptoms, β_e=-.06, p_e<.001, $R^2_{ße}$=.02, but it *decreased* over time in treatment, β_e=-.05, p_e<.001, $R^2_{ße}$=.01. We conducted additional analyses in the exploratory dataset to elucidate why this measure suggested that higher distancing was related to better mental health but also decreased over time, as mental health improved.

Because prior studies using this approach did not have a longitudinal structure, we sought to verify that this approach indeed captured how distanced individuals were within a longitudinal design. The traditional measure of linguistic distance described above presupposes that having a larger proportion of words in a passage that refer to "close" psychological targets (i.e., present-tense verbs and first-person singular pronouns) signifies lower distance. In longitudinal designs, it is possible that changes in use close words across time do not necessarily imply *opposite* changes in distanced words across time. If so, one cannot infer shifts in psychological distance from use of close words alone. Instead, it may be necessary to compute *relative* measures of linguistic distance, in which use of close words (i.e., the number of present-tense verbs and first-person singular pronouns in a text message) are standardized relative to their relevant word classes (i.e., the overall number of verbs and pronouns, respectively).

Consequently, we investigated how subcomponents of the traditional linguistic distance measure varied across time in clients' text messages in the exploratory dataset. We observed that the percentage of words in clients' text messages that were both present-tense verbs, β_e=.14, p_e<.001, $R^2_{ße}$=.06, and first-person singular pronouns, β_e=.06, p_e<.001, $R^2_{ße}$=.01, increased across time in therapy. Because these word types connote psychological "closeness," this resulted in initial analyses showing that the traditional linguistic distance measure *decreased* over therapy (see above), contrary to hypotheses. However, when we examined words that connote psychological distance, we found that clients' use of past-tense verbs, β_e=.13, p_e<.001, $R^2_{ße}$=.05, and future-tense verbs, β_e=.05, p_e<.001, $R^2_{ße}$=.01, also increased across therapy, as did use of pronouns that were not first-person singular (i.e., words like "you," "we," "she," "he," and "they"), β_e=.05, p_e<.001, $R^2_{ße}$=.01. These baseline shift in clients' use of verbs and pronouns across time in therapy raised theoretical concerns with using the traditional measure of linguistic distance: Even though clients were using more "close" words at the end of treatment, it is problematic to conclude that they were less distanced if they *also* used more "distanced" words. Instead, relative measures of linguistic distance that controlled for baseline shifts in verb and pronoun use across treatment were needed.

Following preregistration, we conducted the analyses listed above in the validation dataset, finding consistent results. In the validation dataset, the traditional measure of linguistic distance was negatively related to symptoms, β_v=-.07, p_v<.001, $R^2_{ßv}$=.05, but it also decreased across time in therapy, β_v=-.06, p_v<.001, $R^2_{ßv}$=.01. Although present-tense verb use rose across time, β_v=.11, p_v<.001, $R^2_{ßv}$=03, so did past-tense verb use, β_v=.12, p_v<.001, $R^2_{ßv}$=.04, and future-tense verb use, β_v=.07, p_v<.001, $R^2_{ßv}$=.02. Similarly, although first-person singular pronoun use rose across time in therapy, β_v=.07, p_v<.001, $R^2_{ßv}$=.01, so did use of non-first-person singular pronouns, β_v=.05, p_v<.001, $R^2_{ßv}$=.01. As such, we were justified in using the relative measures of temporal and social distance in both the exploratory and validation datasets. We then averaged these together to form a single measure of linguistic distance. Even though we developed this method to account for longitudinal general increases in use of pronouns and verbs, this approach could also be fruitfully applied in cross-sectional studies that don't have a longitudinal design.

Supplementary Text 2: Discussion of Supplementary Analyses in Tables S1 and S2

Here, we give a general summary and discussion of the supplementary analyses that focus on the temporal and social subcomponents of linguistic distancing and anxiety/depression symptoms. These results are presented in Tables S1-S2 and Figures S2-S4.

Temporal and social subcomponents. Preregistered analyses used temporal distance (i.e., the proportion of verbs that were not present-tense) and social distance (i.e., the proportion of pronouns that were not first-person singular) as primary dependent variables. In the process of revising the paper, we decided to average together these values into a single measure of linguistic distance. Results are largely identical for all three measures, but we present statistics of these subcomponents in Table S1. Both social and temporal measures increased across time in treatment and were negatively associated with internalizing symptoms at between-person and within-person levels. Notably, the between-person relation between internalizing symptoms and social distance showed the largest linguistic effect (βs = .19-.21). Mediation models were inconsistent, with only the temporal distance mediation returning a significant indirect effect in the validation dataset. As such, it's possible that shifts in verb use may play a small explanatory role in symptom reduction. Cluster analyses revealed an interesting divergence between temporal and social distance. Clusters based on temporal distance trajectories differed in symptom change scores but not in baseline internalizing symptom levels, whereas clusters based on social distance trajectories differed in baseline and final internalizing symptom levels but not symptom change scores (see Figures S2-S5). These results replicated in the validation dataset.

These subcomponent analyses lead to similar conclusions as results for the combined measure presented in the main text: Linguistic distance rises over therapy, tracks changing symptom levels, and can be used to discover groups of participants who vary in their symptom severity and treatment response. However, there are also some interesting qualitative differences between temporal and social distance that could motivate future research on how these dimensions might relate to symptoms in slightly different ways. In particular, the regression, mediation, and clustering results suggest that temporal distance (i.e., verb use) may more strongly relate to *within-person* symptom changes, whereas social distance (i.e., pronoun use) may more strongly relate to *between-person* symptom severity. In other words, social distance may provide a trait-like measure of overall internalizing dysfunction, with more first-person singular pronoun use reflecting a more static between-person vulnerability to internalizing problems, even if the individual's symptoms are retreating. This aligns with the notion that major depressive disorder is a *lifetime* diagnosis that merely has phasic *episodes* of illness (5). As such, pronoun use may reflect the cognitive vulnerabilities that characterize people with major depressive disorder, even when their symptoms are in remission (6–10).

Temporal distance may instead reflect within-person shifts in one's retreating symptoms (e.g., the prevalence of rumination or worry—repetitively thinking about past or future negative experiences; [11–13]). Shifts in temporal distance could also reflect other active components of psychological treatment, like *meaning making* (i.e., being able to create a positive integrated narrative about prior experiences [14]). It is worth noting that in the temporal distance clustering for both exploratory and validation datasets, clusters A and B began with similar levels of linguistic distance but achieved significantly different final internalizing symptom scores, and the same is true for clusters C and D. These differences between groups are likely due to their different slopes of linguistic distance over time, further supporting the idea that increasing linguistic distance reflects treatment gains. Future research that parses temporal and social distance at both the linguistic and phenomenological levels (i.e., assessing client's experienced tendency to dilate their psychological focus away from themselves and/or the present moment) could shed further light on these hallmark symptoms of depression and anxiety, as well as the role of this process in successful treatment.

Anxiety and depression symptoms. As can be seen in Table S2, analyses of anxiety and depression scores reveal results that are largely all consistent with what was reported in the main text when the combined internalizing symptom measure was used. Nonetheless, we present statistics from these highly granular analyses for thoroughness in case they are useful for future meta-analyses and to transparently show how summing these scores did or did not affect results. Inconsistencies across measures were constrained to: (i) temporal distance was an inconsistent mediator of depression and anxiety symptoms across the exploratory and validation datasets and (ii) depression scores were significantly different at baseline for temporal distance clusters in the exploratory dataset.

Table S1. Results of analyses testing relations between temporal and social linguistic distance subcomponents and internalizing symptoms.

	Exploratory Dataset		Validation Dataset	
Analysis	Statistic	Significance	Statistic	Significance
Linguistic distance components over time in treatment				
Temporal distance over time	β_e = .06	p_e < .001	β_v = .06	p_v < .001
Social distance over time	β_e = .05	p_e < .001	β_v = .05	p_v < .001
Symptoms and linguistic distance				
Symptoms and raw temporal distance	β_e = -.06	p_e < .001	β_v = -.08	p_v < .001
Symptoms and between-person variance in temporal distance	β_e = -.10	p_e < .001	β_v = -.09	p_v < .001
Symptoms and within-person variance in temporal distance	β_e = -.03	p_e < .001	β_v = -.05	p_v < .001
Symptoms and raw social distance	β_e = -.10	p_e < .001	β_v = -.12	p_v < .001
Symptoms and between-person variance in social distance	β_e = -.19	p_e < .001	β_v = -.21	p_v < .001
Symptoms and within-person variance in social distance	β_e = -.03	p_e = .001	β_v = -.04	p_v = .001
Bayesian mediation analyses				
c path (Bayesian estimate of symptom change over time)	b_e = -.12	[-.13, -.12]	b_v = -.12	[-.13, -.12]
Indirect effect of within-person temporal distance mediating changes in symptoms over time	b_e = -.0003, .2% mediated	[-.0006, .00005]	b_v = -.0005 .4% mediated	[-.001, -.00005]
a path for temporal distance mediation	b_e = .02	[.01, .03]	b_v = .02	[.01, .03]
b path for temporal distance mediation	b_e = -.02	[-.03, .002]	b_v = -.02	[-.04, -.004]
c' path for temporal distance mediation	b_e = -.12	[-.13, -.12]	b_v = -.12	[-.13, -.12]
Indirect effect of within-person social distance mediating changes in symptoms over time	b_e = -.0001, .1% mediated	[-.0004, .0001]	b_v = -.0002 .2% mediated	[-.0006, .0001]
a path for social distance mediation	b_e = .02	[.01, .03]	b_v =.02	[.01, .03]
b path for social distance mediation	b_e = -.005	[-.02, .01]	b_v = -.01	[-.03, .004]
c' path for social distance mediation	b_e = -.12	[-.13, -.12]	b_v = -.12	[-.13, -.12]
Finite mixture regressions				
Difference in baseline symptoms across temporal distance clusters	F_e = 2.59	p_e = .051	F_v = 2.35	p_v = .071
Difference in final symptoms across temporal distance clusters	F_e = 13.10	p_e < .001	F_v = 14.74	p_v < .001
Difference in change in symptoms across temporal distance clusters (controlling for baseline)	F_e = 6.90	p_e < .001	F_v = 9.24	p_v < .001
Difference in baseline symptoms across social distance clusters	F_e = 17.03	p_e < .001	F_v = 11.23	p_v < .001
Difference in final symptoms across social distance clusters	F_e = 18.82	p_e < .001	F_v = 10.50	p_v < .001
Difference in change in symptoms across social distance clusters (controlling for baseline)	F_e = 1.54	p_e = .203	F_v = 0.69	p_v = .558

Notes: Beta estimates from Bayesian mediation analyses represent the median of posterior estimates of the indirect effect, and values in square brackets represent the 95% credible range of this estimate.

Table S2. Results of analyses testing relations between temporal and social linguistic distance components and depression and anxiety symptoms.

	Depression Symptoms				Anxiety Symptoms			
	Exploratory Dataset		Validation Dataset		Exploratory Dataset		Validation Dataset	
Analysis	Statistic	Significance	Statistic	Significance	Statistic	Significance	Statistic	Significance
Symptoms over time	β_e = -.37	p_e < .001	β_v = -.38	p_v < .001	β_e = -.40	p_e < .001	β_v = -.41	p_v < .001
Symptoms and linguistic distance								
Symptoms and raw temporal distance	β_e = -.04	p_e < .001	β_v = -.07	p_v < .001	β_e = -.08	p_e < .001	β_v = -.07	p_v < .001
Symptoms and between-person variance in temporal distance	β_e = -.09	p_e < .001	β_v = -.06	p_v = .005	β_e = -.11	p_e < .001	β_v = -.10	p_v < .001
Symptoms and within-person variance in temporal distance	β_e = -.02	p_e = .041	β_v = -.05	p_v < .001	β_e = -.05	p_e < .001	β_v = -.04	p_v < .001
Symptoms and raw social distance	β_e = -.11	p_e < .001	β_v = -.12	p_v < .001	β_e = -.09	p_e < .001	β_v = -.10	p_v < .001
Symptoms and between-person variance in social distance	β_e = -.20	p_e < .001	β_v = -.23	p_v < .001	β_e = -.15	p_e < .001	β_v = -.17	p_v < .001
Symptoms and within-person variance in social distance	β_e = -.02	p_e = .007	β_v = -.03	p_v = .007	β_e = -.03	p_e = .004	β_v = -.04	p_v < .001
Bayesian mediation analyses								
c path (Bayesian estimate of symptom change over time)	b_e = -.06	[-.06, -.06]	b_v = -.06	[-.06, -.06]	b_e = -.06	[-.07, -.06]	b_v = -.06	[-.07, -.06]
Indirect effect of within-person temporal distance mediating changes in symptoms over time	**b_e = -.00002, .1% mediated**	**[-.0002, .0002]**	**b_v = -.0003 .5% mediated**	**[-.0006, -.0001]**	**b_e = -.0003, .4% mediated**	**[-.0005, -.0001]**	**b_v = -.0002 .3% mediated**	**[-.0004, .00005]**
b path for temporal distance mediation	**b_e = -.001**	**[-.01, .008]**	**b_v = -.01**	**[-.03, -.003]**	**b_e = -.01**	**[-.02, -.006]**	**b_v = -.01**	**[-.02, .002]**
c' path for temporal distance mediation	b_e = -.06	[-.06, -.06]	b_v = -.06	[-.06, -.06]	b_e = -.06	[-.06, -.06]	b_v = -.06	[-.07, -.06]
Indirect effect of within-person social distance mediating changes in symptoms over time	b_e = -.0001, .1% mediated	[-.0002, .0001]	b_v = -.0001 .2% mediated	[-.0003, .0001]	b_e = -.00004, .1% mediated	[-.0002, .0001]	b_v = -.0001 .2% mediated	[-.0003, .00005]
b path for social distance mediation	b_e = -.003	[-.01, .006]	b_v = -.005	[-.01, .005]	b_e = -.002	[-.01, .006]	b_v = -.01	[-.02, .002]
c' path for social distance mediation	b_e = -.06	[-.06, -.06]	b_v = -.06	[-.06, -.06]	b_e = -.06	[-.06, -.06]	b_v = -.06	[-.06, -.06]
Finite mixture regressions								
Difference in baseline symptoms across temporal distance clusters	**F_e = 3.19**	**p_e = .023**	F_v = 1.59	p_v = .191	F_e = 1.52	p_e = .207	F_v = 2.56	p_v = .054
Difference in final symptoms across temporal distance clusters	F_e = 12.29	p_e < .001	F_v = 9.98	p_v < .001	F_e = 10.99	p_e < .001	F_v = 17.38	p_v < .001
Difference in change in symptoms across temporal distance clusters (controlling for baseline)	F_e = 4.44	p_e = .004	F_v = 6.21	p_v < .001	F_e = 8.17	p_e < .001	F_v = 9.99	p_v < .001
Difference in baseline symptoms across social distance clusters	F_e = 21.68	p_e < .001	F_v = 16.50	p_v < .001	F_e = 7.36	p_e < .001	F_v = 3.97	p_v = .008
Difference in final symptoms across social distance clusters	F_e = 20.95	p_e < .001	F_v = 11.50	p_v < .001	F_e = 12.49	p_e < .001	F_v = 7.36	p_v < .001
Difference in change in symptoms across social distance clusters (controlling for baseline)	F_e = 2.61	p_e = .050	F_v = 1.26	p_v = .285	F_e = 1.11	p_e = .344	F_v = 2.60	p_v = .051

Notes: Boldfaced text indicates that the significance of the result differs from expectations such that it was discussed in the results section of the main text. Beta estimates from Bayesian mediation analyses represent the median of posterior estimates of the indirect effect, and values in square brackets represent the 95% credible range of this estimate

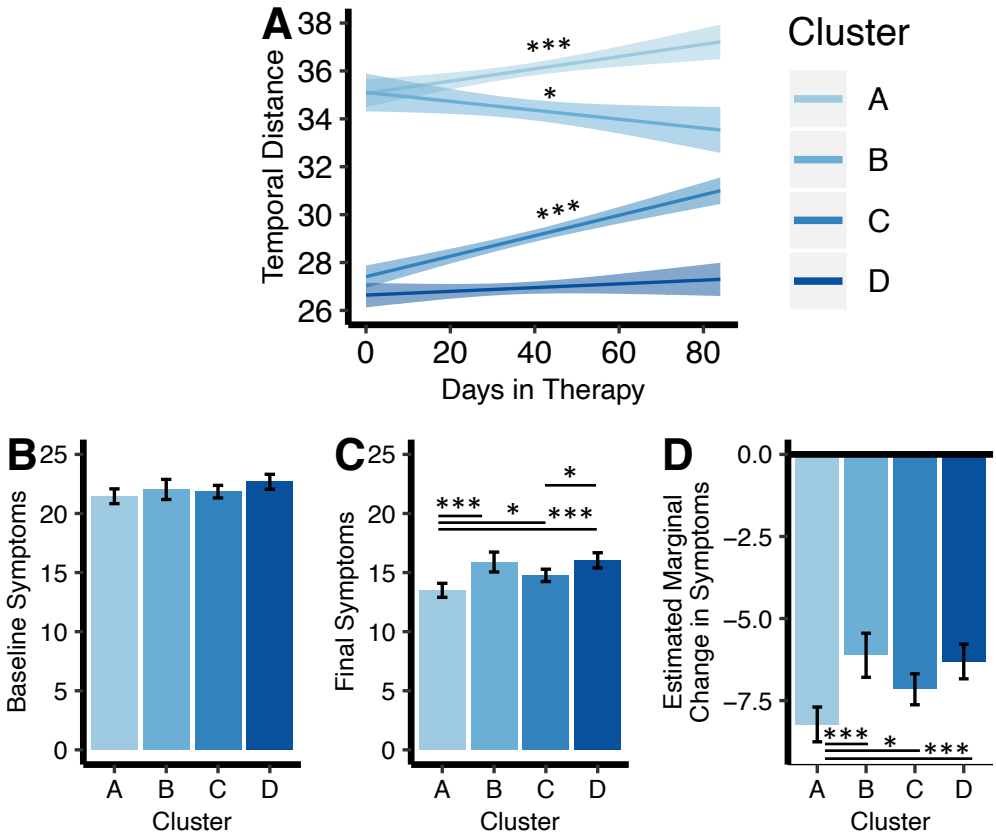

Figure S1. Results of the finite mixture regression clustering participants in the exploratory dataset based on temporal distance. (A) Four clusters were identified. Temporal distance of cluster A_e started high and rose over therapy, β_e=.07, p_e<.001, $R^2_{ße}$=.02, N_e=958, cluster B_e started high and fell over therapy, β_e=-.05, p_e=.045, $R^2_{ße}$=.01, N_e=596, cluster C_e started low and rose over therapy β_e=.15, p_e<.001, $R^2_{ße}$=.07, N_e=1,209, and cluster D_e started low and did not significantly change over therapy, β_e=.02, p_e=.241, $R^2_{ße}$=.002, N_e=964. (B) Clusters did not differ significantly in baseline internalizing symptoms. (C) Clusters differed significantly in final internalizing symptoms, with cluster A reporting significantly fewer symptoms than all other clusters, and cluster C reporting fewer symptoms than cluster D. (D) Clusters differed in their average symptom change over the course of treatment (after controlling for baseline symptom levels), with cluster A experiencing greater reductions than all other clusters. As such, clustering participants based on temporal distance revealed groups of participants who varied in their symptom gains over and above similar baseline symptom levels, with the two clusters that had the strongest increases in temporal distance having lower final symptom scores. *** p < .001, ** p < .01, * p < .05.

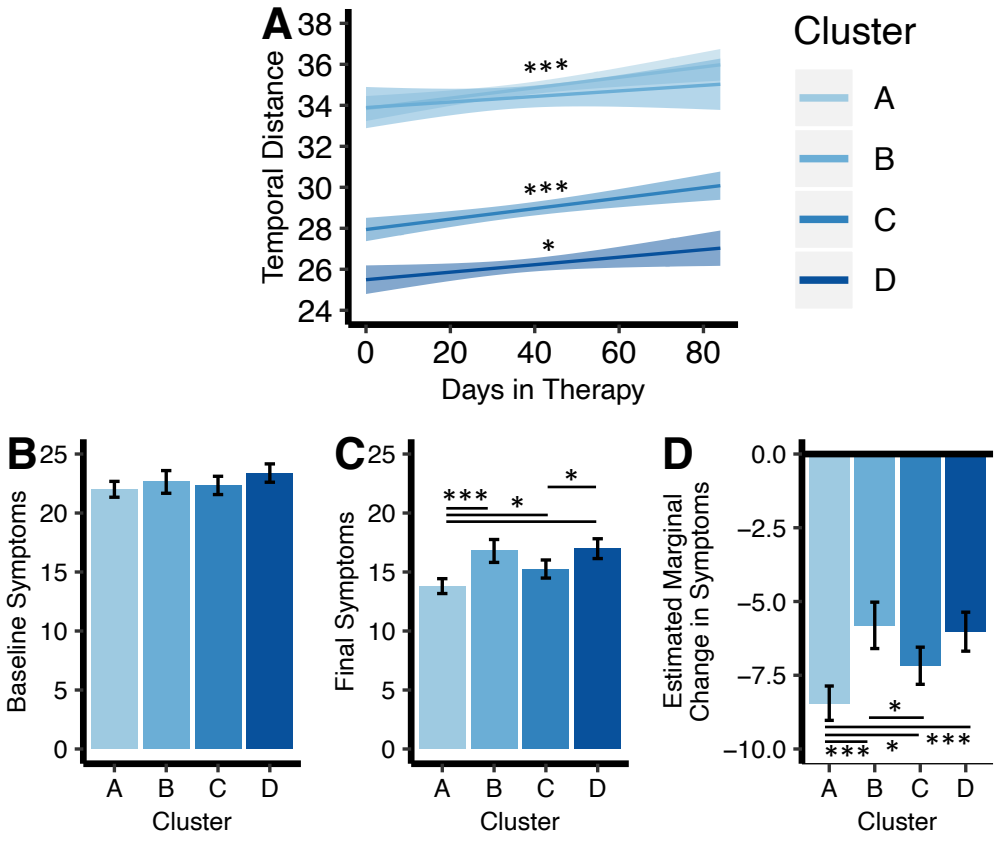

Figure S2. Results of the finite mixture regression clustering participants in the validation dataset based on temporal distance. (A) Four clusters were identified, with temporal distance of cluster A_v starting high and increasing over time β_v=.07, p_v<.001, $R^2_{\beta v}$=.02, N_v=787, cluster B_v starting high and not significantly changing over time, β_v=.03, p_v=.264, $R^2_{\beta v}$=.003, N_v=430, cluster C_v starting low and increasing over time, β_v=.09, p_v<.001, $R^2_{\beta v}$=.03, N_v=672, and cluster D_v starting low and increasing over time, β_v=.05, p_v=.034, $R^2_{\beta v}$=.008, N_v=611. (B) Clusters did not differ significantly in baseline internalizing symptoms. (C) Clusters differed significantly in final internalizing symptoms, with cluster A reporting significantly fewer symptoms than all other clusters, and cluster C reporting fewer symptoms than cluster D. (D) Clusters differed in their average symptom change over the course of treatment (final – baseline, controlling for baseline), with cluster A experiencing greater reductions than all other clusters, and cluster C experiencing greater reductions than cluster B. These results largely replicate those of the exploratory dataset. *** p < .001, ** p < .01, * p < .05.

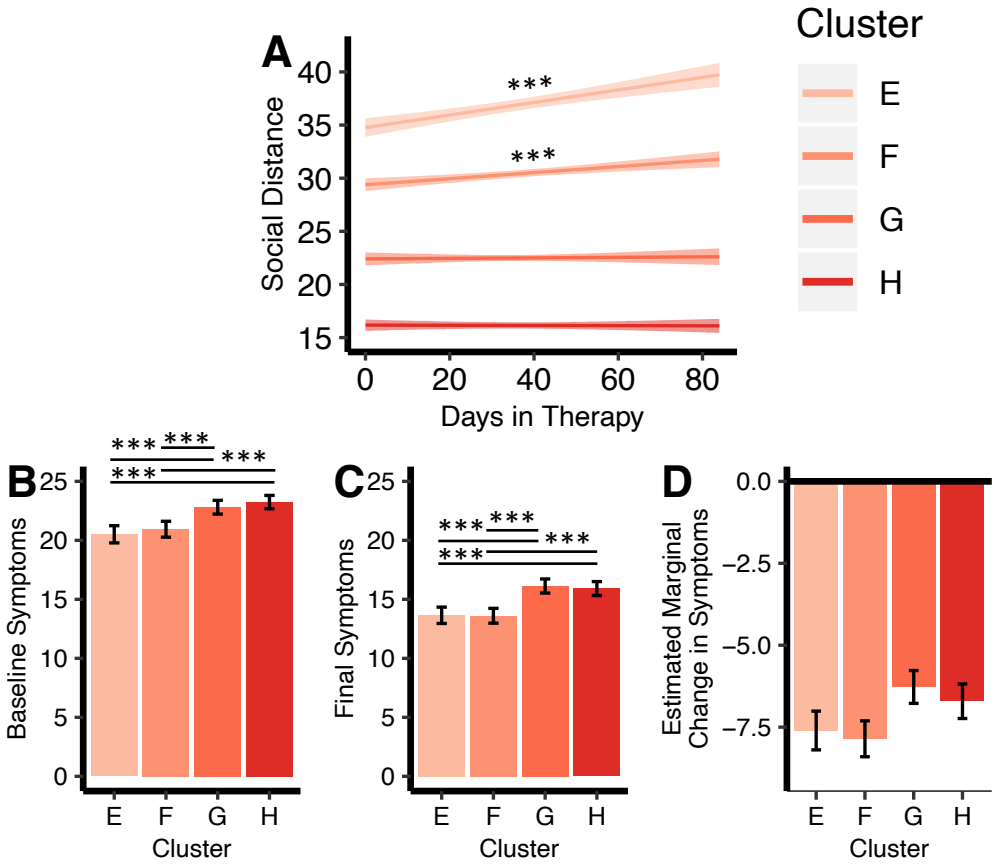

Figure S3. Results of the finite mixture regression clustering participants in the exploratory dataset based on social distance. (A) Four clusters were identified. Social distance for cluster E_e started high and increased over therapy, β_e=.13, p_e<.001, $R^2_{\beta e}$=.05, N_e=775., cluster F_e started lower and increased, β_e=.08, p_e<.001, $R^2_{\beta e}$=.02, N_e=902. cluster G_e started lower still and did not change significantly over treatment, β_e=.01, p_e=.758, $R^2_{\beta e}$=.0001, N_e=1,077, and cluster H_e started lowest of all and did not change significantly, β_e=-.003, p_e=.898, $R^2_{\beta e}$=.00002, N_e=973. (B) Clusters differed significantly in baseline internalizing symptoms, with clusters E and F reporting significantly fewer symptoms than clusters G and H. (C) Clusters also differed significantly in final internalizing symptoms, with clusters E and F reporting significantly fewer symptoms than clusters G and H. (D) However, clusters did not differ significantly in their average symptom change over the course of therapy (final – baseline, controlling for baseline scores). As such, clustering based on social distance revealed groups of participants that varied tonically in their levels of internalizing symptoms but not their treatment response. *** p < .001.

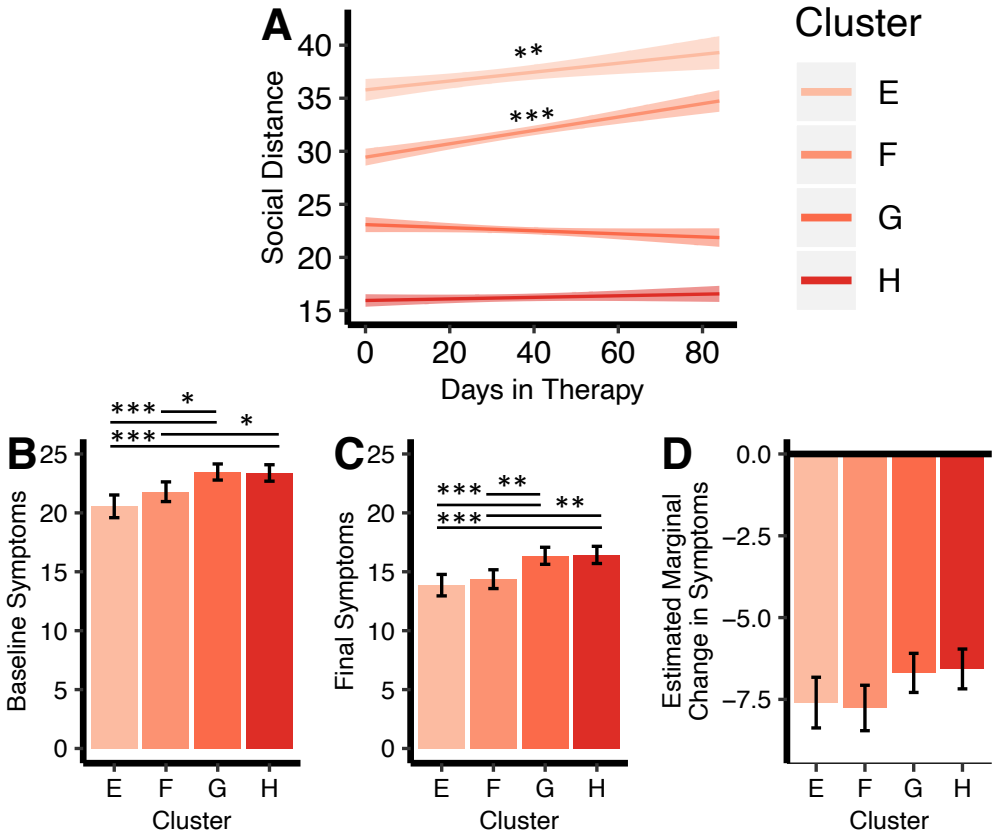

Figure S4. Results of the mixture regression clustering participants in the validation dataset based on social distance. (A) Four clusters were identified, with cluster E_v starting high and increasing over time β_v=.09, p_v=.002, $R^2_{\beta v}$=.04, N_v=453, cluster F_v starting slightly lower and increasing over time, β_v=.17, p_v<.001, $R^2_{\beta v}$=.08, N_v=560, cluster G_v starting lower and not significantly changing over time, β_v=-.04, p_v=.097, $R^2_{\beta v}$=.004, N_v=757, and cluster H_v starting the lowest and not significantly changing over time, β_v=.02, p_v=.289, $R^2_{\beta v}$=.002, N_v=730. (B) Clusters differed significantly in baseline internalizing symptoms, with clusters E and F reporting significantly fewer symptoms than clusters G and H. (C) Clusters also differed significantly in final internalizing symptoms, with clusters E and F reporting significantly fewer symptoms than clusters G and H. (D) Clusters did not differ significantly in their average symptom change over the course of therapy. Results replicate the exploratory dataset. *** p < .001, ** p < .01, * p < .05.

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