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Intraindividual change in pain tolerance and negative affect over 20 years: findings from the MIDUS study

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ABSTRACT

Pain tolerance, defined as the ability to withstand physical pain states, is a clinically important psychobiological process associated with several deleterious outcomes, including increased pain experience, mental health problems, physical health problems, and substance use. A significant body of experimental work indicates that negative affect is associated with pain tolerance, such that increased negative affect is associated with *decreased* pain tolerance. Although research has documented the associations between pain tolerance and negative affect, little work has examined these associations over time, and how change in pain tolerance is related to changes in negative affect. Therefore, the current study examined the relationship between intraindividual change in self-reported pain tolerance and intraindividual change in negative affect over 20 years in a large, longitudinal, observation-based national sample of adults ($n = 4{,}665$, $M_{age} = 46.78$, $SD = 12.50$, 53.8% female). Results from parallel process latent growth curve models indicated that slope of pain tolerance and negative affect were associated with each other over time ($r = .272$, 95% CI [.08, .46] $p = .006$). *Cohen's d* effect size estimates provide initial, correlational evidence that changes in pain tolerance may precede changes in negative affect. Given the relevance of pain tolerance to deleterious health outcomes, better understanding how individual difference factors, including negative affect, influence pain tolerance over time, are clinically important to reduce disease-related burden.

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Pain tolerance; negative affect; longitudinal; latent growth curve modelling

Pain tolerance, or the ability to withstand physical pain states, is a clinically important psychobiological process that is associated with pain experience, as well as mental health, substance use, and physical health (Edwards et al., 2003; Fales et al., 2021; Mikkelsson et al., 1992). For instance, lower pain tolerance levels distinguish those with fibromyalgia (a chronically painful condition) from those without (Mikkelsson et al., 1992), and those with lower pain tolerance generally show poorer recovery from pain over time (Edwards et al., 2003; Kasch et al., 2005). Lower pain tolerance has also been associated with personality dimensions, such as neuroticism (Lynn & Eysenck, 1961) and capability for

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suicide (Franklin et al., 2011). Other work suggests that greater pain tolerance is related to psychopathic traits (Miller et al., 2014) and borderline personality disorder (BPD; Fales et al., 2021). In terms of substance use, lower pain tolerance has been associated with substance use disorders (M. A. Compton, 1994), and substance use reduction, particularly opioids, is associated with a clinically meaningful increase in pain tolerance (P. Compton et al., 2022). Further, in terms of physical health, lower pain tolerance is associated with greater disease severity of Alzheimer's disease (Benedetti et al., 1999) as well as increased blood pressure (Peckerman et al., 1991). Although largely correlational in nature, this past work suggests that pain tolerance may be an important endophenotype to experiencing more severe pain and its consequences and may be a clinically important variable. Additionally, there is merit in exploring individual difference factors, specifically negative affect-related, that may contribute to and exacerbate levels of pain tolerance and associated consequences, including emotional symptoms and disorders (Sauer-Zavala et al., 2012).

Past work suggests that negative affect may precipitate, maintain, and exacerbate low pain tolerance (Bobey & Davidson, 1970), but the findings are mixed. To date, a significant body of work has focused on the relationship between negative affect and pain tolerance. In general, pain-related negative emotion is associated with lower pain tolerance (Rainville et al., 2005), and the relationship between depression and pain tolerance may be best accounted for by anxiety and poor coping responses (Adler & Gattaz, 1993). Experimental research has found negative mood is related to lower pain tolerance (Carter et al., 2002; Zelman et al., 1991), and that experiential avoidance (avoidance of negative emotions) is also associated with lower pain tolerance (Feldner et al., 2006). Further, experimental negative mood induction (depression, anger, sadness) studies have found that greater negative mood is associated with decreased pain tolerance (Tang et al., 2008; van Middendorp et al., 2010). Additionally, research suggests that negative affect may moderate the relationship between systemic inflammation and pain tolerance levels among healthy adults, such that inflammation lowered pain tolerance for those with elevated negative affect (Lacourt et al., 2015). Further, treatment research suggests that mindfulness practice is associated with greater pain tolerance (Kingston et al., 2007). However, more recent work among individuals with BPD, a disorder that is primarily characterized by elevated negative affect and significant emotion dysregulation, suggests that on average, these individuals report *higher* levels of pain tolerance (and lower levels of pain sensitivity), which is likely related to increase self-injurious and suicidal behavior (Bekrater-Bodmann, 2021; Schmahl et al., 2010; Selby et al., 2022). Therefore, there is a need for more exploration of the relationship between pain tolerance and negative affect.

Although the link between pain tolerance and negative affect has been established in the literature (Carter et al., 2002; Cimpean & David, 2019; Rainville et al., 2005), little work has examined these associations in daily life and over time; specifically, whether pain tolerance and negative affect relate to one another over time. Some related research has found that a related construct – pain sensitivity (defined as proneness to respond to physically painful stimuli; Ravn et al., 2012) — and negative affect independently decrease with age over time (Elliott et al., 2000; Lautenbacher et al., 2017; Shallcross et al., 2013). However, the majority of work examining the relationship between pain tolerance and negative affect has examined manipulation-induced pain tolerance including heat, cold, and pressure, not self-report measures. This limitation is critical, as administering self-report measures is often more cost-effective than objective pain testing, as well as less of a burden on research participants. However, there is limited work that has examined the correspondence between experimental and self-reported pain tolerance, and the work that does exist suggests that self-reported pain tolerance was not associated with experimental pain tolerance, rather it was associated with pain-related negative affect (Edwards & Fillingim, 2007b). A related construct also assessed via self-report, distress tolerance, has been associated with exacerbated pain experience (Rogers et al., 2018). Although distress tolerance is not completely analogous to pain tolerance (Zvolensky et al., 2011), it reflects a clinically important self-reported construct that can be targeted with treatment, suggesting there is utility in assessing pain tolerance via self-report.

Considering this work as well as the demonstrated associations between experimental pain tolerance and negative affect referenced above, it is possible that changes in self-reported pain tolerance are similarly related to changes in negative affect over time. Further, as pain may precipitate negative affect (Gaskin et al., 1992), it is plausible that this relationship may apply to the pain tolerance-negative affect relationship. Having a better understanding of the temporal relations between pain tolerance and negative affect may have important clinical implications. Given the psychosocial intervention is efficacious for the treatment of chronic pain conditions (Otis, 2007), there is merit in better understanding potential mechanisms of association and subsequent change. By examining the relationship between pain tolerance and negative affect concurrently over time, it is possible to adapt existing treatment based on mechanism of change.

The current study aimed to examine the relationship between intraindividual change in self-reported pain tolerance and intraindividual change in negative affect over 20 years in a large, national, longitudinal, observational cohort study. It was hypothesized that both pain tolerance and negative affect would change over time, and that there would be preliminary evidence to suggest that changes in pain tolerance would precede changes in negative affect.

Method

Participants

The current study included participants from waves 1, 2, and 3 of the Midlife in the United States (MIDUS) study, including the Random Digit Dialing (RDD), twin, sibling, and minority over sampling participants (Brim et al., 2019). A total of 7108 participants were interviewed first in 1995–1996 (MIDUS-I: age range 20–75 years, $M = 46.40$, SD = 13.00; 51.1% female). Of the initial participants, 4963 were followed up a second time in 2004–2006, and 3294 for a third time in 2013–2014. For a full analysis of study attrition, see Radler and Ryff (2010). Due to how the questions were ordered and administered, only participants who completed both the phone interview and self-administered questionnaires (SAQ) were included, as well as those that also participated in at least MIDUS 2.

Participants at Wave 1 for the current investigation included 4,665 ($M_{age} = 46.78$, $SD = 12.50$, 53.8% female) non-institutionalized adults who completed both the phone interview and the SAQ. Given that participants were only invited to participate in wave 3 if they participated in wave 2, only those participants that participated in both waves 1 and 2 were included in the current study. At wave 2, 3,925 of the wave 1 participants provided usable SAQ data, and 3,160 participants completed wave 3. In terms of demographic differences between those that completed the SAQ and those that only completed the phone interview, those that completed the SAQ were significantly older ($t(7047) = -10.19$, $p < .001$), and a greater proportion of females completed the SAQ than not ($\chi^2(1) = 19.32$, $p < .001$).

In terms of race and ethnicity, most participants (90.7%) identified as White, 5.2% as Black/African American, 1.9% as other, 0.9% as Asian/Pacific Islander, 0.7% as multiracial, and 0.6% as American Indian/Alaskan Native. A large proportion (37.8%) of the sample reported attending high school or less, 30.1% reported attending some college, 18.1% reported graduating from a 4–5 year undergraduate college/university, and 13.8% of participants reported post-graduate education. More than half (63.1%) of the sample reported being currently employed. In terms of marital status, 67.6% reported being married, 13.2% divorced, 11.7% single/never married, 5.0% widowed, and 2.4% separated.

Measures

Demographics

Demographic information, including age, sex, marital status, and employment status. These variables were included to describe the sample, and age was also included as a covariate in the statistical models.

Physical health status

To assess perceived physical health status, participants were asked a single item derived from the short-form health survey (Stewart et al., 1988), 'In general, would you say your physical health is . . . ', and responded on a 5-point Likert scale from *poor* to *excellent*. Perceived physical health status at baseline was included as a covariate in the statistical models to explain variability in intercept and slope parameters.

Pain tolerance

To assess pain tolerance, participants responded to a single item ('I have low pain tolerance'), and were asked to rate this item, as it applies to them generally, on a 4-point Likert scale from *not at all true* to *extremely true*. Single-item self-report measures of pain are widely used and accepted in clinical and research settings as having strong psychometric properties (Butt et al., 2008; Jensen, 2003; Mannion et al., 2014; Stinson et al., 2006). However, there is mixed evidence regarding the association between self-report measures of pain tolerance compared to objective pain testing, with past work suggesting that self-reported pain tolerance is associated with pain-related negative affect (Edwards & Fillingim, 2007b). Participants were asked this question at waves 1, 2, and 3, and pain tolerance (reverse scored) was included as an outcome variable in the current study.

Negative affect

To assess negative affect, participants were asked to what degree they experienced a range of negative emotions, including sadness, nervousness, restlessness, hopeless, worthless, and tasks requiring more effort. Participants were asked to rate how much they experienced these emotions in the past 30 days, and responses were rated on a 5-point Likert scale from *all the time* to *none of the time*. A significant body of work supports the validity of single-item composite measures of affect (Abdel-Khalek, 2006; Killgore, 1998; Russell et al., 1989), and for the current study, a composite mean 'negative affect' variable was computed and included as an outcome variable in the current study.

Procedure

The MIDUS study included a national sample of adults (aged 25–75) in the United States was collected over 3 waves, with wave 1 occurring 1995–1996 (MIDUS 1), wave 2 occurring between 2004–2006 (MIDUS 2) and wave 3 occurring between 2013–2014 (MIDUS 3). Participants were recruited via national random digit dialing (RDD) and included a representative sample of noninstitutionalized adults living in the 48 contiguous states. Additionally, along with the RDD sample, additional oversampling was conducted (and included in the current analysis), including twins, siblings, and African American participants from Milwaukee. For the current study, all participants completed both a phone-based interview, as well as a battery of self-report questionnaires. Given that the current study used data from a publicly available national dataset, the current study was exempt from IRB approval.

Data analysis

Data analyses were conducted with Mplus version 8 (Muthén & Muthén, 2017) using maximum likelihood estimation with robust standard errors (MLR estimation), which accounts for missing data in a manner that is as good as, if not better, than multiple imputation (Allison, 2003). First, descriptive statistics and latent correlations, accounting for missing data, were examined. Then, as series of latent growth models, as described below, were fit to the data. Model fit was assessed using root mean square error of approximation (RMSEA), Comparative Fit Index (CFI), Tucker-Lewis Index (TLI), and Standardized Root Mean Square Residual (SRMR). RMSEA values of 0.06 or lower, CFI and TLI values of 0.95 or greater, and SRMR values of 0.08 or less indicate good model fit (Hu & Bentler, 1999).

To estimate intraindividual change in pain tolerance and negative affect over the three waves of data, a series of linear growth curve models were estimated. First, individual growth curve models for pain tolerance and negative affect were estimated from wave 1 to wave 3 to ensure the constructs changed over time. Next, latent growth curve models were estimated to determine if intraindividual change in pain tolerance was associated with intraindividual change in negative affect over the three waves. A parallel process latent growth curve model was used to examine the associations between the intercepts and slopes (allowed to correlate) of pain tolerance and negative affect over time. Then, a conditional parallel process model was run, including theoretically relevant covariates (age, perceived health status), which were included as predictors of intercepts and slopes.

Cohen's d values were calculated as estimates of effect size of change in mean levels of both pain tolerance and negative affect from one time point to the next to estimate at which point each construct appeared to demonstrate change.

Results

Means, latent correlations, and effect sizes

Examining the latent means of the repeated wave variables (pain tolerance and negative affect), indicates decreasing means over time for negative affect (wave 1–1.519, wave 2–1.515, wave 3–1.489) and pain tolerance (wave 1–1.981, wave 2–1.867, wave 3–1.843; see Figure 1). See Table 1 for latent correlations between all variables.

Effect size estimates

Negative affect demonstrated a small decrease from wave 1 to 2 (*Cohen's d* = −.034, *95% CI* [−0.076, 0.006]), and the greatest change from wave 2 to wave 3 (*Cohen's d* = −.077, *95% CI* [−0.127, −0.028]). Pain tolerance demonstrated the greatest change from wave 1 to wave 2 (*Cohen's d* = −.143, *95% CI* [−0.185, −0.102]), with a smaller decrease occurring between wave 2 and wave 3 (*Cohen's d* = −.041, *95% CI* [−0.091, 0.008]).

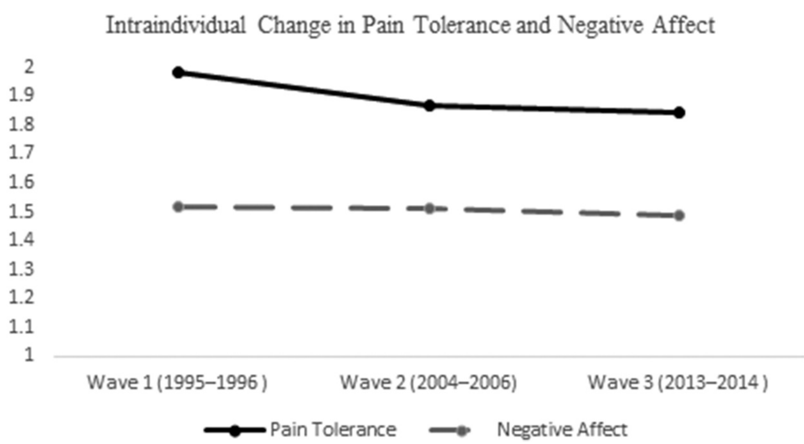

Figure 1. Intraindividual change in pain tolerance and negative affect.

Table 1. Latent correlations.

	1.	2.	3.	4.	5.	6.	7.
1. NA Wave 1	-						
2. NA Wave 2	.507	-					
3. NA Wave 3	.439	.594	-				
4. PT Wave 1	.133	.116	.111	-			
5. PT Wave 2	.108	.155	.149	.498	-		
6. PT Wave 3	.113	.164	.178	.438	.511	-	
7. Health	−.281	−.263	−.256	−.087	−.106	−.102	-
8. Age	−.115	−.100	−.051	−.002	.102	.147	−.116

NA – Negative Affect; PT – Pain Tolerance; Health – Perceived Health Status.

Change in negative affect

Estimating the change in negative affect from wave 1 to wave 3 resulted in good model fit (χ^2 (1) = 2.00, p = .15, RMSEA = .02 90% CI [0.000, 0.045], CFI = .999, TLI =.996, SRMR =.01). The slope of negative affect demonstrated statistically significant decline (M= −.08, p = .01), and intercept was significantly positively correlated with negative affect (β = 3.44, p < .001). There was also statistically significant variance in intercept and slope (p's < .001), suggesting that individuals varied in their starting levels of negative affect and declined at differing degrees. The correlation between intercept and slope of negative affect was negative and statistically significant that was small in magnitude (r = −.24, p = .004).

Change in pain tolerance

Estimating the change in pain tolerance from wave 1 to wave 3 resulted in good model fit (χ^2 (1) = 10.85, p = .001, RMSEA = .046, 90% CI [0.024, 0.072], CFI = .992, TLI = .977, SRMR = .01). The slope of pain tolerance (low pain tolerance) demonstrated statistically significant decline (indicating increases in pain tolerance; M = −.332, p < .001), and intercept was significantly positively associated with pain tolerance (β = 2.84, p < .001). There was also statistically significant variance in intercept and slope (p's < .001), suggesting that individuals varied in their starting levels of pain tolerance and declined to differing degrees. The slope between pain tolerance intercept and slope was negative and statistically significant that was moderate in magnitude (r = −.38, p = .004).

Parallel process model

The parallel process model of change in negative affect to change in pain tolerance resulted in a well-fitting model (χ^2 (7) = 18.05, p = .001, RMSEA =.018, 90% CI [0.008, 0.029], CFI =.996, TLI =.991, SRMR = .01). The slope of negative affect was significantly positively associated with slope in pain tolerance, and the association was small to moderate in magnitude (r = .277, p = .003). This finding suggests that reductions in negative affect are associated with increases in pain tolerance (reductions in low pain tolerance). The intercept of negative affect demonstrated a small, yet significant positive association with the intercept of pain tolerance (r = .235, p < .001). The intercept of negative affect was not significantly associated with the slope of pain tolerance (r = −.06, p = .273), and the intercept of pain tolerance was not significantly associated with the slope in negative affect (r = −.04, p = .387; see Figure 2).

Covariate-adjusted parallel process model

Age and perceived health status were added to the model as predictors of intercept and slope parameters for both constructs. This resulted in a well-fitting model (χ^2 (11) = 25.57, p = .004, RMSEA =.018, 90% CI [0.01, 0.026], CFI = .996, TLI =.989, SRMR =.01). The correlation of the between the slope of negative affect and pain tolerance remained statistically significant and of similar magnitude to the unconditional model (r = .272, p = .006). Age was a significant predictor of both intercept (β = −.21, p < .001) and slope of

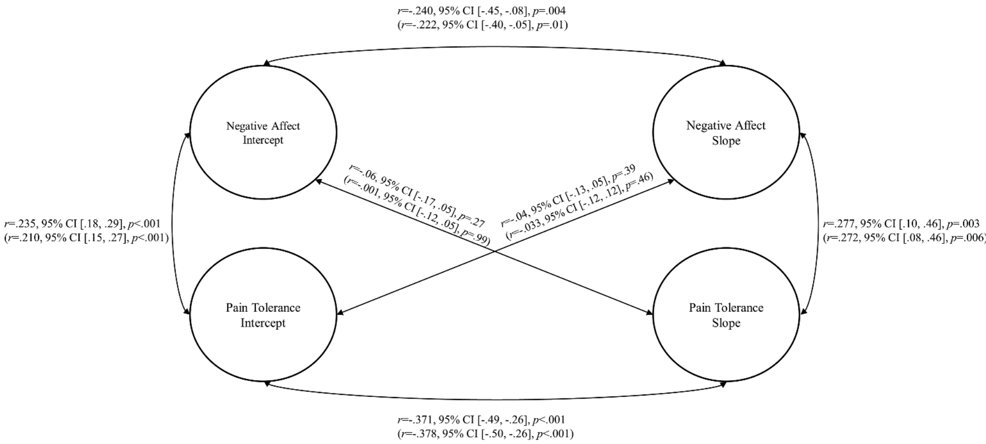

Figure 2. Correlations presented for parallel process models examining intercepts and slopes of negative affect and pain tolerance in the unadjusted (values on top) and adjusted (values in parentheses on bottom) models. 95% confidence intervals presented in brackets for each correlation.

negative affect (β = .111, p = .001), but was only a significant predictor of slope of pain tolerance (β = .313, p < .001), not intercept (β = −.007, p = .709). Perceived health status was associated with intercept (β = −.400, p < .001), but not slope (β = .061, p = .09) for negative affect, and was associated with intercept (β = −.122, p < .001) but not slope (β = .014, p = .730) of pain tolerance (see Figure 2).

Discussion

The current study examined how intraindividual change in pain tolerance was associated with intraindividual change in negative affect in a large, national sample of adults in the United States over a 20-year period. Results of unconditional latent growth models indicated that pain tolerance increased over time, while negative affect decreased over time. The conditional parallel process model provided additional evidence that the change in pain tolerance was associated with change in negative affect from wave one to wave three, such that decreases in negative affect were associated with increases in pain tolerance (or decreases in low pain tolerance), and these results were evident over and above the variance accounted for by age and perceived health status. These findings are in line with past work documenting experimental associations between pain tolerance and negative affect (Tang et al., 2008; van Middendorp et al., 2010), and extends past work by documenting that these constructs relate to each other over time. The findings from the current study may have important clinical implications, particularly in the context of acute pain management in medical-based settings. Not only does negative affect impact pain tolerance and sensitivity, but negative affect, such as anxiety and depression, is associated with greater perceived pain severity (Michaelides & Zis, 2019), leading to avoidance of often necessary medical procedures (Pancekauskaitė & Jankauskaitė, 2018; Taber et al., 2015). Therefore, considering the results of the current study, there is additional support for the use of non-pharmacological acute pain management strategies that aim to reduce negative affect and therefore increase pain tolerance (Pourmand et al., 2018; Richard Chapman & Turner, 1986).

Intervention work focused on pain tolerance, specifically, indicates that acceptance and mindfulness-based interventions are efficacious for increasing pain tolerance (Branstetter-Rost et al., 2009; Powers et al., 2018; Wang et al., 2019) as well as decreasing negative affect (Goldin & Gross, 2010; Hayes, 2004). Further research is warranted to provide additional evidence to the temporal ordering (or bi-directional nature) of pain tolerance and negative affect. Relatedly, considering third variables, including perceived stress, depression, and the presence of chronic medical conditions, might further explain the relationship between pain tolerance and negative affect.

Although not central aims of the current study, there are other findings that warrant brief comment. First, the intercept of pain tolerance was associated with the intercept of negative affect, thereby providing additional evidence that pain tolerance and negative affect are consistently related. However, the intercept of negative affect was not associated with slope of pain tolerance, and the intercept of pain tolerance was not associated with slope of negative affect. This finding suggests that the starting levels of pain tolerance and negative affect are not related to how these constructs change over time; therefore, the potential importance lies in *change* rather than absolute level of pain tolerance and negative affect.

The current study is not without limitations. First, due to the nature of the data collection, the measures of pain tolerance and negative affect were limited to self-report (and a single item for pain tolerance). Although past work using the MIDUS dataset has utilized single-item measures in longitudinal analyses (Donoho et al., 2015; Edwards et al., 2008), the utility of these measures may be somewhat limited. Future work should replicate and extend the current findings using self-report measures with established validity, as well as multimethod measures of pain tolerance and negative affect. Second, pain characteristics of the sample were not available in the data at wave 1. While data were available at wave 2, it is possible that these pain conditions may have developed between wave 1 and 2, and therefore pain tolerance ratings would not have been related to any chronic pain conditions at wave 1. It is also possible that the observed relations may have been influenced by clinical pain status. To help account for this issue, perceived health status was included as a covariate. Some work suggests that pain may be encompassed by perceived health status (Hunt et al., 1981), but it will be important to specifically focus on pain status in future research. Third, while the correlation between slope and negative affect was statistically significant, the magnitude of the associations was small. Thus, the clinical significance of the interplay between pain tolerance and negative affect may be minimal. Finally, it is possible that at least some of the participants in the current study were receiving treatment for pain or negative affect problems. Treatment engagement could have influenced results, but we could not account for this variable in the models. Replicating the current findings with data that includes treatment utilization would be useful.

Overall, the current study provides empirical support for the pain tolerance-negative affect relationship, suggesting that change in pain tolerance is associated with change in negative affect over time. Given the relevance of pain tolerance to a number of deleterious health outcomes (M. A. Compton, 1994; Edwards & Fillingim, 2007a; Mikkelsson et al., 1992), better understanding how individual difference factors, including negative affect, influence pain tolerance over time, is clinically important to reduce disease-related burden.

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