

Bodily responses to bullying

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Abstract

Peer victimization has marked long-term somatic and psychological consequences for individuals, but little is known about acute bodily responses to bullying. We mapped bodily sensations and emotions evoked by bullying and other social behaviours across four experiments involving 1255 participants. In Experiment 1, the participants rated the observed behaviour as well as their own subjective emotions and reactions evoked by social scenarios described in written vignettes. In Experiment 2, the participants indicated on a human silhouette the bodily regions in which they felt changes in activity while imagining themselves in scenarios described by the same vignettes. In Experiment 3, these procedures were replicated with first-person video stimuli. To compare the bodily sensations evoked by bullying with emotion-specific bodily sensations, we quantified bodily maps of discrete emotions in a separate study (Experiment 4). Bullying experiences induced by both vignettes and videos evoked consistent bodily sensations in the head, chest, stomach, and hand regions. In line with the strong bodily responses, bullying exposure evoked stronger distressing emotions, higher arousal, and greater emotional distance from others in comparison to conflict, neutral, and prosocial conditions. Furthermore, comparisons with the bodily maps of discrete emotions suggest that bodily sensations evoked by bullying reflect the experience of multiple negative emotions. These results highlight the significant bodily component of the bullying experience and underline bullying as a distressing and embodied experience in adulthood, indicating that bodily experiences should be better accounted for in interventions designed for victimized children and youth.

Keywords: Bullying, peer victimization, emotion, body

1. Introduction

Bullying is a significant emotional and somatic stressor for children and adolescents (Christina et al., 2021). It severely undermines two basic human needs - physical safety and need to belong (Baumeister & Leary, 1995; Maslow & Maslow, 1999). Emotions play an important role in maximizing our adaptive behaviour and well-being by guiding our perceptions, attention, and decision making (Brosch et al., 2013; Nummenmaa & Saarimäki, 2019). Emotions also influence bodily states such as muscle tension, cardiorespiratory functions and secretion of stress hormones that prepare the body for action during threatening situations (Damasio & Carvalho, 2013). The subjective experience of these changes elicits vivid emotional experiences such as "I am afraid". Despite the critical role of emotions in psychological and somatic survival support, evidence regarding bodily experiences during exposure to bullying remains sparse and is limited to the experience of bystanders (Barhight et al., 2013; Desrumaux et al., 2018) or based on retrospective reports of emotions felt during victimization (Hunter & Borg, 2006; Ortega et al., 2009; Vie et al., 2012). The immediate bodily responses evoked by being bullied however remain poorly characterised, despite bullying being a well-established risk factor for somatic and emotional problems, such as headache, abdominal pain, sleeping disturbances, and depressive symptoms (Gini & Pozzoli, 2013; Ye et al., 2023).

Laboratory experiments have established that social rejection causes immediate increases in cortisol levels and heart rate (Blackhart et al., 2007; Iffland et al., 2014; Stroud et al., 2002), suggesting that social threats evoke a physiological state of stress (although conflicting results exist, see Gunther Moor et al., 2010; Zöller et al., 2010). Moreover, brain imaging studies indicate that exposure to bullying engages large-scale limbic and paralimbic emotions circuits accompanied by the activation of the somatosensory and motor cortices as well as midbrain arousal systems (Paranko et al., 2025), suggesting that victimization prepares the body for an immediate fight-or-flight response.

Victimization and chronic rejection in adolescence are also associated with longer-term altered functioning of brain regions that control interoception, emotions and social

processing (De Water et al., 2017; Hollarek et al., 2023; Paranko et al., 2025; Rudolph et al., 2021; Will et al., 2016). Thus, chronic exposure to peer victimization could lead to either emotional numbing or increased sensitivity to social stressors, which should be reflected in increased or decreased bodily sensations when facing social stress in adulthood. Despite well-established links between victimization, physical stress reactions, and acute and chronic alterations in functions of brain regions processing bodily experiences, the subjective bodily experiences evoked by victimization remain elusive.

The current study

Here we used self-reports of observed behaviour, subjective emotions, reactions, and bodily sensations to map the experiences felt during simulated bullying across four experiments ($N_{\text{total}} = 1255$). Participants either watched first-person bullying victimization and neutral videos, or read vignettes describing exposure to different types of bullying (physical, verbal, relational, and cyber), neutral, conflict-related (without bullying), and prosocial scenarios. They rated the behaviour they observed in the vignettes and videos, as well as the subjective emotions and reactions evoked by the stimuli. Furthermore, subjective bodily sensations elicited by the stimuli were measured using a previously validated emBODY tool (Nummenmaa et al., 2014). The bodily sensations elicited by the social vignettes were compared with bodily sensations evoked by discrete emotions. Finally, we examined the association between past victimization experiences and bodily sensations during vignette-simulated bullying exposure using Structural equation modelling (SEM). We found that bullying exposure evoked stronger distressing emotions (particularly anger, annoyance, and shame), higher arousal, and greater emotional distance from others in comparison to conflict, neutral, and prosocial vignette conditions. Exposure to bullying induced consistent bodily sensations in the head, chest, stomach, and hand regions in both video and vignette experiments. These bodily topographies had high similarity with bodily sensations evoked with a wide variety of discrete emotions (anger, fear, shame, etc.). Finally, past victimization experiences were associated with changes in bodily responses to relational bullying, but not with bodily responses to other forms of bullying.

2. Methods

Altogether we ran four experiments summarized in **Table 1**. In Experiment 1 and 2 we used written vignettes describing social scenarios involving different types of bullying, social conflict, as well as neutral and prosocial behaviour. In Experiment 1, participants used Likert-type scales to evaluate the behaviour observed in each vignette (e.g. bullying, conflict) as well as subjective emotions (e.g. anger, fear) and reactions (e.g. I would be likely to escape / withdraw) evoked by the vignettes. In Experiment 2, we quantified the topographical bodily responses to the vignettes. Because guided mental imagery based on vignettes requires high-level abstract cognitive processing, we ran a conceptual replication in Experiment 3 using first-person, naturalistic videos presenting bullying and neutral social behaviour. Finally, to compare the bodily sensations evoked by bullying with those associated with discrete emotional states (e.g. anger, fear, joy), emotion-specific bodily sensation maps were obtained using mental imagery in Experiment 4.

Table 1. *Overview of the experiments.*

	<i>N</i>(subjects)	Stimuli	Observed behaviour measures	Emotion experience measures	Reaction measures	Bodily maps
Experiment 1	402	Vignettes	X	X	X	
Experiment 2	400	Vignettes				X
Experiment 3	275	Videos	X	X		X
Experiment 4	199	Mental imagery				X

2.1 Participants

A total of 1255 participants were included in the experiments (see **Table S1**). A total of 38 participants were excluded due to failed attention checks ($n_s = 11, 3,$ and 24 in Experiments 1, 2, and 4, respectively) and 75 because of technical problems (primarily video playback issues in browser), missing data, and incomplete data in Experiment 3. Participants in

Experiments 1, 2, and 4 were English-speaking and participants in Experiment 3 were Finnish-speaking.

For all experiments, exclusion criteria included self-reported diagnosed psychiatric and neurological disorders and using of corresponding medication for the past three months. The study protocols were approved by the Ethics Committees for Human Sciences at the University of Turku, Finland (except for Experiment 3 which was approved by the ethics board of the Hospital District of Southwest Finland). All participants gave written informed consent. Online participants were recruited through the online recruitment service Prolific (<https://www.prolific.com/>) and via social media. Prolific users were compensated for their time. Onsite participants for Experiment 3 were students from the University of Turku, and they received movie tickets as compensation. Data for all experiments was collected through the online experiment platform Gorilla (gorilla.sc).

2.2 Stimuli

2.2.1 Vignettes (Experiments 1 and 2)

In Experiments 1 and 2 we used short vignettes that described typical social situations adults might experience. The vignettes were written from the second-person perspective to maximize affective engagement and participants were asked to imagine themselves in the situation as vividly as possible. We initially developed a set of 42 vignettes describing physical, verbal, relational, and cyber bullying, social conflict, as well as neutral and prosocial scenarios (see **Table 2** for examples). These vignettes were then rated by pilot subjects ($N = 45$) for the presence of bullying, mean, and kind behaviour, as well as their capacity to evoke distressing and positive emotions. The final set of 35 vignettes (five per condition) was chosen based on these ratings. In Experiments 1 and 2, each participant read 21 vignettes, containing three randomly assigned vignettes from each condition. There was no time limit for reading the vignettes. See **Appendix 1** for all the vignettes and vignette-wise ratings.

Table 2 *Sample vignettes.*

- **Physical bullying:** *You are playing basketball in the park with some friends, when one of them deliberately tackles you down to the hard concrete. When you get up, the person keeps on pushing and mocking you.*
- **Verbal bullying:** *You are in a meeting, when a colleague starts to mock you for the way you talk. They continue to belittle you in front of your boss and the entire team.*
- **Relational bullying:** *You are in a hobby group, where one person always sighs and rolls their eyes when seeing you. They refuse to cooperate with you and encourage others to also avoid you.*
- **Cyberbullying:** *You receive a series of emails containing personal and sensitive information about you and your family members. The sender threatens to spread the information and ruin your reputation. Based on the content of the email, you can tell that the sender is someone you know.*
- **Social conflict:** *You and your partner are discussing your weekend plans. You would like to go together to an event that is important to you, while your partner would prefer another event. Neither of you is willing to compromise and you end up arguing.*
- **Neutral social scenario:** *You step out of your door for a walk and notice your neighbor raking leaves in their front yard. You exchange greetings and chat about the weather before continuing your way to your jogging route.*
- **Prosocial scenario:** *You are on a walk with your friend in a beautiful park. Your friend tells you they are thankful for your friendship and for the opportunity to share moments like this with you.*

2.2.2 Videos (Experiment 3)

To map the bodily sensations and emotions evoked by bullying in a life-like setting, we used 12 first-person videos depicting bullying and neutral social scenarios as stimuli. Bullying behaviour consisted of physical, verbal, and relational victimization, such as being called names by peers or being left out of a peer group. The videos were filmed in a school with child actors. Each video lasted from 20 to 87 seconds, and the same pool of actors and locations was used in all the videos (see Paranko et al., 2025 for details). The online participants watched a subset of 4 videos in a randomized order, whereas onsite participants first watched all the videos during an eye-tracking experiment (see Paranko et al., 2025), after which they

were presented with a representative 6–14-second-long clip of each video for assessing the bodily sensations and emotions.

2.2.3 Mental imagery task (Experiment 4)

To quantify bodily basis of different discrete emotions and compare them with those evoked by social vignette scenarios, participants were presented with emotion words (such as “anger”) and instructed to imagine the bodily regions whose activity they typically felt changing when feeling the indicated emotion and localize the sensations in the silhouette of a human body presented simultaneously. The imagery task consisted of the six basic emotions (anger, disgust, fear, joy, sadness, and surprise), shame, anxiety, and neutral state.

2.3 Measuring observed behaviour, behavioural reactions, and subjective emotions

All measurements in Experiment 1 were obtained using five-point Likert scales. Measures of observed behaviour included the presence of bullying, offensive, and kind behaviour, as well as social conflict. Measures of behavioural reactions included the likelihood of attacking, approaching, escaping, or withdrawing from the social interaction. The measured emotional experiences involved anger, annoyance, anxiety, disgust, fear, joy, sadness, shame, and surprise. The vividness and realism of the scenarios were measured similarly. Finally, we obtained ratings for the basic dimensions of the social situations on a bipolar five-point scales between the opposite claims “I felt like an outsider/ I felt emotionally close to others”, “The situation felt unpleasant/ The situation felt pleasant”, and “I felt calm/ I felt emotionally aroused”. Half of the Experiment 1 participants rated the vignettes for observed behaviour and their behavioural reactions, while the other half rated their own emotions, the realism of the scenarios and the basic dimensions of the social scenarios.

In Experiment 3, online participants rated the intensity of either bullying (offensive behaviour) or positive social interaction (kind behaviour) for a subset of four videos using a dynamic response slider for the whole duration of the videos, ranging from “None” to “Very high”.

Onsite participants used a six-point Likert Scale to rate the intensity of bullying and positive social interaction for each of the 12 videos while taking part in an eye-tracking experiment. Additionally, online participants rated the intensity of six basic emotions (anger, disgust, fear, joy, sadness, surprise), shame, anxiety, depression, and pride evoked by the videos using a seven-point Likert scale, while onsite participants rated the intensity of anger, fear, joy, and sadness on a six-point Likert Scale. Onsite rating tasks were designed to be concise because the experiment was designed to also suit children.

2.4 Bodily sensation maps (BSMs)

In Experiments 2, 3, and 4, bodily sensation maps (BSM) were acquired with the emBODY tool developed by Nummenmaa et al. (2014). The emBODY tool can be used for mapping the net sensations arising from multiple different physiological systems (Nummenmaa et al., 2014, 2018; Putkinen et al., 2024) and the resulting BSMs are culturally universal for different emotions and concordant across sexes (Volynets et al., 2020). Participants were asked to use their computer mouse (or finger if using a tablet) to indicate on a blank human figure where they experienced alterations in bodily functioning during reading vignettes, watching videos or feeling discrete emotions.

2.5 Self-report questionnaires

In Experiments 1 and 2, participants reported the duration of their victimization at school and outside of school before adulthood, scored from 0 (“Never”) to 4 (“Throughout my school years”), and the higher score out of these two measures was used as the retrospective victimization score. Depression and anxiety symptoms were measured using the sum scores of the Depression and Anxiety subscales from the Depression, Anxiety and Stress Scale - 21 Items (DASS-21) (Lovibond & Lovibond, 1995). DASS-21 subscales have acceptable reliability ($\alpha \geq .74$) under the bifactor structure (Lee et al., 2019), and reliability was good to excellent in Experiment 1 and 2 samples ($\alpha_{\text{Depression}} = .84$, $\alpha_{\text{Anxiety}} \geq .91$). In Experiment 3, online participants reported if they had ever been bullied (0 = “I have never been bullied or seen bullying”, 1 = “I have not been bullied but I have seen bullying”, 2 = “Yes, every now and then for one semester”, 3 = “Yes, repeatedly for one semester”). DASS-21 subscales for Depression

and Anxiety were utilized for measuring internalizing symptoms. Online participants only reported how often they had been bullied at school (0 = “Never”, 4 = “Every day”). No self-report data was collected in Experiment 4. Summaries of self-report measures are reported in **Table S2**, and correlations between age and self-report measures in **Figure S1**.

2.6 Bot checks and data quality control

Experiments 1, 2, and 4 contained a bot check in which participants had to form two well-known phrases out of scrambled words. Only participants who passed the task could continue to take part in the study. One attention check was embedded in each of the main tasks in Experiments 1, 2, and 4 (e.g. “You are taking part in a study. This is an attention check. Please colour both knees of the human figure”), and participants failing this task were excluded. Additionally, Experiments 1 and 2 had two attention checks embedded in the self-reports, and participants who failed both checks were excluded. BSMs were visually inspected for aberrant responses such as scribbling or writing on the bodies, and all responses outside the body were masked out.

2.7 Statistical analysis

2.7.1 Observed behaviour, subjective emotions, and behavioural reactions

In Experiment 1, the intensity of observed bullying, conflict, offensive and kind behaviour, as well as levels of realism and vividness were compared between conditions using non-parametric paired Wilcoxon signed-rank test for the condition-specific subject means for each of these variables. Differences in intensities of subjective emotions and probabilities of reactions across conditions were tested similarly. In Experiment 3, ratings for observed behaviour varied with time within videos, and were hence weighted with their durations within videos. Thereafter, the weighted ratings for behaviour and the subjective emotion ratings were analysed across conditions similarly to what was done in Experiment 1. Multiple

comparisons were controlled for with False discovery rate (FDR) correction ($\alpha = .05$) (Benjamini & Hochberg, 1995).

2.7.2 Bodily sensation maps

Bodily sensation maps were analysed as described previously (Nummenmaa et al., 2014). In Experiments 2 and 3, subject-wise BSMs were averaged across trials (vignettes or videos) for each condition for each participant. In Experiment 4, each emotion was only presented once per participant, thus no within-participant averaging was needed. Pixel-wise intensities were then tested against zero separately for each condition in each experiment using mass univariate t -tests. T -values were converted to point biserial correlation values to create effect size maps (r -maps), where pixel intensities reflect the proportion of variance in bodily sensations explained by the condition. Multiple comparisons were controlled for with False discovery rate (FDR) correction ($\alpha = .05$) (Benjamini & Hochberg, 1995) for the r -maps.

To test for differences in bodily experiences between neutral and other vignette conditions in Experiment 2, pixel-wise mass univariate paired t -tests were run to create effect size maps (r -maps), where pixel intensities reflect effect sizes for differences in bodily sensations between neutral social scenarios and other social scenarios, thresholded at $q < .05$. To quantify the similarity of bodily sensations evoked by the vignettes, Euclidean distances were computed for the mean maps for each pair of conditions. The distances were further converted to standardized Euclidean similarity (NES) by normalizing the distances with square root of number of pixels and subtracting from one. To quantify the extent of the bodily sensations in each condition in Experiments 2 and 3, subject-wise mean percentage of coloured body area (pixels) per condition was computed. Differences between conditions were tested with paired Wilcoxon tests (FDR corrected).

2.7.3 Region of interest analysis

To better localize topographical differences between conditions in Experiment 2, the total body area was divided to the following regions of interest: head, shoulders, arms, hands, core,

pelvis, legs, and feet. The extent of bodily sensations in each region was quantified as the subject mean of the percentage of pixels coloured within each region for each condition. Regional differences between conditions were tested with paired Wilcoxon tests. Additionally, as the sensations felt in the head region are likely to reflect emotional and cognitive responses of the mind (Nummenmaa et al., 2018; Nummenmaa & Hari, 2023), the ratios between total number of pixels coloured for the head region and the total number of pixels coloured within the whole body were compared between conditions using paired Wilcoxon test (FDR corrected, excluding trials where no sensations were felt).

2.7.4 Representational similarity analysis

As our experiences of the external (e.g. others' behaviour) and internal (e.g. emotions and bodily states) world are closely tied together (Brosch et al., 2013; Damasio & Carvalho, 2013; Nummenmaa & Saarimäki, 2019), we tested whether similarity of the subjective emotions evoked by vignettes would also be reflected in the similarity structure of bodily sensation as well as observed behaviour and behavioural reactions. To that end, we ran a representational similarity analysis. Euclidean distances between vignettes were determined separately for the mean vignette-wise ratings for observed behaviour and reactions (Experiment 1), subjective emotions (Experiment 1), and BSMs (Experiment 2), resulting in three distance matrices. Similarities between the distance matrices were then tested using Mantel test with 2,000 permutations (see Putkinen et al., 2024).

2.7.5 Comparing bodily sensations evoked by social scenarios and discrete emotions

Because distinct emotions evoke distinct bodily activation patterns (Nummenmaa et al., 2014), we next tested which bodily emotions the bullying-evoked bodily sensations resemble the most. To test the similarity between bodily sensations evoked by social scenarios and the bodily sensations evoked by discrete emotions, normalized Euclidean similarities (See section "2.7.2 Bodily sensation maps") between the social vignette BSMs (Experiment 2) and BSMs representing bodily sensations evoked by six basic emotions

(anger, disgust, fear, joy, sadness, surprise), shame, anxiety, and neutral state (Experiment 4) were computed.

2.7.6 Associations between victimization experiences and bodily responses

To examine associations between the retrospective reports of past victimization experiences and bodily responses to vignette-induced bullying exposure in Experiment 2, we conducted structural equation modelling (SEM) in R using the lavaan package (Rosseel, 2012). We evaluated model fit based on convention measures of fit: CFI, TLI, χ^2 divided by degrees of freedom, RMSEA and SRMR (Bentler, 1995). For each bullying exposure vignette condition, a difference score was calculated between the percentage of pixels coloured for the bullying condition and neutral social scenario, and these scores were used as the dependent variables. The difference scores were predicted by retrospective reports of victimization, controlling for depression, anxiety, age, and sex. In the models, we controlled for the residual covariance between all dependent variables, as well as the covariances between victimization, depression, and anxiety. Adequate sample size for modelling individual differences in bodily sensations was determined using the online versions of the R package semPower (Moshagen & Bader, 2024). Sample size of 400 participants gives a power of 0.80 for adequate fit (RMSEA = 0.75) (Browne & Cudeck, 1993; Steiger, 1989) with six degrees of freedom at the significance level of 0.05.

3. Results

3.1 Observed behaviour, subjective emotions, and reactions

As expected, bullying vignettes contained more intense bullying and offensive behaviour than other vignette conditions, and less kind behaviour (see statistics for observed behaviour and reactions in **Figures S2–S3**). Ratings for observed conflict were slightly higher for bullying conditions than conflict situations. All social scenarios presented in the vignettes were perceived as realistic and vivid, with highest ratings for neutral and prosocial scenarios and lowest for the bullying conditions. Intentions for escaping and attacking were higher for bullying conditions in comparison to other conditions, but withdrawal was as likely in bullying

Figure 1. Median ratings for A) observed behaviour and reactions, and B) evoked subjective emotions for the different social vignette conditions.

Similar results were obtained in Experiment 3. The median intensity for bullying for the videos classified as bullying videos was higher than for videos classified as neutral with a large effect size in both online ($Mdn_{\text{BullyingVideos}} = 27.48$, $Mdn_{\text{NeutralVideos}} = 1.65$, $r = .87$, $p < .0001$, scale: 0-100) and onsite ($Mdn_{\text{BullyingVideos}} = 5.57$, $Mdn_{\text{NeutralVideos}} = 1.00$, $r = .87$, $p < .0001$, scale: 1-6) samples. Likewise, the median intensity for positive social interaction was higher for neutral videos in comparison to bullying videos with a large effect size in both online ($Mdn_{\text{BullyingVideos}} = 12.44$, $Mdn_{\text{NeutralVideos}} = 49.05$, $r = .86$, $p < .0001$, scale: 0-100) and onsite ($Mdn_{\text{BullyingVideos}} = 1.14$, $Mdn_{\text{NeutralVideos}} = 4.80$, $r = .87$, $p < .0001$, scale 1-6) samples. Bullying videos evoked consistently more distressing emotions (anger, sadness, etc.) and less joy and pride in comparison to the neutral videos. See **Figure S6** for all statistics between bullying and neutral videos for all emotions in both online and onsite samples.

3.2 Bodily sensation maps (BSMs)

Figure 2 (top row) shows the BSMs for the different social scenarios presented in the vignettes in Experiment 2. All bullying scenarios evoked bodily sensations in the head, chest, abdominal area and hands, and in physical bullying bodily sensations were also felt in the legs and feet. In comparison to neutral social scenarios, bullying conditions were felt more consistently especially in the head and abdominal region, as well as in the chest and hands (**Figure 2, bottom row**). Increased activation of the legs was salient only for physical bullying in comparison to neutral condition and markedly absent for verbal, relational, and cyberbullying.

Bodily sensation maps were most similar between verbal, relational, and cyber bullying (Normalized Euclidean similarities, $NES = .80-.88$), as well as between these three forms of bullying and conflict vignettes ($NES = .76-.84$) (**Figure S7**). Physical bullying had moderate similarity with other forms of bullying ($NES = .61-.65$) and conflict ($NES = .51$). Bodily sensations evoked by the prosocial and neutral vignettes were most dissimilar from the bodily

sensations evoked by all the other conditions, normalized Euclidean similarities ranging from .26 for prosocial vs. neutral to .57 for neutral vs. conflict.

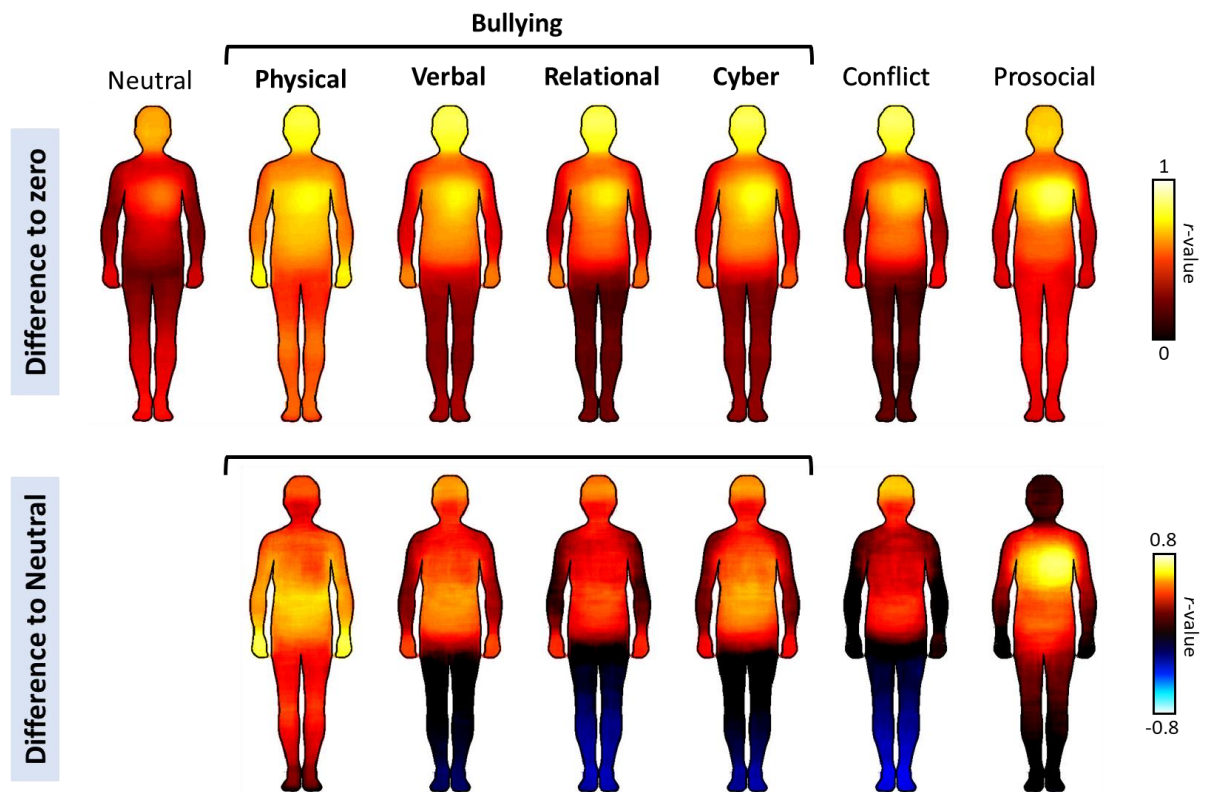


Figure 2. *Bodily sensations evoked by social scenarios.* Top row: Topographies of condition-wise bodily sensations. The maps show r -values for regions whose activation was significantly different from zero in each social condition (mass univariate t -test, $q < .05$, FDR corrected). Bottom row: Difference maps show the condition specific r -values for areas where activation was significantly higher or lower than in neutral condition (paired t -test, $q < .05$, FDR corrected). Warm colours indicate stronger activation in contrast to neutral condition, and cold colours indicate weaker activation.

On average, participants coloured 14% of the pixels inside the silhouette. The bodily sensations were most extensive in the physical bullying condition (as indicated by the percentage of coloured pixels, $Mdn_{Physical} = .17$), and weakest for the neutral condition ($Mdn_{Neutral} = .06$). Verbal, relational, and cyber bullying evoked comparable amount of bodily sensations ($Mdn_{Verbal} = .13$, $Mdn_{Relational} = .11$, $Mdn_{Cyber} = .12$). All conditions differed significantly from the neutral condition (Wilcoxon $rs \geq 0.60$, **Figure 3**). Effect sizes and FDR

corrected q -values for paired Wilcoxon tests for all pairs of conditions are reported in **Figure S8**.

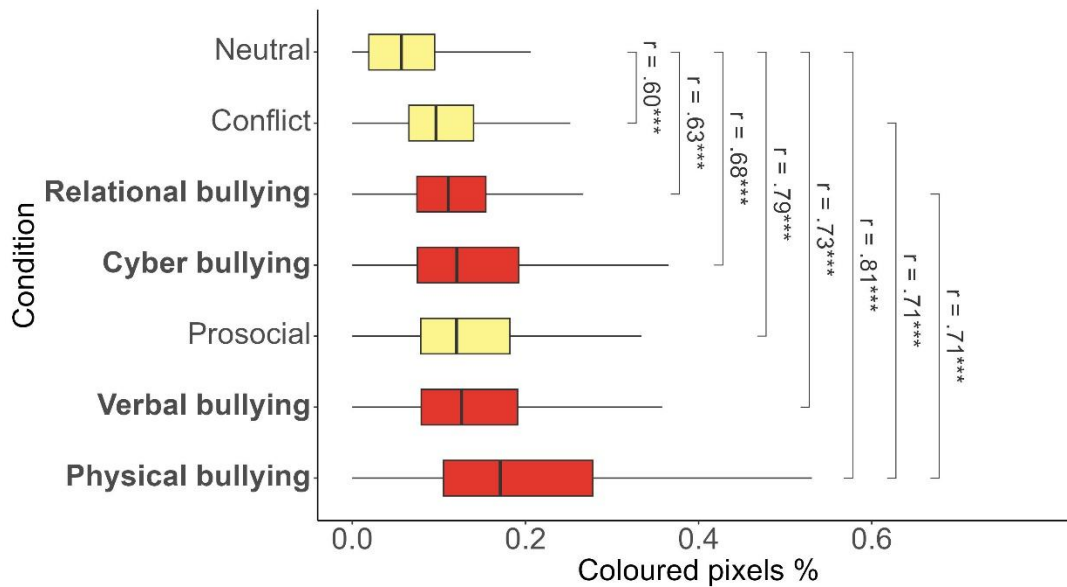


Figure 3. Percentage of coloured pixels in each social scenario. The vertical line indicates the median, the lower and upper ends of the boxes indicate the lower and upper quartiles, and error bars indicate the 1.5 interquartile range. The non-parametric Wilcoxon paired signed-rank test was used for comparing percentages of pixels coloured between conditions. Only large effects ($r > .5$) are presented for clarity. *** $q < .0001$, FDR corrected.

3.3 Region of interest analysis

All social scenarios in Experiment 2 evoked sensations consistently in the head, with the strongest activation for verbal bullying ($Mdn_{\text{Head}} = .46$) and the weakest for neutral social scenarios ($Mdn_{\text{Head}} = .17$) (**Figure 4**). The core region was also consistently activated ($Mdn_{\text{Core}} = .14-.24$) in all but neutral scenarios ($Mdn_{\text{Core}} = .02$). Only physical bullying was consistently felt in the hands ($Mdn_{\text{Hands}} = .32$). Widespread activation of the body for physical bullying was also seen in the low ratio between sensations felt in the head in relation to rest of the body, whereas conflict situations were felt relatively more in the head region (**Figure S9**). Large (Wilcoxon $r \geq 0.5$) differences between conditions within regions of interest are reported in **Figure S10** and effect sizes for all comparisons can be found in **Figure S11**.

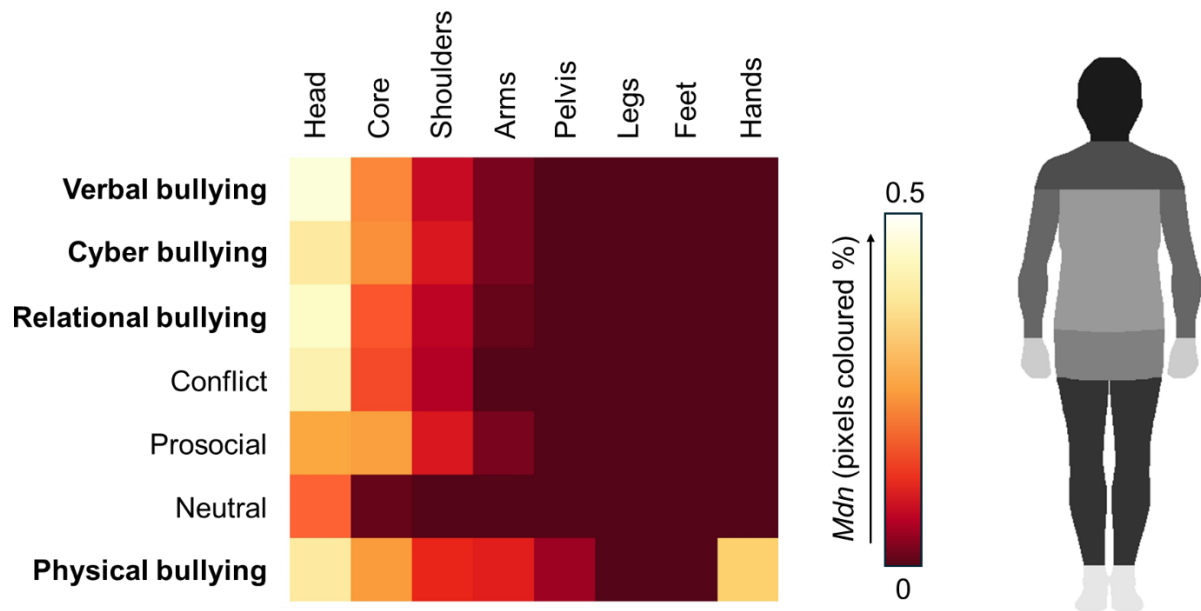


Figure 4. Median percentage of pixels coloured for each ROI in each social scenario. Regions of interest are visualized on the human silhouette.

3.4 Similarity between behaviour ratings, subjective emotions, and bodily sensations

The distance matrix of the vignette-wise emotion ratings were strongly correlated with the distance matrix of observed behaviour and reaction ratings ($r = .94, p < .001$, assessed using Mantel test with 2,000 permutations), indicating that similarity in subjective emotions predicted similarity for ratings in observed behaviour and reactions (**Figure 5**). The distance matrix of the BSMs had moderate correlation with the distance matrix of observed behaviour and reaction ratings ($r = .40, p < .001$, assessed using Mantel test with 2,000 permutations), and with the distance matrix of emotions ($r = .46, p < .001$, assessed using Mantel test with 2,000 permutations), indicating moderate predictive value between bodily sensations and observed behaviour and reactions, as well as emotional responses for the social scenario vignettes.

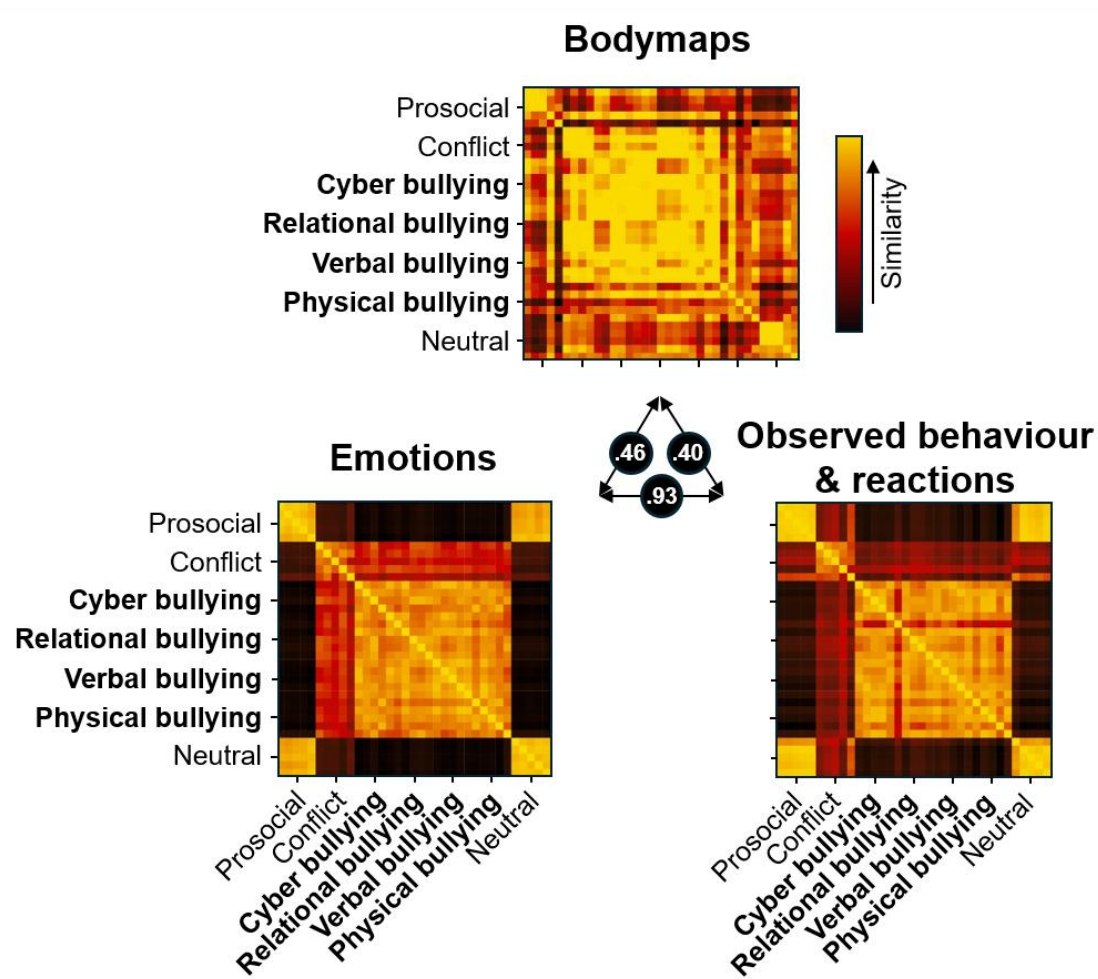


Figure 5. Similarity matrices for vignette-wise bodily sensation maps (top), subjective emotions (bottom left), and observed behaviour and reactions (bottom right). Black disks in the middle represent correlations between matrices, all significant at $p < .001$ in Mantel's test with 2,000 permutations.

3.5 Bodily sensation maps during naturalistic bullying exposure

In line with the results from Experiment 2, first-person bullying videos (Experiment 3) evoked more widespread bodily sensations in comparison to neutral conditions as measured by the percentage of pixels coloured in both online and onsite samples ($r_s > .69$, FDR corrected $q_s < .0001$). The bodily sensations evoked by the bullying videos were topographically highly similar to those evoked by the vignettes ($\rho = .90$ for onsite sample, $\rho = .92$ for online sample, FDR corrected $q_s < .0001$), including sensations in the head, chest, abdominal region, and hands (**Figure 6**). However, vignettes evoked topographically more widespread sensations than the videos (**Figure S12**). Especially the activation of the head region was stronger for the

bullying vignettes in comparison to the bullying videos. When comparing the bodily sensations evoked by the bullying videos across the onsite and online samples, only minor differences were observed with slightly weaker activation in the online sample for the neck, pelvic, and lower limb regions (**Figure S12A**) and lower percentage of pixels coloured (**Figure S12B**) in comparison to the same videos presented onsite.

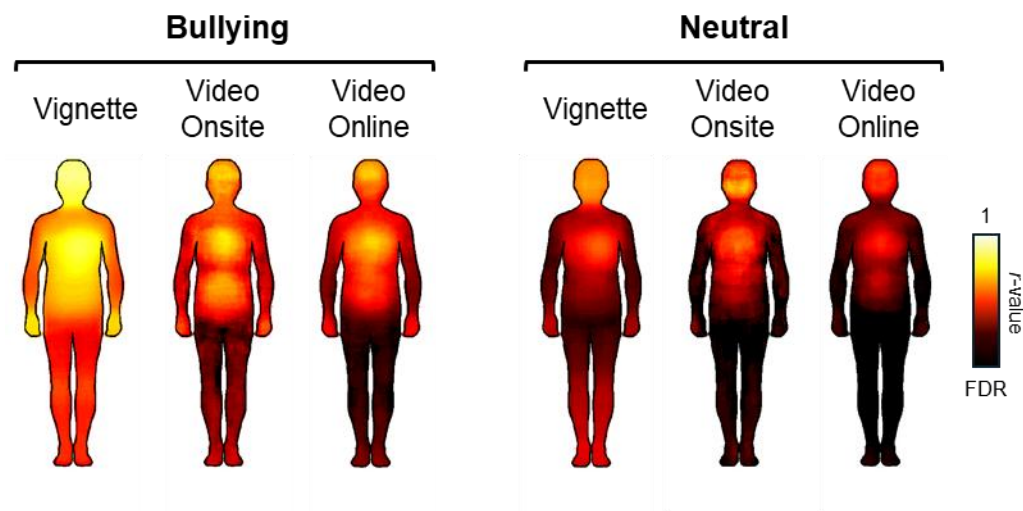


Figure 6. Bodily sensations evoked by bullying and neutral social scenario vignettes and first-person videos. The maps show r -values for regions whose activation was significantly different from zero in each social condition (mass univariate t -test, $q < .05$, FDR corrected within condition).

3.6 Similarity between bodily sensation evoked by social vignettes and discrete emotions

Normalized Euclidean similarities (NES) between BSMs for social vignettes and discrete emotions are shown in **Figure S13**. Bodily sensation maps for verbal, relational, and cyber bullying, as well as conflict situations (Experiment 2) had the highest similarities with anxiety, shame, sadness, neutral state, and joy ($NES = .64-.82$), and they had moderate similarities with all the other tested emotions as well ($NES > .50$) (Experiment 4). Bodily sensation maps for physical bullying had highest similarity with bodily maps of anxiety ($NES = .66$), anger ($NES = .56$), and fear ($NES = .55$), and lower similarities with rest of the emotions ($NES = .36-.50$). Neutral vignettes evoked bodily sensations that had highest similarity with sensations evoked

by surprise, joy, and the neutral state ($NES = .58-.60$). Bodily sensations evoked by prosocial social interaction were most dissimilar with the bodily sensations evoked by the discrete emotions, similarities ranging from .20 for anger to .56 for joy.

3.7 Associations between victimization experiences and bodily responses to bullying exposure

The structural equation model for testing the association between retrospective victimization and bodily responses to the bullying exposure vignettes had adequate fit: $CFI = .99$, $TLI = .93$, $\chi^2/df=15.214/6$, $p = .019$, $RMSEA = .06$, $SRMR = .03$. Higher retrospective victimization was associated with increased bodily responses to the relational bullying vignettes in contrast to neutral social scenario vignettes ($b = .10$, $SE = .05$, $p = .026$; **Figure 7**) but was not significantly associated with bodily responses to any other bullying condition ($ps \geq .34$).

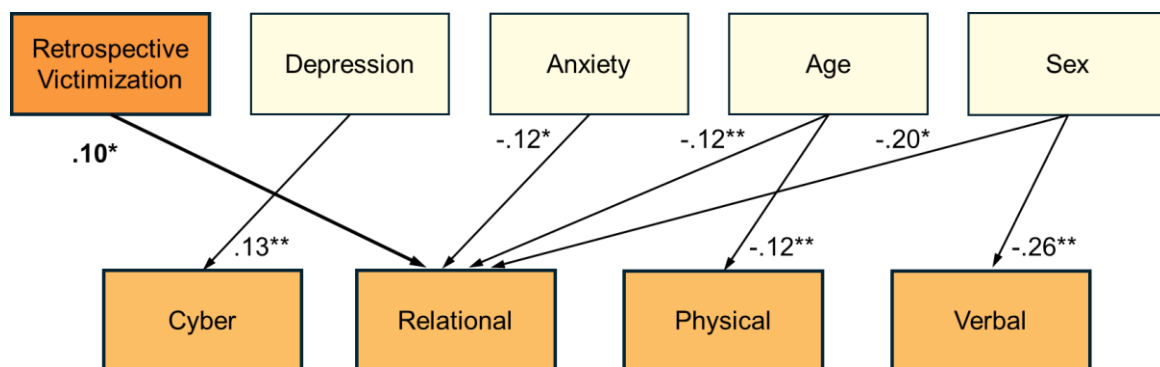


Figure 7. Structural equation model representing the associations between retrospective victimization and bodily responses to bullying vignettes in contrast to neutral social scenario vignettes. $*p < .05$, $**p < .01$. Standardized coefficients are presented. Residual variances, correlated residuals, and covariances between victimization, depression, and anxiety were included in the model, but are not depicted for clarity. Only significant associations are presented for clarity. Coding of sex: 0 = female, 1 = male.

4. Discussion

Our main finding was that bullying is an emotionally distressing experience that is associated with salient bodily sensations resembling those evoked by anxiety, fear, and shame. The subjective emotional and bodily responses were stronger for bullying than for other types of social conflict, highlighting the social stress evoked by bullying. Bullying also evoked stronger distressing emotions (particularly anger, annoyance, and shame), higher arousal, and greater emotional distance from others in comparison to conflict, neutral, and prosocial conditions irrespective of whether it was physical, verbal, relational, or cyberbullying in nature. Altogether these data underline the embodied component of the bullying experience, suggesting that the bodily experiences and increased autonomic activation during exposure to bullying might be an important pathway explaining the adverse health outcomes associated with being bullied.

4.1 Bodily responses to bullying

All types of bullying evoked topographically widespread bodily sensations. In comparison with neutral social scenarios, bullying evoked stronger bodily sensations particularly in the head, chest, stomach and hand regions. These responses were consistent during vignette-based mental imagery as well as while viewing first-person videos of naturalistic bullying scenarios. Physical bullying evoked stronger activation of the upper and lower limbs than other conditions. These bodily sensations could reflect preparing for defensive behaviours such as kicking and hitting, or escaping the situation. Unlike physical bullying, other bullying conditions and social conflict evoked less activation of the lower limbs in comparison to neutral situation. The ratio between bodily sensations in the head versus rest of the body was low for physical bullying but also for positive social interaction, indicating a strong bodily experience for these forms of social interaction, in contrast to potentially more cognitively or emotionally loaded experiences of other forms of bullying and conflict situations (Nummenmaa et al., 2018; Nummenmaa & Hari, 2023).

Overall, the bodily sensations evoked by bullying resembled most closely the bodily sensation maps of negative emotions such as anxiety, shame, sadness, and fear. This suggests that the bodily sensations evoked by bullying are not driven by a single emotion, but arise as a result of simultaneous engagement of multiple approach and avoidance-related emotion systems.

This aligns well with the self-reported emotions evoked by the bullying vignettes and videos, which indicated an experience of a wide constellation of distressing emotions ranging from fear to shame, disgust, anger, and anxiety (see **Figure 1B** and **S6B** and **D**). It should be noted however, that even though the bodily emotions topographically independent from each other (Nummenmaa et al., 2014), the BSMs only capture the topographical differences in emotions but not the quality of the sensations. For example, the moderately high similarity of bodily sensations evoked by bullying vignettes and bodily sensations of joy could arise as a result of high topographical similarity of bodily sensations of joy and sadness. Altogether these results indicate that peer victimization causes significant allostatic load to the individual through the engagement of multiple emotional distress systems at the same time (Suinn, 2001).

4.2 Emotions and reactions evoked by bullying

Bullying vignettes evoked stronger emotional distress (particularly anger, annoyance, and shame), higher arousal, and greater emotional distance from others in comparison to other vignette conditions. Similar results were obtained using first-person bullying videos. These results accord with prior studies reporting feelings of distress and anger in victimized children and adolescents (Hunter & Borg, 2006; Hutson, 2018; Ortega et al., 2009; Sampaio et al., 2015; Vie et al., 2012), and activation of the brain's stress and alarm circuits during simulated bullying (Paranko et al., 2025). Importantly, also cyberbullying evoked strong feelings of distress, including even higher levels of fear than relational and verbal bullying, higher arousal than relational bullying, and highly similar bodily sensations than verbal ($NES = .88$) and relational bullying ($NES = .80$) despite the lack of physical proximity of the perpetrator, highlighting the threatening nature of bullying even when it takes place online.

In line with the limb-focused bodily sensations during vignette-induced experience of physical bullying, this form of bullying evoked stronger intentions for attacking or escaping than non-physical forms of bullying. However, intentions for escaping and attacking were higher for all bullying conditions in comparison to other conditions. In contrast, withdrawal was as likely in conflict situations as in bullying conditions, indicating that all socially challenging interactions evoke behavioural responses used to avoid the situation. Conversely, prosocial (and to some

extent neutral) vignettes evoked profound feelings of joy and closeness, which was also manifested as increased subjective experiences throughout the body and particularly in the chest area, indicative of positive emotional engagement.

The tight relationship between emotions, bodily states, and behaviour was further reflected in the representational similarity analysis of the social vignettes (**Figure 5**). Subjective emotions had high representational similarity with the observed behaviour and reactions, suggesting that being involved in social situations evokes adaptive emotions that in turn elicit specific behavioural reactions suitable for the situation, such as escaping or acting in a prosocial manner. Furthermore, moderately high correlations between the distance matrices of bodily sensation maps and subjective emotions were observed. This is in line with previous studies using representational similarity analysis for bodily sensation maps and emotions (Putkinen et al., 2024), suggesting that the guiding role of emotions in our social behaviour takes place through altering the physical state of the body.

4.3. Associations between victimization experiences and bodily responses to bullying

We also found some support for associations between past victimization experiences and increased bodily responses, though this was limited to relational bullying. This suggests that childhood victimization experiences may sensitize the body for subsequent experiences of relational harm. Additionally, experiences of relational bullying during adulthood may act as reminders of the bodily sensations evoked by past bullying experiences in victimized participants. However, no consistent associations between past victimization experiences and bodily sensations evoked by other forms of bullying were observed. One possible explanation for the discrepancy between the results is that some people might react to continuous victimization experiences by suppressing their feelings whereas others might become increasingly sensitized to subsequent victimization, leading to a lack of associations between past victimization experiences and bodily sensations in most of the tested bullying conditions. This hypothesis is in line with inconsistent results on long-term cortisol reactivity in victims of bullying (Chen et al., 2018; Kliwer, 2016; Knack et al., 2011; Ouellet-Morin et

al., 2011), suggesting that individual differences in coping strategies can alter the stress responses to bullying. These individual differences should be further considered in the future research.

5. Limitations

Realistic victimization is difficult to simulate in controlled laboratory context, and individual differences in imagination capabilities across participants can affect the vividness of the experience when reading social vignettes. However, on average all vignettes were rated as realistic and vivid. Furthermore, bodily aspect of victimization was also replicated using naturalistic video stimuli. We assessed the relationship between childhood victimization experiences and bodily responses to bullying exposure using retrospective self-reports. Retrospective self-reports however introduce a degree of uncertainty and do not allow for interpretation of causative connections between victimization history and concurrent bodily experiences. Our sample only contained healthy (per self-report) individuals and those for whom victimization has caused more severe psychological consequences had to be excluded from the study. Future studies should address the relationship between real-life victimization experiences and bodily responses to bullying in individuals with documented victimization history as well as in clinical populations, such as patients with social anxiety disorder or generalized anxiety disorder. Finally, because peer victimization is especially prevalent during school years, the experiment could be replicated using adolescent participants, and the long-term consequences of bullying on bodily experiences should be studied using longitudinal data.

6. Conclusions

Peer victimization is an emotionally distressing event that evokes high arousal and emotional distance from others, as well as topographically widespread bodily sensations. These results are in line with the long-term psychosomatic consequences of victimization and suggest that

somatic aspects and mind-body oriented therapies should be considered when providing help for the victims of bullying.

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