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Latent Trajectories of Trauma Symptoms and Resilience: The 3-Year Longitudinal Prospective USPER Study of Danish Veterans Deployed in Afghanistan

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ABSTRACT

Objective: To identify trajectories of posttraumatic stress disorder (PTSD) symptoms from before to 2.5 years after deployment and to assess risk factors for symptom fluctuations and late-onset PTSD.

Method: 743 soldiers deployed to Afghanistan in 2009 were assessed for PTSD symptoms using the PTSD Checklist (PCL) at 6 occasions from predeployment to 2.5 years postdeployment (study sample = 561). Predeployment vulnerabilities and deployment and postdeployment stressors were also assessed.

Results: Six trajectories were identified: a resilient trajectory with low symptom levels across all assessments (78.1%) and 5 trajectories showing symptom fluctuations. These included a trajectory of late onset (5.7%), independently predicted by earlier emotional problems (OR = 5.59; 95% CI, 1.57–19.89) and predeployment and postdeployment traumas (OR = 1.10; 95% CI, 1.04–1.17 and OR = 1.13; 95% CI, 1.00–1.26). Two trajectories of symptom fluctuations in the low-to-moderate range (7.5% and 4.1%); a trajectory of symptom relief during deployment, but with a drastic increase at the final assessments (2.0%); and a trajectory with mild symptom increase during deployment followed by relief at return (2.7%) were also found. Symptom fluctuation was predicted independently by predeployment risk factors (depression [OR = 1.27; 95% CI, 1.16–1.39], neuroticism [OR = 1.10; 95% CI, 1.00–1.21], and earlier traumas [OR = 1.09; 95% CI, 1.03–1.16]) and deployment-related stressors (danger/injury exposure [OR = 1.20; 95% CI, 1.04–1.40]), but not by postdeployment stressors.

Discussion: The results confirm earlier findings of stress response heterogeneity following military deployment and highlight the impact of predeployment, perideployment, and postdeployment risk factors in predicting PTSD symptomatology and late-onset PTSD symptoms.

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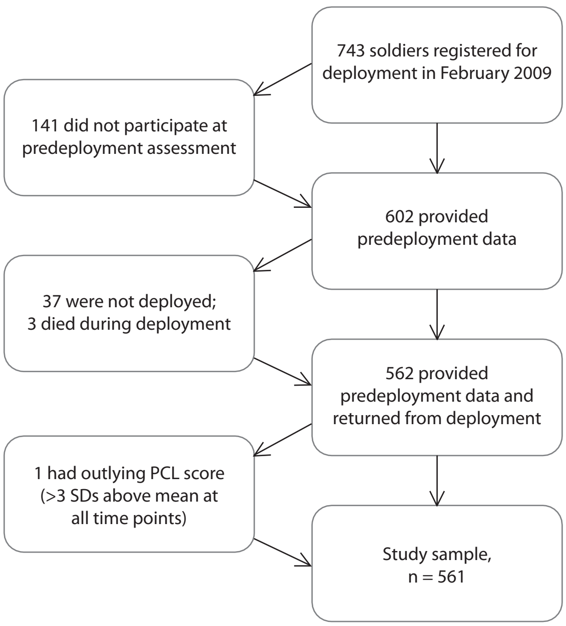
Recent longitudinal studies[1,2] have identified heterogeneous trajectories of posttraumatic stress disorder (PTSD) symptoms following exposure to potentially traumatic events during military deployment. This information questions the assumption of a homogenous stress response pattern and suggests that the complex nature of postdeployment stress responses is not adequately captured by presence or absence of a PTSD diagnosis.[3] Hence, data-driven methods that can extract heterogeneous posttraumatic stress response patterns might better identify natural fluctuations of PTSD symptomatology over time.[4,5]

Longitudinal studies[6,7] have also challenged the assumption of a dose-response relationship between magnitude of the traumatic event and posttraumatic stress reactions, since the onset and course of PTSD symptoms cannot be explained by the size and nature of the stressor alone. Hence, other potential risk indicators have been studied: personal characteristics and vulnerabilities, including personality traits, preexisting PTSD symptomatology, and adverse childhood experiences have been found to influence PTSD symptom development and maintenance,[8–11] as have social support[12] and occurrence of additional stressful life events.[13] However, uncertainties regarding the relative importance of predeployment vulnerabilities, deployment, and homecoming stressors remain. Furthermore, in some cases, onset of PTSD might be delayed, ie, symptoms appear 6 months or more after the traumatic experience.[14] However, underlying mechanisms of delayed-onset PTSD are not yet fully understood.

In an earlier wave of the current study, Berntsen and colleagues[15] identified 6 unique trajectories of PTSD symptoms from before to 7 months after deployment to Afghanistan: 2 resilient and 4 nonresilient trajectories. Membership of symptomatic trajectories was predicted by predeployment emotional problems and predeployment traumas, but not by deployment-related stressors. Given the relatively short follow-up time of this earlier wave (the final assessment was 7 months' postdeployment), the authors did not investigate whether postdeployment trauma exposure was related to PTSD symptomatology. Understanding the relative contribution of predeployment, perideployment, and postdeployment vulnerability factors in predicting trajectory membership may guide future efforts to prevent and treat PTSD symptomatology.

The current study is a follow-up on Berntsen et al[15] conducted 2.5 years after the soldiers' return from deployment and has 2 aims. First, we assess stress response heterogeneity through identification of long-term PTSD symptom trajectories from before to 2.5 years after return. Second, we assess the relative contribution of predeployment vulnerabilities, deployment stressors, and postdeployment stressors in describing the different PTSD symptom trajectories, with a special focus on individuals with late-onset PTSD symptomatology.

Figure 1. Flowchart of Participant Inclusion



Abbreviations: PCL = PTSD Checklist, PTSD = posttraumatic stress disorder.

Clinical Points

- Prior traumas, higher trait neuroticism, and a history of depression increase the risk of posttraumatic stress disorder (PTSD) symptom fluctuation following military combat.
- Clinicians may identify particularly vulnerable traumatized soldiers by assessing for prior traumas, higher trait neuroticism, and history of depression.
- Clinicians should pay attention to additional life stressors occurring after deployment, since such events increase the risk for late-onset PTSD symptoms.

METHOD

Sample and Procedure

The current study is part of a prospective, longitudinal study of 743 Danish soldiers deployed to Afghanistan in 2009 (the USPER study) and encompasses the entire population deployed to Afghanistan at the time (for details, see Berntsen et al[15]). Written informed consent was obtained from all the participants, and the study was approved by the Danish Data Protection Agency (Copenhagen, Denmark). The soldiers were assessed at 6 occasions: 5–6 weeks before deployment (T1), during deployment (T2), 1–3 weeks after deployment at homecoming meetings (T3), and 2 months (T4), 7 months (T5), and 2.5 years after return by questionnaires distributed by mail.

A flowchart of participant inclusion can be seen in Figure 1. Of the total population (N = 743), 602 provided predeployment data, and, of these, 37 did not eventually deploy, and 3 died during deployment. Finally, 1 was excluded due to outlying PTSD Checklist (PCL) score (> 3 SDs) at all assessments. Hence, the study sample consisted of 561 participants. Compared to participants from the original sample who did not deploy or who died during deployment (n = 40), the 561 included participants had served significantly longer in the military ($P < .01$) and reported lower levels of neuroticism ($P = .02$)[16] and depression ($P < .01$)[17] and lower PCL score prior to deployment ($P = .03$). There were no differences in gender distribution, marital status, age, level of education, long- or short-term employment, number of prior deployments, or personality traits other than neuroticism.

Of the 561 soldiers in the study sample, 86.8% (n = 487) also participated at T2, 82.2% (n = 461) at T3, 51.2% (n = 287) at T4, 45.5% (n = 255) at T5, and 81.3% (n = 456) at T6. For the latent growth mixture modeling (LGMM) analysis, we included all participants who participated at T1 to avoid listwise deletion. To test whether this relatively wide inclusion criterion caused bias, we also conducted the LGMM including only participants who provided data in at least 4 assessments (n = 416). This procedure produced a largely identical model to the one including all participants. Hence, to maintain larger sample size and power for the post hoc analysis, we included all participants in the model.

Measures

The PTSD Checklist, Civilian Version. The PTSD Checklist, Civilian Version (PCL-C)[18] is a 17-item self-report measure assessing PTSD symptoms as described in *DSM-IV*. Respondents rate each item using a 5-point Likert scale, yielding a summary score of symptom severity (range, 17–85). The PCL-C includes military trauma as well as trauma endorsed outside the military. The PCL-C has demonstrated high internal consistency ($\alpha = .94$),[18] which was also found in our sample ($\alpha = .94$).

Assessment of traumatic life events before and after deployment. The Traumatic Life Events Questionnaire (TLEQ),[19] accommodated to a cohort of Danish soldiers, was administered before deployment. The TLEQ items are designed to meet criterion A1 of the *DSM-IV* PTSD diagnosis.[14] At T6, we administered an adapted version of the TLEQ, assessing the occurrence of traumatic events occurring after deployment.

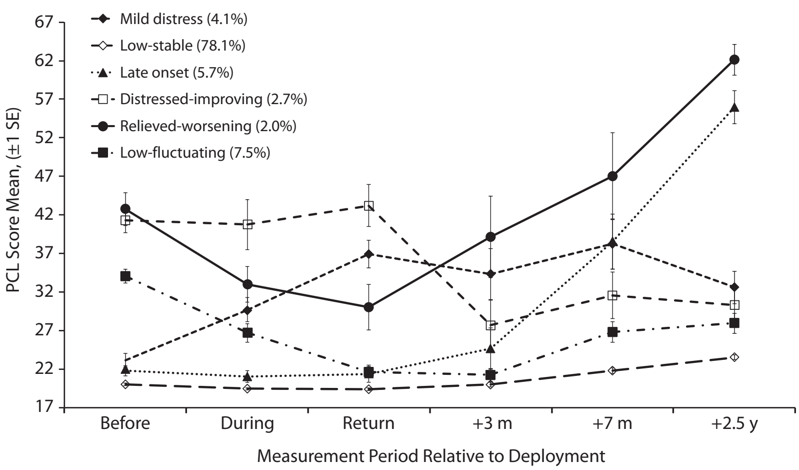
Additional questionnaires. To test predictors of trajectory membership, we included a wide range of variables that have previously been identified as predictors of PTSD or PTSD symptomatology.[9,20] The predeployment assessment included demographics as well as the Beck Depression Inventory-II (BDI-II),[17] NEO Personality Inventory,[16] the Multidimensional Scale of Perceived Social Support (MSPSS),[21] and a single item measuring earlier psychological or psychiatric treatment for emotional problems. At soldiers' return, the MSPSS was applied again alongside 4 single items measuring (1) the frequency of emotional stressful situations experienced during deployment (1 = never to 4 = very often), (2) the frequency of experienced or witnessed threat to life during deployment (0 = never to 6 = more than 5 times), (3) the occurrence of the soldier being wounded or injured

Table 1. Goodness-of-Fit Statistics for 1 to 8 Class Solutions

Model	AIC	BIC	Adj BIC	Entropy	LoMR Likelihood Ratio Test, P	Bootstrapped Likelihood Ratio Test
1 class	16,574.38	16,617.68	16,585.94			
2 classes	16,320.67	16,381.29	16,366.85	0.92	<.001	<.001
3 classes	16,128.74	16,206.68	16,149.54	0.93	.27	<.001
4 classes	16,003.76	16,099.02	16,029.18	0.93	.19	<.001
5 classes	15,933.67	16,046.25	15,936.71	0.93	.8	<.001
6 classes[a]	**15,836.67**	**15,966.56**	**15,871.32**	**0.93**	**.35**	**<.001**
7 classes	15,765.28	15,903.49	15,795.56	0.94	.11	<.001
8 classes	15,707.89	15,872.42	15,751.79	0.93	.21	<.001

[a]Bold indicates the selected model.
Abbreviations: AIC = Akaike information criterion, BIC = Bayesian information criterion, LoMR = Lo-Mendell-Rubin.

Figure 2. Developmental Trajectories of Posttraumatic Stress Disorder (PTSD) Symptoms at 6 Time Points Before, During, and After Deployment (N = 561)



Abbreviations: PCL = PTSD Checklist, SE = standard error.

(1 = yes, 0 = no), and (4) the occurrence of the soldier having killed an enemy during deployment (1 = yes, 0 = no). Combat exposure and danger/injury were assessed at return by using the respective Combat Exposure Scale[22] and a Danger/Injury Exposure Scale[15] developed by the Danish military. Finally, a single item at T6 assessed whether the solider had received psychological or psychiatric help since return.

Structured Clinical Interview for DSM-IV. At T6, 429 of the participants were assessed with the Structured Clinical Interview for *DSM-IV-TR* Axis I Disorders, Research Version, Patient Edition (SCID-I/P).[23] For this study, we utilized SCID data to assess the index trauma (for SCID procedure, see Karstoft et al[24]).

Data Analysis

We applied LGMM to empirically identify heterogeneous trajectories of PTSD symptoms over time and hierarchical multivariable logistic regressions to examine potential predictors of class membership. See Data Analysis and LGMM sections in the supplementary material for procedure and details of model estimation and selection. Post hoc univariate analyses and multivariable hierarchical logistic regression analyses are also described in Supplementary eAnalysis (available at PSYCHIATRIST.COM).

RESULTS

LGMM

We estimated LGMM models from 1 to 8 classes with free intercept variance and estimation of linear and quadratic terms. On the basis of fit indices, entropy, parsimony, and interpretability of the model as described in the supplement, we selected the 6-class model as optimal for our data (Table 1).

Six unique PTSD symptom trajectories were identified (Figure 2), for which we here present trajectory slopes (S) and quadratic (Q) estimates. The majority of the sample fell into a trajectory with low symptom levels across all 6 assessments (low-stable: n = 438 [78.1%]; S = −0.99, $P = .03$; Q = 0.34, $P < .001$). The second-largest group had mild symptoms before deployment, symptom decrease during deployment, and a mild symptom increase upon return (low-fluctuating: n = 42 [7.5%]; S = −9.08, $P < .001$; Q = 1.64, $P < .001$). One group had low initial symptoms, increasing to a subclinical level during and following deployment (mild distress: n = 23 [4.1%]; S = 8.37, nonsignificant [NS]; Q = −1.28, NS), while another group saw a mild symptom increase during deployment followed by relief at return (distressed-improving: n = 15 [2.7%]; S = 0.85, NS; Q = −0.69, NS). Further, a group had low-stable symptoms until 3 months after return, followed by a drastic symptom increase (late onset: n = 32 [5.7%]; S = −5.23, $P < .001$; Q = 2.36, $P < .001$). Finally, a small group had a temporary symptom relief during deployment, followed by a drastic symptom increase continuing through 2.5 years after return (relieved-worsening: n = 11 [2.0%]; S = −12.30, $P < .001$; Q = 3.32, $P < .001$).

In summary, the LGMM analysis identified 1 low-stable or *resilient* group with low PTSD symptom levels before, during, and after deployment. The remaining 5 groups had fluctuating symptom levels across the 6 assessments. To address differences between resilience and symptom fluctuation, we collapsed the 5 symptomatic classes to create a dichotomous outcome variable of resilience versus symptom fluctuation. This dichotomous variable is the primary outcome in the following predictor analysis. Further, in a second step, we compared the resilient trajectory to that of late onset to identify specific covariates of late-onset PTSD symptoms.

Index Trauma

SCID interview data (n = 429) at T6 showed that, for 85% of those who reported an index trauma, it was deployment related. For individuals in the symptomatic classes, the proportion was 89%. Of specific interest for this study, 95% of those who belonged to the late-onset trajectory reported a deployment-related index trauma. Further, for 73% of the late-onset individuals who reported a military-related index trauma, the index trauma occurred during the 2009 deployment or earlier, while the exact time of the index trauma mission was not clear for the remaining 22%.

Resilience Versus Symptom Fluctuation

Results from univariate analyses can be seen in Table 2. Significant predictors from the univariate analyses were subsequently entered into a 3-step multivariable hierarchical logistic regression analysis predicting membership of the resilient versus the symptom-fluctuation group* (Table 3). The final model (step 3) was statistically significant (n = 292; $\chi^2_{18} = 128.56$, $P < .001$) and correctly classified 63.8% of those in the symptomatic group and 95.6% of those in the resilient group (overall classification success rate = 89.2%).

In the final model, 4 variables significantly predicted membership of the symptom-fluctuation group. Higher predeployment depression, neuroticism, and more earlier traumas increased odds of symptomatic trajectory membership. More exposure to dangerous mission environments also increased the risk of belonging to the symptom-fluctuation group.

Resilient Group Versus Late-Onset Group

Table 4 shows univariate and multivariable hierarchical logistic regressions with the dichotomous variable of late onset versus resilience as the dependent variable. Predeployment emotional problems, exposure to more traumatic events prior to deployment, and exposure to more traumatic events after homecoming were significant covariates of membership in the late-onset trajectory.

Postdeployment Traumatic Life Events

A breakdown of the specific adverse life events reported by the resilient and the late-onset group showed that a significantly higher proportion of respondents in the late-onset group (n = 28) compared to the resilient group (n = 359) experienced accidents (39.3% vs 10.6%; OR = 5.47; 95% CI, 2.38–12.53), life-threatening disease (7.1% vs 1.4%; OR = 5.45; 95% CI, 1.01–29.44), robbery involving a weapon (14.3% vs 1.4%; OR = 11.80; 95% CI, 2.97–46.82), threat of death or serious bodily harm (39.3% vs 17.3%; OR = 3.10; 95% CI, 1.38–6.94), intimate partner abuse (10.7% vs 2.8%; OR = 4.19; 95% CI, 1.08–16.20), and other life-threatening or physically damaging event (25.0% vs 11.7%; OR = 2.52; 95% CI, 1.01–6.27) after homecoming and up to 2.5 years later (unadjusted analyses).

DISCUSSION

In this prospective study of Danish soldiers deployed to Afghanistan, 6 trajectories of PTSD symptoms related to military deployment were identified: a resilient trajectory, with low-stable PTSD symptoms from predeployment to 2.5-year postdeployment, and 5 trajectories showing varying degrees and fluctuations of PTSD symptoms. Except for the late-onset trajectory identified in our analysis, these trajectories are similar to the trajectories previously identified in this sample by Berntsen et al[15] from before deployment to 7-month postdeployment[15] and are consistent with several longitudinal studies that all demonstrate heterogeneity of posttraumatic stress responses related to military deployment.[1,2,15,25]

Importantly, our results demonstrate several unique posttraumatic stress response patterns with significant fluctuations over time (as seen by significant slopes and quadratic terms for 4 of 6 trajectories). Previous studies have investigated fluctuation of PTSD over time by evaluating individuals' diagnostic status in longitudinal designs.[26,27] However, such an approach does not accurately capture symptom fluctuations. The PTSD diagnosis is based on fulfilling a specific combination of symptoms within different symptom clusters, and, in some instances, even great changes in symptom level might not change diagnostic status. This can occur when an individual, in spite of significant reduction in symptom severity, still fulfills the cluster combination for PTSD diagnosis. The change in severity is therefore not captured when considering diagnostic status. Conversely, minor symptom-level changes might cause change in diagnostic status since change in just 1 symptom might cause fulfillment of the needed clusters. In this case, insignificant changes in severity cause change in diagnostic status.[3] The data-driven extraction of symptom trajectories applied in this study overcomes the caveats of a priori definitions of resilience and symptomatology by identifying latent groups and their fluctuations in symptomatology.

The results of our predictor analyses suggest that exposure to traumatic events, higher trait neuroticism, and higher depression score before deployment increases the risk of belonging to the symptom-fluctuation group. Similarly, feeling exposed to dangerous mission environments entails greater risk for PTSD symptomatology. This is consistent with longitudinal studies[1,2,15] showing that past traumatic events, neuroticism, and depression before deployment increase the risk of PTSD symptomatology over time. The results are also in line with other studies[28] finding that more war-zone stressors increase the risk of subsequent PTSD symptomatology.

Our findings underline that fluctuating PTSD symptom levels are explained by both factors prior to and during deployment. Hence, accurate predeployment prediction of postdeployment PTSD symptomatology might be difficult to achieve. Additionally, while overall classification accuracy and specificity based on predeployment factors alone were high (88.9% and 96.9%, respectively), sensitivity was low to moderate (56.9%). Adding deployment stressors (assessed at homecoming) increased sensitivity to 65.5% while retaining a high specificity (96.9%). Adding postdeployment trauma occurring until 2.5 years after return did not increase accuracy of classification into the resilient or the symptomatic group.

*Psychological or psychiatric treatment after deployment was not included as a predictor variable in the analyses, since this should be considered an outcome more than a predictor of trajectory membership.

Table 2. Comparison of Risk Factors Across the 6 Groups and the Comparison of Risk Factors for the Symptom-Fluctuation Group Versus the Resilient Group

Risk Factor[a]	Groups: (1) Low-Stable (n = 438)	(2) Low-Fluctuating (n = 42)	(3) Distressed-Improving (n = 15)	(4) Mild Distress (n = 23)	(5) Late Onset (n = 32)	(6) Relieved-Worsening (n = 11)	All Groups[b]	Symptom Fluctuation vs Resilient, OR (95% CI) (univariate)[c]
Predeployment measure								
Age, mean, y	26.67	22.67	22.20	25.43	27.56	23.18	$F_{5.554} = 4.15$**	0.95 (0.92–0.98)**
Female sex, %	4.8	7.1	13.3	8.7	0	9.1	$\chi^2_{5,561} = 6.05$, NS	0.72 (0.31–1.68), NS
Combat soldiers, %	40.4	58.5	60.0	52.2	46.9	72.7	$\chi^2_{5,558} = 11.81$*	0.54 (0.36–0.81)**
No. of years in military	6.08	3.52	2.87	3.61	6.77	2.64	$F_{5.552} = 2.52$*	0.94 (0.92–0.99)*
No. of earlier missions	1.09	0.65	0.38	0.39	1.67	0.20	$F_{5.535} = 2.68$*	0.89 (0.76–1.03), NS
Contract (short-term vs permanent employment), %	27.4	34.1	40.0	34.8	50.0	36.4	$\chi^2_{5,556} = 8.43$, NS	1.72 (1.13–2.61)*
Depression score[d]	3.65	12.00	14.73	6.87	4.19	17.62	$F_{5.538} = 52.55$***	1.21 (1.16–1.26)***
PTSD symptoms score[e]	20.01	34.05	41.27	23.23	21.78	42.73	$F_{5.555} = 261.64$***	1.36 (1.28–1.44)***
NEO neuroticism score[f]	28.62	34.90	35.29	32.65	28.43	36.60	$F_{5.529} = 16.29$***	1.13 (1.09–1.17)***
NEO openness score[f]	37.51	38.27	37.43	39.04	37.19	37.88	$F_{5.525} = 0.40$, NS	1.01 (0.98–1.05), NS
NEO extraversion score[f]	44.04	41.49	42.71	44.96	45.58	37.00	$F_{5.526} = 4.71$***	0.97 (0.94–1.01), NS
NEO agreeableness score[f]	40.61	38.85	37.71	38.61	39.94	37.80	$F_{5.530} = 1.87$, NS	0.95 (0.92–0.99)**
NEO conscientiousness score[f]	44.97	40.56	39.71	45.00	44.55	42.10	$F_{5.522} = 6.20$***	0.94 (0.90–0.97)***
Earlier traumas score[g]	8.90	14.03	19.14	7.97	10.39	12.34	$F_{5.542} = 14.04$***	1.07 (1.05–1.09)***
Low education, %	26.6	52.4	66.7	26.1	43.8	54.4	$\chi^2_{5,559} = 25.91$***	2.46 (1.63–3.72)***
Earlier emotional problems, %	13.5	42.9	40.0	39.1	37.5	45.5	$\chi^2_{5,559} = 42.10$***	4.38 (2.78–6.88)***
Perceived social support score[h]	5.75	5.87	5.40	5.67	5.84	5.21	$F_{5.514} = 1.18$, NS	0.97 (0.77–1.21), NS
Stressors measured 1 to 3 weeks after homecoming								
Combat exposure score[i]	12.55	13.68	14.00	17.44	15.53	10.50	$F_{5.417} = 1.18$, NS	1.03 (1.00–1.06)*
Danger/injury exposure score[i]	20.34	21.28	22.23	22.56	22.79	22.83	$F_{5.431} = 2.14$, $P = .06$	1.07 (1.03–1.13)**
Emotional stress[j]	2.05	2.21	2.58	2.83	2.10	2.00	$F_{5.447} = 5.70$***	1.78 (1.28–2.46)**
Times when life was in danger[k]	3.72	4.18	4.42	4.28	4.39	4.00	$F_{5.446} = 0.80$, NS	1.11 (1.0–1.22), $P = .05$
Killed an enemy, %	22.9	35.9	36.4	50.00	47.1	50.0	$F_{5,440} = 14.94$**	2.41 (1.48–3.92)***
Wounded-injured, %	15.9	28.2	7.7	22.2	31.6	40.0	$F_{5,453} = 9.17$, $P = .08$	1.82 (1.06–3.13)*
Perceived social support score	5.68	5.59	5.15	5.00	5.61	4.55	$F_{5,455} = 3.17$**	0.77 (0.62–0.94)*
Stressors measured 3 years after deployment								
Postdeployment traumas score	1.41	1.97	2.25	1.71	2.96	2.78	$F_{5.449} = 6.90$***	1.14 (1.08–1.21)***
Redeployed (after ISAF 7), %	33.4	30.0	33.3	23.5	35.7	22.2	$\chi^2_{5,455} = 1.26$, NS	0.86 (0.53–1.40), NS
Emotional problems after but not prior to deployment, %	24.1	40.0	37.5	91.7	89.5	80.0	$\chi^2_{5,371} = 61.23$***	6.45 (3.60–11.56)***

[a]Values shown are mean unless stated otherwise.
[b]Pearson χ^2 or Fisher exact test.
[c]The symptom fluctuation group consists of an aggregation of groups 2, 3, 4, 5, and 6 versus the low-stable group (1).
[d]Depression was measured using the second edition of the Beck Depression Inventory.[17]
[e]Symptoms of PTSD were measured using the PTSD Checklist.[18]
[f]Neuroticism, extraversion, openness to experience, agreeableness, and conscientiousness were measured using the NEO Five-Factor Inventory.[16]
[g]Earlier traumas were measured using the Traumatic Life Events Questionnaire.[19]
[h]Social support was measured using the Multidimensional Scale of Perceived Social Support.[21]
[i]Combat exposure and danger/injury exposure were measured using the Combat Exposure Scale[22] and the Danger/Injury Exposure Scale constructed by the Danish military.
[j]Emotional stress was measured on a scale from 1 (never) to 4 (very often).
[k]The number of times when life was in danger was measured on a scale from 0 (never) to 6 (more than 5 times).
*$P < .05$.
**$P < .01$.
***$P < .001$.
Abbreviations: ISAF 7 = International Security Assistance Force, NS=nonsignificant, OR = odds ratio, PTSD = posttraumatic stress disorder.

Table 3. Comparison of Risk Factors for the Symptom-Fluctuation Group Versus the Resilient Group[a]

Risk Factor	Step 1 OR (95% CI)	Step 2 OR (95% CI)	Step 3 (final model) OR (95% CI)
Measurements before deployment			
Mean age (y)	0.96 (0.86–1.06)	0.96 (0.86–1.07)	0.98 (0.87–1.10)
Combat soldiers (ref: other) (%)	1.26 (0.58–2.76)	1.14 (0.39–3.33)	1.41 (0.47–4.22)
Contract (short-term vs permanent employment)	0.85 (0.38–1.93)	0.71 (0.29–1.71)	0.77 (0.31–1.88)
Years in military	1.03 (0.94–1.13)	1.04 (0.94–1.15)	1.02 (0.92–1.14)
Depression score	1.23 (1.13–1.34)***	1.27 (1.15–1.39)***	1.27 (1.16–1.39)***
NEO neuroticism score	1.09 (1.01–1.19)*	1.09 (0.99–1.19)	1.10 (1.00–1.21)*
NEO agreeableness score	0.98 (0.92–1.04)	0.98 (0.92–1.05)	0.98 (0.92–1.05)
NEO conscientiousness score	1.05 (0.97–1.13)	1.00 (0.91–1.09)	0.99 (0.91–1.08)
Earlier traumas score	1.12 (1.07–1.18)***	1.11 (1.06–1.18)***	1.09 (1.03–1.16)**
Low education (%)	1.38 (0.56–3.40)	1.50 (0.55–4.08)	1.56 (0.57–4.26)
Earlier emotional problems (%)	1.68 (0.72–3.94)	1.59 (0.61–4.16)	1.41 (0.53–3.79)
Stressors measured 1 to 3 weeks after homecoming			
Combat exposure score		0.93 (0.84–1.03)	0.91 (0.81–1.01)
Danger/injury exposure score		1.20 (1.04–1.39)*	1.20 (1.04–1.40)*
Emotional stress		2.12 (1.03–4.33)*	2.08 (1.00–4.33)
Killed an enemy		1.91 (0.67–5.50)	2.19 (0.74–6.49)
Perceived social support score		0.88 (0.56–1.38)	0.92 (0.59–1.45)
Wounded-injured		2.41 (0.93–6.26)	2.31 (0.88–6.09)
Stressors measured 3 years after deployment			
Postdeployment traumas score			1.11 (0.99–1.24)
Sensitivity, %	56.90	65.50	63.80
Specificity, %	96.90	96.90	95.60
Overall success rate, %	88.90	90.60	89.20
Nagelkerke (pseudo) R^2	0.47	0.56	0.57
−2 Log likelihood	186.97	163.5	160.36
χ^2 (*df*)	101.92 (11)***	125.36 (17)***	128.56 (18)***

[a]Total n = 287: symptom-fluctuation group, n = 58; reference = resilient group, n = 229. Multivariable hierarchical logistic regression in 3 steps: step 1 = measurements before deployment, step 2 = measurements before deployment and after homecoming, and step 3 = measurements before deployment, after homecoming, and 3 years after deployment.
*$P < .05$.
**$P < .01$.
***$P < .001$.
Abbreviation: OR = odds ratio.

In line with previous trajectory studies,[2,29] we identified a trajectory of late-onset PTSD symptoms. This late-onset trajectory is *not* defined according to *DSM* criteria of *delayed onset*, but empirically derived and characterized by a very low symptom level from before deployment to 3 months after deployment, followed by a rise in symptom level starting at the 7-month assessment and continuing to rise through the 2.5-year assessment. As noted in the Results section, the trajectories were not derived in relation to an index trauma, but 95% of individuals in the late-onset trajectory who were also SCID interviewed reported that their index trauma was deployment related. Further, later redeployments were not significant in the predictor analysis of late-onset PTSD symptoms. Hence, we suggest that the late-onset trajectory in our sample does indeed capture late-onset PTSD symptomatology.

Membership in the late-onset PTSD symptom trajectory was predicted by earlier emotional problems and exposure to traumatic events before deployment, which is in accord with several studies showing that prior trauma, especially adverse childhood experiences, increases the risk of developing PTSD following subsequent potentially traumatic events among both military personnel[30] and civilian populations.[31] Several studies,[33–35] but not all,[32] have found an association between childhood abuse and PTSD symptoms among veterans. While prior traumas were not directly tested in our study, our results lend support to the notion that these traumas have a sensitizing effect on soldiers, making them more vulnerable to subsequent stressors and late-onset symptomatology.

Members of the late-onset trajectory were exposed to more additional traumatic life events after deployment than members of the resilient trajectory. This finding is consistent with a recent longitudinal study[26] that followed trauma injury survivors during hospitalization and at 3, 12, and 24 months after the trauma. In a subgroup of survivors with no PTSD at 3 months, higher levels of PTSD symptom severity at 24 months were predicted by exposure to more stressful life events experienced after the initial 3 months (when the researchers controlled for initial PTSD severity and other relevant covariates), which the authors explained as the result of fear of reinstatement. In the hypothesized fear reinstatement mechanism, fear associations linked to the original traumatic experience are not properly eradicated, and subsequent exposure to trauma will therefore readily reinstate the initial fearful association from the original trauma. Notably, for fear reinstatement to occur, the recent stressor and the original trauma must be similar in kind, or must evoke similar psychopathological and physiological reactions. Our detailed analysis of the nature of experienced postdeployment traumatic events in the late-onset group showed that life-threatening events, accidents, and robberies were the most frequently experienced traumatic events after deployment. These can be considered fairly intense and

Table 4. Comparison of Risk Factors for the Late-Onset Group Versus the Resilient Group via Univariate Logistic Regressions and Prediction of Late-Onset Group Membership via 2-Step Multivariable Hierarchical Logistic Regression[a]

Risk Factor[b]	Resilient Group (n = 268)	Late-Onset Group (n = 16)	Resilient vs Late Onset, OR (95% CI)		
			Univariate	Step 1	Step 2 (final model)
Predeployment measures					
Age, y	26.67	27.56	1.02 (0.97–1.06)		
Female sex, %	4.80	0.00			
Combat soldiers, %	40.40	46.90	0.77 (0.37–1.58)		
Years in military	6.08	6.77	1.01 (0.97–1.06)		
No. of earlier missions	1.09	1.67	1.12 (0.97–1.29)		
Contract (short-term vs permanent employment)	27.40	50.00	2.65 (1.28–5.46)**	0.50 (0.15–1.62)	0.60 (0.17–2.09)
Depression score	3.65	4.19	1.03 (0.95–1.12)		
PTSD symptoms score	20.00	21.78	1.15 (1.05–1.27)**		
NEO neuroticism score	28.62	28.48	1.00 (0.94–1.06)		
NEO openness score	37.51	37.19	0.99 (0.93–1.05)		
NEO extraversion score	44.04	45.58	1.05 (0.98–1.11)		
NEO agreeableness score	40.61	39.94	0.98 (0.93–1.04)		
NEO conscientiousness score	44.97	39.94	0.99 (0.99–1.05)		
Earlier traumas score	8.90	18.47	1.36 (1.21–1.53)***	1.31 (1.07–1.20)***	1.10 (1.04–1.17)**
Low education, %	26.60	43.80	2.15 (1.03-4.45)*	1.52 (0.44–5.20)	1.60 (0.43–5.99)
Earlier emotional problems, %	13.50	37.50	3.83 (1.78–8.25)**	5.31 (1.61–17.48)**	5.59 (1.57–19.89)**
Perceived social support score	5.75	5.84	1.12 (0.73–1.71)		
Stressors measured 1 to 3 weeks after homecoming					
Combat-exposure score	12.55	15.53	1.05 (0.98–1.11)		
Danger/injury-exposure score	20.34	22.79	1.11 (1.01–1.23)*		1.01 (0.86–1.18)
Emotional stress	2.05	2.10	1.11 (0.58–2.09)		
Times when life was in danger	3.72	4.39	1.13 (0.91–1.41)		
Killed an enemy, %	22.90	47.10	2.99 (1.12–8.00)*		2.35 (0.56–9.75)
Wounded-injured, %	15.90	31.60	2.45 (0.89–6.70)		
Perceived social support score	5.68	5.61	0.94 (0.60–1.47)		
Stressors measured 3 years after deployment					
Postdeployment traumas score	1.41	2.96	1.61 (1.31–1.98)***		1.13 (1.00–1.26)*
Redeployed (after ISAF 7), %	33.40	35.70	1.11 (0.50–2.47)		
Emotional problems after but not prior to deployment, %	24.10	89.50	26.76 (6.04–118.55)***		
Sensitivity, %				25.00	25.00
Specificity, %				99.30	98.90
Overall success rate, %				95.10	94.70
Nagelkerke (pseudo) R^2				0.34	0.4
−2 Log likelihood				87.29	80.45
χ^2 (*df*)				35.83 (4)***	42.68 (7)***

[a]Total n = 284: late-onset group, n = 16; reference = resilient group, n = 268. Step 1 = measurements before deployment, step 2 = measurements before deployment and 3 years after deployment.
[b]Values shown are mean unless otherwise stated.
*$P < .05$.
**$P < .01$.
***$P < .001$.
Abbreviations: ISAF 7 = International Security Assistance Force, OR = odds ratio.

physiologically arousing events that most likely evoke bodily reactions that are similar to traumatic events experienced during deployment. While fear reinstatement is a likely mechanism of late-onset symptomatology in our study, this remains speculative, and we cannot completely discard the possibility that the association between postdeployment trauma exposure and late-onset symptomatology is simply explained by the postdeployment trauma being the index trauma of the posttraumatic stress reaction.

The prospective, longitudinal follow-up study reported here has a number of limitations. First, our study did not have enough power to examine male and female soldiers separately. Second, the results are based on self-report measures and may be influenced by reporting biases. However, the prospective nature of the study encompassing a predeployment assessment of prior trauma exposure reduces the likelihood of a spurious association between PTSD and prior trauma considerably. Third, while most measures were standardized and validated psychometric scales, we included a number of items developed especially for this study, including single-item measures that have not been validated. Fourth, 2 of the symptomatic trajectories derived by LGMM were small, hence precluding the possibility of conducting multivariate predictor analyses of these trajectories. To study predictors of these highly symptomatic and clinically relevant trajectories with greater scrutiny, targeted sampling toward more symptomatic samples may be needed.

CONCLUSION

The analyses presented in this article highlight the complexity of PTSD symptom development following a potentially traumatic event and underscore the heterogeneity in adjustment patterns. Further, the findings stress the importance of considering earlier traumas in predeployment screening and postdeployment intervention strategies for soldiers and the effects of postdeployment adverse life events on late-onset PTSD. Understanding the nature of predeployment vulnerability factors and postdeployment stressors may provide important knowledge for future efforts to prevent and treat posttraumatic stress reactions.

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REFERENCES

1. Dickstein BD, Suvak M, Litz BT, et al. Heterogeneity in the course of posttraumatic stress disorder: trajectories of symptomatology. *J Trauma Stress*. 2010;23(3):331–339. 10.1002/jts.
2. Bonanno GA, Mancini AD, Horton JL, et al; Millennium Cohort Study Team. Trajectories of trauma symptoms and resilience in deployed US military service members: prospective cohort study. *Br J Psychiatry*. 2012;200(4):317–323.
3. Galatzer-Levy IR, Bryant R. 636,120 ways to have posttraumatic stress disorder. *Perspect Psychol Sci*. 2013;8(6):651–662.
4. Bonanno GA. Loss, trauma, and human resilience: have we underestimated the human capacity to thrive after extremely aversive events? *Am Psychol*. 2004;59(1):20–28.
5. Solomon Z, Mikulincer M. Posttraumatic intrusion, avoidance, and social functioning: a 20-year longitudinal study. *J Consult Clin Psychol*. 2007;75(2):316–324.
6. Dohrenwend BS, Dohrenwend BP. *Stress Life Events: Their Nature and Effects*. New York, NY: John Wiley & Sons; 1974.
7. Wyler AR, Masuda M, Holmes TH. Magnitude of life events and seriousness of illness. *Psychosom Med*. 1971;33(2):115–122.
8. Breslau N. Epidemiologic studies of trauma, posttraumatic stress disorder, and other psychiatric disorders. *Can J Psychiatry*. 2002;47(10):923–929.
9. Brewin CR, Andrews B, Valentine JD. Meta-analysis of risk factors for posttraumatic stress disorder in trauma-exposed adults. *J Consult Clin Psychol*. 2000;68(5):748–766.
10. Jones M, Sundin J, Goodwin L, et al. What explains post-traumatic stress disorder (PTSD) in UK service personnel: deployment or something else? *Psychol Med*. 2013;43(8):1703–1712.
11. Yehuda R, McFarlane AC. Conflict between current knowledge about posttraumatic stress disorder and its original conceptual basis. *Am J Psychiatry*. 1995;152(12):1705–1713.
12. Pietrzak RH, Johnson DC, Goldstein MB, et al. Psychosocial buffers of traumatic stress, depressive symptoms, and psychosocial difficulties in veterans of Operations Enduring Freedom and Iraqi Freedom: the role of resilience, unit support, and postdeployment social support. *J Affect Disord*. 2010;120(1–3):188–192.
13. Vogt D, Smith B, Elwy R, et al. Predeployment, deployment, and postdeployment risk factors for posttraumatic stress symptomatology in female and male OEF/OIF veterans. *J Abnorm Psychol*. 2011;120(4):819–831.
14. American Psychiatric Association. *Diagnostic and Statistical Manual of Mental Disorders*, Fourth Edition. Washington, DC: American Psychiatric Association; 1994.
15. Berntsen D, Johannessen KB, Thomsen YD, et al. Peace and war: trajectories of posttraumatic stress disorder symptoms before, during, and after military deployment in Afghanistan. *Psychol Sci*. 2012;23(12):1557–1565.
16. Costa PT, McCrae RR. *NEO PI/FFI Manual Supplement for Use with the NEO Personality Inventory and the NEO Five-Factor Inventory*. Lutz, FL: Psychological Assessment Resources; 1989.
17. Beck AT, Steer RA, Brown GK. *BDI-II, Beck Depression Inventory Manual*. 2nd ed. San Antonio, TX: Psychological Corp; 1996.
18. Blanchard EB, Jones-Alexander J, Buckley TC, et al. Psychometric properties of the PTSD Checklist (PCL). *Behav Res Ther*. 1996;34(8):669–673.
19. Kubany ES, Haynes SN, Leisen MB, et al. Development and preliminary validation of a brief broad-spectrum measure of trauma exposure: the Traumatic Life Events Questionnaire. *Psychol Assess*. 2000;12(2):210–224.
20. Ozer EJ, Best SR, Lipsey TL, et al. Predictors of posttraumatic stress disorder and symptoms in adults: a meta-analysis. *Psychol Bull*. 2003;129(1):52–73.
21. Zimet GD, Dahlem NW, Zimet SG, et al. The Multidimensional Scale of Perceived Social Support. *J Pers Assess*. 1988;52(1):30–41.
22. Keane TM, Fairbank JA, Caddell JM, et al. Clinical evaluation of a measure to assess combat exposure. *Psychol Assess*. 1989;1(1):53–55.
23. First MB, Spitzer RL, Gibbon M, et al. *Structured Clinical Interview for DSM-IV-TR Axis I Disorders, Research Version*, Patient Edition. (SCID-I/P). New York, NY: Biometrics Research, New York State Psychiatric Institute; 2002.
24. Karstoft K-I, Andersen SB, Bertelsen M, et al. Diagnostic accuracy of the Posttraumatic Stress Disorder Checklist-Civilian Version in a representative military sample. *Psychol Assess*. 2014;26(1):321–325.
25. Orcutt HK, Erickson DJ, Wolfe J. The course of PTSD symptoms among Gulf War veterans: a growth mixture modeling approach. *J Trauma Stress*. 2004;17(3):195–202.
26. Bryant RA, O'Donnell ML, Creamer M, et al. A multisite analysis of the fluctuating course of posttraumatic stress disorder. *JAMA Psychiatry*. 2013;70(8):839–846.
27. Solomon Z, Mikulincer M. Trajectories of PTSD: a 20-year longitudinal study. *Am J Psychiatry*. 2006;163(4):659–666.
28. Steenkamp MM, Nickerson A, Maguen S, et al. Latent classes of PTSD symptoms in Vietnam veterans. *Behav Modif*. 2012;36(6):857–874.
29. Karstoft K-I, Armour C, Elklit A, et al. Long-term trajectories of posttraumatic stress disorder in veterans: the role of social resources. *J Clin Psychiatry*. 2013;74(12):e1163–e1168.
30. Sareen J, Henriksen CA, Bolton S-L, et al. Adverse childhood experiences in relation to mood and anxiety disorders in a population-based sample of active military personnel. *Psychol Med*. 2013;43(1):73–84.
31. McLaughlin KA, Conron KJ, Koenen KC, et al. Childhood adversity, adult stressful life events, and risk of past-year psychiatric disorder: a test of the stress sensitization hypothesis in a population-based sample of adults. *Psychol Med*. 2010;40(10):1647–1658.
32. Seifert AE, Polusny MA, Murdoch M. The association between childhood physical and sexual abuse and functioning and psychiatric symptoms in a sample of US Army soldiers. *Mil Med*. 2011;176(2):176–181.
33. Engel CC Jr, Engel AL, Campbell SJ, et al. Posttraumatic stress disorder symptoms and precombat sexual and physical abuse in Desert Storm veterans. *J Nerv Ment Dis*. 1993;181(11):683–688.
34. Lapp KG, Bosworth HB, Strauss JL, et al. Lifetime sexual and physical victimization among male veterans with combat-related post-traumatic stress disorder. *Mil Med*. 2005;170(9):787–790.
35. Clancy CP, Graybeal A, Tompson WP, et al. Lifetime trauma exposure in veterans with military-related posttraumatic stress disorder: association with current symptomatology. *J Clin Psychiatry*. 2006;67(9):1346–1353.

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Supplementary Material

Article Title: Latent Trajectories of Trauma Symptoms and Resilience: The 3-Year Longitudinal Prospective USPER Study of Danish Veterans Deployed in Afghanistan

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List of Supplementary Material for the article

1. **eAnalysis** Data Analytic Approach

Disclaimer

This Supplementary Material has been provided by the author(s) as an enhancement to the published article. It has been approved by peer review; however, it has undergone neither editing nor formatting by in-house editorial staff. The material is presented in the manner supplied by the author.

Supplementary eAnalysis. Data Analytic Approach

The main analysis was conducted in Mplus version 7[1].

We included all soldiers who participated at the first assessment in the trajectory analysis to aid model estimation and avoid listwise deletion. Missing data were handled using the method of Full Information Maximum Likelihood (FIML;[2]). To check for potential bias of including all participants, we also conducted the analysis including only participants who provided data in at least four assessments (N=416). The model resulting from this procedure was very similar to the model including all participants. Hence, to maintain larger sample size and power for the subsequent analysis, we included all participants in the model.

We used Latent Growth Mixture Modeling (LGMM) to empirically identify heterogeneous trajectories of PTSD-symptoms over time. LGMM combines the methods of Latent Class Analysis (LCA) and Growth Modeling, and as such, it expects different subpopulations with unique growth trajectories within the sample [3]. LGMM allows intragroup variance of growth parameters. To accommodate expected fluctuations over time, we estimated linear as well as quadratic terms.

Initially, we estimated a series of LGMM-models with number of classes ranging from 1-8. We evaluated these models based on available fit indices, namely the Bayesian Information Criteria (BIC), the Akaike Information Criteria (AIC;[4]), and the Sample-Size adjusted BIC (SSBIC). For all three fit indices, lower values imply better fit of the model. Furthermore, we assessed the entropy of the model, which assesses the ability of the model to distinguish between classes (ranges from 0-1, where values closer to 1 represents better distinction by the model). Finally, we tested the improvement in fit with the addition of each extra class by implementing the Lo-Mendell-Rubin likelihood ratio test (LMR;[5]) and the Bootstrap Likelihood Ratio Test (BLRT). However, even with the evaluation of the mentioned fit indices, model selection also relies on subjective evaluation of the models parsimony and theoretical meaningfulness [6]. Hence, the final selection of the appropriated model relied on the combined information from fit indices and meaningfulness and parsimony of the model.

Due to a very small sample size in one of the resulting classes, and a theoretical wish of investigating several possible predictors, it was not possible to conduct multinomial logistic regression analysis nested within the LGMM analysis. Hence, the class membership variable was exported to the full dataset, and analysis of the relevant covariates was conducted post hoc outside of the model. For models with high entropy (>.80), this is viable alternative to including predictors in the model[7]. As our model had high entropy (.93), the risk of bias using the procedure is considered low. In the post hoc analyses, stepwise multivariable hierarchical logistic regression analyses were used to examine potential predictors of class membership. We selected variables for the multivariate hierarchical logistic regressions based on their significance in a series of univariate analyses. Potential predictors entered into these analyses were entered into the full model in the order of collection; namely background, demographic, and personality variables collected at Time 1, deployment stressors collected at Time 3, and post deployment support and life events after deployment collected at Time 6. Only results from the final model will be described.

Results

LGMM

Models with number of classes ranging from 1-8 can be seen in Table 1. Fit increased with the addition of every class, including the 7- and 8-class models. Whereas the BLRT suggest that each extra class added significantly to the model, the LMR suggested that no additional information was added beyond the fourth class. Of these two, BLRT is assumed to be the best class indicator[3], hence suggesting superiority of models with more classes. The entropy was identical for models with 3 through 6 classes (.93) increasing marginally with the addition of the 7th (.94) class and then returning to the 6-class entropy level for the 8-class model (.93).

Since the fit indices of these models did not unequivocally suggest on model over the others, we evaluated meaningfulness and parsimony of each model carefully. With addition of each new class through the six class model, all identified trajectories were unique, theoretically meaningful, and the model seemed parsimonious. However, the addition of a 7th class, this seemed to split an existing class into two very similar classes, hence providing a less parsimonious solution. Further, one class in the 7-class model contained only 1.5% of the participants. The addition of the 7th class therefore resulted in a clearly unparsimonious model, whereas the six class model revealed six unique trajectories that all seemed theoretically relevant. Two classes in this model were small (2.0 and 2.7% of the participants, respectively), but were nonetheless clearly different from the other trajectories. Hence, we settled on the six class model as the best fit of our data.

References

1. Muthen, L. K., & Muthen BO. *Mplus User's Guide*. Seventh Ed. Los Angeles, CA.; 2012.

2. Enders CK. The impact of nonnormality on full information maximum-likelihood estimation for structural equation models with missing data. *Psychological methods*. 2001;6(4):352–70.

3. Jung T, Wickrama K a. S. An Introduction to Latent Class Growth Analysis and Growth Mixture Modeling. *Social and Personality Psychology Compass*. 2008;2(1):302–317.

4. Akaike H. Factor analysis and AIC. *Psychometrika*. 1987;52(3):317–332.

5. Lo Y, Mendell NR, Rubin DB. Testing the number of components in a normal mixture. *Biometrika*. 2001;88(3):767–778.

6. Nylund KL, Asparouhov T, Muthen BO. Deciding on the Number of Classes in Latent Class Analysis and Growth Mixture Modeling: A Monte Carlo Simulation Study. *Structural Equation Modeling: A Multidisciplinary Journal*. 2007;14(4):535–569.

7. Clark SL, Muthén B. Relating latent class analysis results to variables not included in the analysis. *Submitted*.

8. DiStefano C, Kamphaus RW. Investigating Subtypes of Child Development: A Comparison of Cluster Analysis and Latent Class Cluster Analysis in Typology Creation. *Educational and Psychological Measurement*. 2006;66(5):778–794.