Contextual and endogenous effects on physiology during a haunted house fear induction

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Abstract

Threat exposure elicits physiological and psychological responses, the frequency and intensity of which, and concordance between, has implications for survival. Ethical and practical limitations on human laboratory fear inductions make it essentially impossible to measure response to extreme threat. Furthermore, ecologically valid investigations of group effects on fear are lacking in humans. The current preregistered study measured tonic and phasic electrodermal activity in 156 human participants while they participated in small groups in a 30 minute sequence of threats of varying intensity (a haunted house). Results revealed that (i) friends increased overall arousal, (ii) unexpected attacks elicited greater phasic responses than expected attacks, (iii) subjective fear increased frequency of phasic spikes, and (iv) startle had dissociable effects on frequency and amplitude of phasic reactivity. Findings show that etiology of emotional contagion varies depending on relationship type (increased among friends) and subjective fear is associated with temporal aspects of physiological arousal.

Keywords: fear, physiology, skin conductance, social, threat

Statement of Relevance

Threat of danger elicits defensive behaviors and supporting physiological responses that promote survival. Temporal and spatial aspects of these adaptive responses is proposed to vary with contextual and endogenous factors. However, laboratory constraints make it difficult to study group context, and subjective and physiological responses to intense threat. Identifying how externally and internally-focused factors (e.g., presence of others and fear-related meta-cognition) relate to physiology will advance understanding of fear-based psychopathology. This study supports a model of dynamic physiological responding in response to continuous threat. Data point to friend-related emotional contagion, subjective-objective emotional concordance, and threat predictability as important contributors to mounting electrodermal responses to threat.

Behavioral responses to fear-eliciting stimuli are common across species because danger provides important motivation to seek safety. Intense subjective fear is a challenging state to induce empirically given ethical constraints on human laboratory experiments. In this study, groups of participants went through a 30 minute haunted house experience as an intense fear-inducing threat manipulation. Real-time physiological-monitoring wristbands measured electrodermal activity (EDA). EDA was examined in relation to four factors: contextual factors of group composition and threat imminence, as well as endogenous personal factors of subjective fear and startle response.

Group composition

Under threat, the presence of others can act as a safety or danger signal, or both. Ecological models suggest larger group sizes can reduce fear by facilitating risk dilution (Foster & Treherne, 1981). In animals' natural ecologies, larger group sizes can deter predators and also increase vigilant threat detection (Mobbs et al., 2015). Unlike most animal prey, humans are under threat from other humans, which may flip the way social others are perceived during threat, from protective to more dangerous. In cases of intense fear it is also possible that social others act to spread fear rather than alleviate it (Jeon, 2010). Further, relationships among individuals matter. In rodents, for example, the familiarity of a social counterpart increases observational fear learning (Gonzalez-Liencres et al., 2014).

Whether groups reduce or contagiously increase fear in humans, and how those effects are moderated, is mostly unknown. The reason for this is that most experimental knowledge about human fear stems from Pavlovian fear conditioning paradigms with physically aversive shocks, but rarely with group context manipulation. Uncovering more about the effects of social groups on human fear is especially important because humans experience both social affiliation and predatory threat from conspecifics, unlike most animals. The current study tested whether group composition, measured as the ratio of friends to strangers present, increased or reduced physiological responding.

Imminence

"Imminence" is the spatial and temporal proximity of threat. Spatiotemporal estimates interact to determine subjective predatory attack probability (Fanselow & Lester, 1988). The imminence continuum ranges from safe states, during which attack probability is close to zero, to circa-strike (CS), during which a predator is about to attack or is attacking. Defensive behaviors and physiological reactions intensify as imminence increases to protect against increasing danger (Mobbs et al., 2007). Difficulty in estimating attack probability due to unpredictability can also increase fear and defensive behavior. Unpredictability itself is generally aversive and can lead to sustained arousal when pertaining to threat (Grillon et al., 2004; Kirschner et al., 2016). Imminence, including predictability of CS, was tested as a contextual factor hypothesized to increase physiological responding in the current study.

Subjective fear

Humans are uniquely able to report subjective fear experiences. Therapeutic interventions have been shown to alleviate both subjective and physiological experiences of fear (Shurick et al., 2012). However, subjective and objective fear responses do not always align; people can feel more afraid than they should (as is the case in certain phobias) or experience deficient fear (as is the case in aberrant risk taking). Discordant fear responses are present in threat-related psychopathology and differ by gender (Diemer et al., 2016; Stoyanova & Hope, 2012). The current study tested whether self-reported fear was aligned with physiological markers of fear. Gender was also tested as a moderator of associations between subjective fear and physiological responding.

Startle

Startle responses are innate reflexive responses to sudden threat (Sevenster et al., 2014). Startle can occur independent of cognitive processing (Sevenster et al., 2014), but is sensitive to context and pre-existing fear (Anokhin & Golosheykin, 2010; Grillon et al., 1997). Fear-potentiated startle is thought to reflect individual differences in reactivity of the defensive survival system. Higher initial startle is generally associated with faster habituation to aversive stimuli (Blanch et al., 2014). Deficits in habituation are often indicators of anxiety in humans (Campbell et al., 2014). Typically studies of startle habituation use repeated exposure to identical stimuli (aversive tones). In the current study, identical stimuli (fear events in distinct "rooms" in the haunted house) were not repeated, allowing us to test whether initial startle is associated with habituation during varied and continuous fear exposure.

Electrodermal activity

Fundamentally, emotions support adaptive behavioral response to ecologically relevant stimuli and changing environmental demands (Mobbs et al., 2018). Emotions, including fear, are inextricably linked to the autonomic nervous system (Kreibig, 2010). The autonomic nervous system has two divisions, the sympathetic and parasympathetic. They primarily operate unconsciously, and regulate somatic functions including cardiac, vascular, and electrodermal responses. The sympathetic system is of particular interest in the study of fear as it supports "fight or flight" reactions to threat. To accomplish this, the sympathetic system increases blood flow and sweating, which enables thermoregulation during conditions of increased physical activity (McCorry, 2007). Accordingly, the most common measure of sympathetic arousal is EDA. EDA is a general term for alterations in the electrical properties of the skin and includes phasic and tonic components. Phasic responses (SCRs) are short-term responses to specific external stimuli (e.g., SCR will ramp up if you hear a loud noise). Tonic levels (SCLs) are less reactive to external stimuli and represent slow drifts in general physiological responding. In this study, both phasic and tonic EDA were measured as indicators of physiological arousal to threat.

Current Study

The current study makes a significant advance in understanding of human fear response using a unique threat experience. The haunted house experience involved a variety of threatening encounters in 17 distinct rooms of a fictious penitentiary. Threats included inability to escape a speeding oncoming truck, mimicked suffocation, high-voltage electric shocks, being shot with pellets by a "firing squad" while blindfolded, among others. Although participants knew they were not in actual physical danger, this type of intense threat manipulation is not replicable in the lab. Participants attended the experience in groups of varying size and composition, creating a rare opportunity to examine group effects on fear among a combination of friends and strangers. The current study therefore tested how group composition, imminence, subjective fear, and initial startle response related to physiological responding.

Method

Participants

Participants who paid an entrance fee and signed a legal waiver to participate in the haunted house were then recruited to participate in this study. Data were collected from 157 adults. Data from one participant was excluded due to a trigger failure during collection, age=24 years, male. The resulting 156 participants were included in analyses, M_{age}=25.79, SD_{age}=5.90, $range_{age}$=18-59, 85 females. One participant did not report age and one participant did not report gender. Sample size was based on collecting maximum available data given experimental constraints including a limited run season for the experience (<20 days) and the number of wearable devices. All participants provided written consent in accordance with the policies of the Institutional Review Board and study procedures were conducted in accordance with the American Psychological Association guidelines for human research.

Haunted house threat manipulation

The 17th Door Haunted House attraction is an established haunted house experience involving 17 discrete rooms, loosely linked to a theme about a dangerous prisoner in a fictitious prison. Each room was designed to induce a certain type of fear, some of which are more fear-inducing than is ethically allowed in campus laboratory experiences in the United States. The entire experience lasted approximately 30 minutes. Room and threat descriptions are provided in Supplemental Materials Table S1.

Electrodermal reactivity

EDA was measured continuously throughout the experience using the Empatica E4 system (E4). The E4 is a wrist-worn wireless sensor that records SC exosomatically (sampling frequency: 4 Hz, resolution: 1 digit ~900 picoSiemens). Data were downsampled to 1 Hz for processing. Using LedaLab (version 3.4.9,Benedek & Kaernbach, 2010), artefact removal was performed using a first-order Butterworth filter with a cut-off frequency of 0.05 Hz. Next, the SC signal was decomposed into tonic and phasic components using the continuous decomposition analysis (CDA). CDA is particularly useful for data with high phasic activity, as is the case in a continuous threat manipulation. Finally, a threshold value of 0.05 μS was applied to SCRs (Boucsein et al., 2012). Metrics were z-transformed to facilitate between-event and between-subject comparison by reducing variance due to peripheral factors unrelated to the experiment (e.g. skin properties). For each event, average SCL, frequency of SCRs (temporal component), and summed amplitude of SCRs (spatial component) were assessed. All metrics are expressed in μS.

Group composition

Participants self-reported on the number of friends and strangers in their group during the experience. The entire group composition was beyond experimenter control (though an effort was made to recruit both smaller and larger friend groups). A ratio of friends:strangers was calculated by subtracting the proportion of strangers from the proportion of friends. Positive values indicate more friends than strangers and negative values indicate more strangers than friends.

Imminence

Imminence is typically defined to include four phases of threat: safety, pre-encounter, post-encounter, and circa-strike (Fanselow & Lester, 1988). 'Circa-strike threat' (CS) exists when a predator is prepared to attack or has attacked. Imminence was coded based on the presence and predictability of a CS on a scale of 'no CS'=0, 'anticipated CS'=1, 'unexpected CS'=2, 'anticipated and unexpected CS'=3. Higher scores were given to compound fear experiences consisting of both expected and surprise scares.

Subjective fear

Before the experience, participants reported anticipated fear on a scale of 1 (low) to 10 (high). After the experience, participants reported experienced fear on the same scale. To avoid artificial skew due to floor or ceiling effects, analyses were conducted for experienced fear controlling for anticipated fear.

Startle

Startle responses were operationalized as SCR frequency and summed amplitude during the first room of the haunted house experience. Startle was tested as a predictor of subsequent SCR habituation. Habituation was operationalized as individual slopes of SCR frequency and summed amplitude over the remainder of the experience, rooms 2-17. Slope coefficients were extracted from linear growth curve models. Gender differences (female=0, male=1) in startle reactivity were also assessed.

Analytic approach

Data analyses were performed using R statistical software (version 3.6.1; R Core Team, 2019) and the lme4 (version 1.1-21; Bates, Maechler, Bolker, & Walker, 2015) and reghelper packages. Mixed effects models was tested using the lmer function (lmerTest assessed t-tests using Satterthwaite's method). Effect sizes reported as R^2 are reported as conditional effects of variance explained by the entire model (Nakagawa et al., 2017). Model comparisons were performed using the anova function. Linear models were tested using the lm function.

EDA_{ij} reactivity for the jth participant (j) at the ith room (i) was modeled as a function of time (room order) and factors of interest (group composition, imminence, subjective fear). Using linear models, habituation was modeled a function of initial startle. Because startle was an independent question of interest, models excluding startle only use data for rooms 2-17. Model diagnostics are provided in Supplemental Materials Fig. S1.

Results

Initial fit statistics for mixed effects models assessing EDA reactivity are depicted in Table 1. First, an unconditional model was run specifying separate random intercepts for individuals, to confirm there were significant individual differences in EDA. Intraclass correlation coefficients (ICCs) indicated it was appropriate to include random intercepts in subsequent models (Koo & Li, 2016). Next, fixed effects of time (room order) were added and model fit significantly improved for all models. Thus, effects of time were included in subsequent models.

Table 1. Model fit statistics and comparisons.

Model	DV	$N_{observations}$	$N_{individuals}$	*AIC*	*BIC*	*-2LL*	ICC
Random intercepts	Tonic SCL	2496	156	16018.0	16035.4	-8006.0	.81
	SCR frequency	2496	156	15397.5	15415.0	-7695.8	.55
	SCR amplitude	2496	156	13864.9	13882.4	-6929.5	.59

Model	DV	$N_{observations}$	$N_{individuals}$	*AIC*	*BIC*	*-2LL*	χ^2	*p*
Random intercepts + Time	Tonic SCL	2496	156	14474.4	14497.7	-7233.2	1545.6	<.001
	SCR frequency	2496	156	15011.8	15035.1	-7501.9	387.7	<.001
	SCR amplitude	2496	156	13457.4	13480.7	-6724.7	409.6	<.001

Group composition

Number of friends per group ranged from 1 to 8, M=3.47, SD=1.60 (excluding count of the responding participant). Number of strangers per group ranged from 0 to 7, M=3.23, SD=1.85. Number of friends and strangers were highly correlated because the haunted house management preferred similarly-sized groups of 8-10 individuals meaning more friends resulted in fewer strangers, $r(156)=-.70$, $p<.001$. This high correlation motivated the use of the difference in friend and stranger ratios, which ranged from -.75 to 1, *M*=.07, *SD*=.49.

An increased ratio of friends to strangers was significantly associated with higher tonic SCL, controlling for effects of time (Table 2A). Time and friend ratio interacted such that tonic SCL deviated more depending on group composition at the end of the experience but did not significantly differ at the beginning (Fig. 1A).

Imminence

Of the 16 non-startle rooms (excluding the first room deliberately), 12.50% were coded as no CS, 18.75% as anticipated CS, 31.25% as unexpected CS, and 37.50% as combination anticipated and unexpected CS. Imminence was not significantly associated with time, estimate=-.031, *SE*=.06, *t*=-.52, *p*=.61, 95% CI[-.16, .10], thus imminence was not confounded with any possible temporal sensitization or habituation effects.

Imminence was linearly associated with SCR amplitude, estimate=.15, *SE*=.06, *t*=2.42, *p*=.016, 95% CI[.03, .28], R^2=.66, σ^2=10.38, τ_{00}=17.96. Linear effects of imminence were not associated with SCR frequency. Imminence was quadratically associated with both SCR frequency and amplitude (Table 2B-C, Fig. 1B-C), and quadratic models were a better fit: SCR frequency χ^2=9.81, *p*=.002; SCR amplitude χ^2=17.74, *p*<.001. Unpredictable CS evoked the highest reactivity.

Subjective fear

Anticipated fear, measured in the pre-experience survey, ranged from 1 to 10, *M*=7.87, *SD*=2.03. One participant did not report their anticipated fear. Experienced fear, measured in the post-experience survey, ranged from 2-10, *M*=7.16, *SD*=2.17. Women reported higher subjective anticipated and experienced fear than men (Fig 2A-B). Anticipated and experienced fear were significantly positively correlated, $r(155)=.37$, $p<.001$ (Fig. 2C).

Greater experienced fear was associated with greater frequency of SCR reactivity, controlling for anticipated fear (Table 2D; Fig. 1D). Gender did not significantly moderate effects of experienced fear on SCR frequency: estimate=.14, $SE=.41$, $t=.35$, $p=.73$, 95% CI[-.65, .94].

Startle and habituation

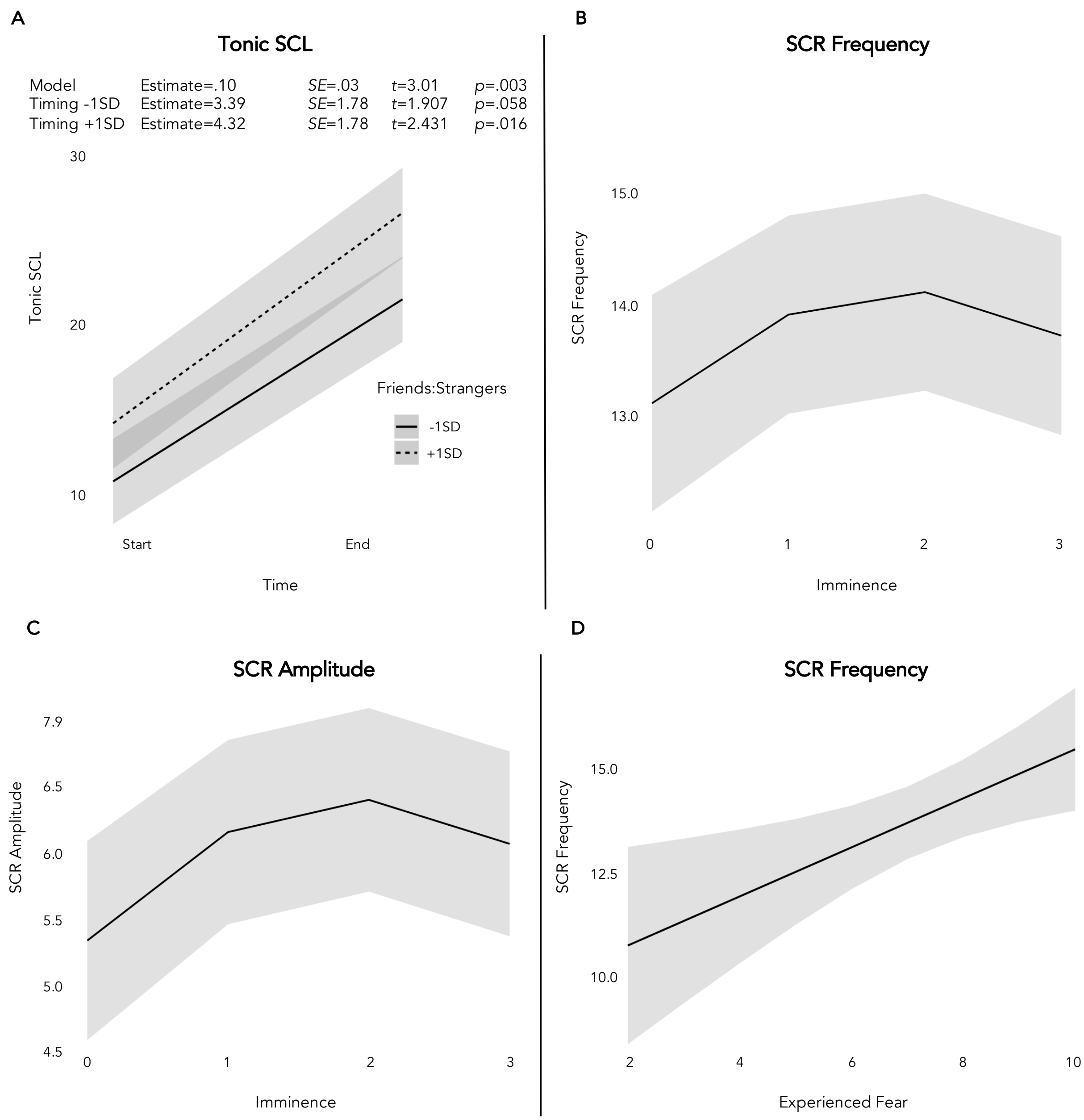
Random slopes were extracted for SCR frequency and amplitude as a measure of linear habituation (positive and negative scores indicate sensitization and habituation, respectively). SCR startle frequency in room 1 was significantly associated with faster SCR frequency habituation (Table 2E). SCR startle amplitude in room 1 was significantly associated with SCR amplitude sensitization (Table 2F). Although higher initial startle is generally associated with faster habituation, magnitude of EDA startle was associated with greater subsequent magnitude whereas frequency of startle, indicative of reactive sensitivity, was associated with faster habituation (Fig. 1E-F).

Table 2. Significant linear and mixed effects model results.

Model	Estimate	*SE*	*t*	*p*	95% CI	R^2	σ^2	τ_{00}
A. Friend Ratio and Tonic SCL[1]	3.86	1.77	2.18	.029	[.39, 7.33]	.90	14.28	115.23
B. Imminence and SCR Frequency[1,2]	-13.96	4.46	-3.13	.002	[-22.69, -5.23]	.62	19.51	28.45
C. Imminence and SCR Amplitude[1,2]	-13.66	3.24	-4.22	<.001	[-20.00, -7.31]	.66	10.30	17.96
D. Experienced Fear and SCR Frequency[1]	.58	.21	2.71	.007	[.16, .99]	.62	19.60	27.21
E. Startle and SCR Frequency Habituation	-.01	.004	-2.86	.005	[-.02, -.003]	.05	—	—
F. Startle and SCR Amplitude Sensitization	.01	.003	3.20	.002	[.004, .02]	.06	—	—

[1]Controlling for effects of time. [2]Quadratic effects.

Note. Models A-E are mixed effects models including random intercepts. Models F-G are linear regressions. All models list the contextual/endogenous predictor first and the electrodermal activity outcome second. SCR=skin conductance response, SCL=skin conductance level.


A
Tonic SCL
Model Estimate=.10 SE=.03 t=3.01 p=.003
Timing -1SD Estimate=3.39 SE=1.78 t=1.907 p=.058
Timing +1SD Estimate=4.32 SE=1.78 t=2.431 p=.016
Tonic SCL
30
20
10
Start
End
Time
Friends:Strangers
-1SD
+1SD
B
SCR Frequency
SCR Frequency
15.0
14.0
13.0
0
1
2
3
Imminence
C
SCR Amplitude
SCR Amplitude
7.9
6.5
6.0
5.5
5.0
4.5
0
1
2
3
Imminence
D
SCR Frequency
SCR Frequency
15.0
12.5
10.0
2
4
6
8
10
Experienced Fear

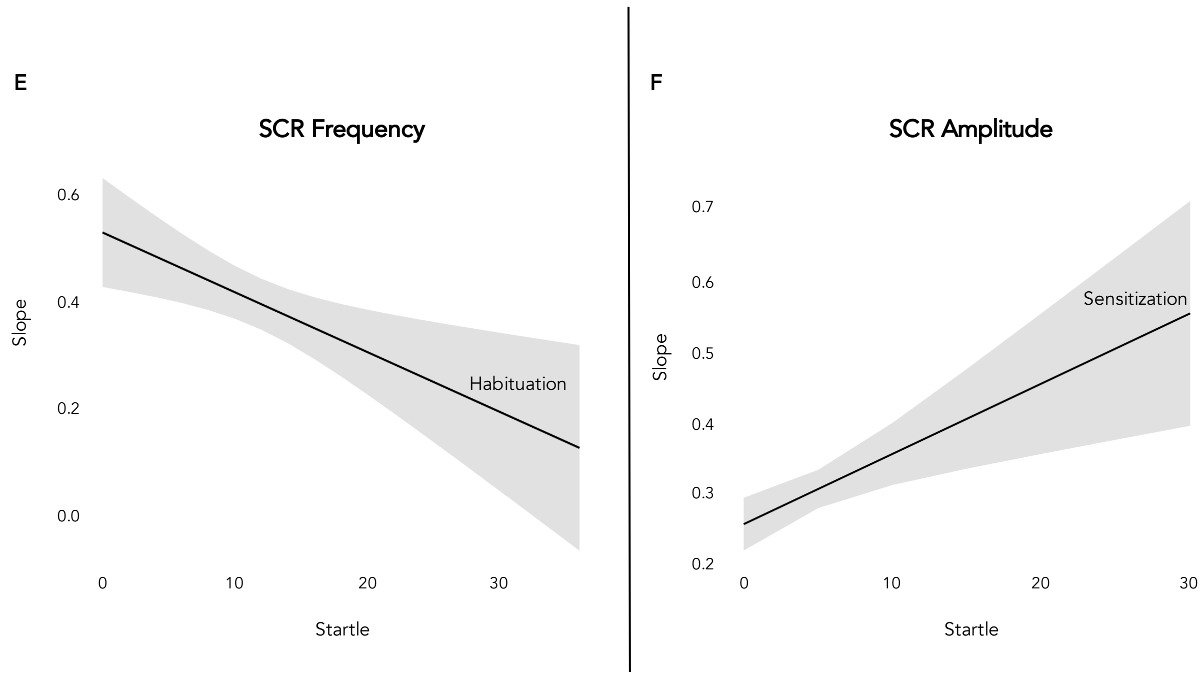


Fig. 1. Model estimates of effects of context and endogenous variables (friends, imminence, fear, startle) on physiological measures. **A.** Time and friend ratio interaction are significantly associated with tonic SCL. **B.** Imminence is quadratically associated with SCR frequency, controlling for time. **C.** Imminence is quadratically associated with SCR amplitude, controlling for time. **D.** Experienced fear is significantly associated with greater SCR frequency, controlling for anticipated fear. **E.** SCR startle frequency is significantly associated with faster SCR frequency habituation. **F.** SCR startle amplitude is significantly associated with increased SCR amplitude sensitization.

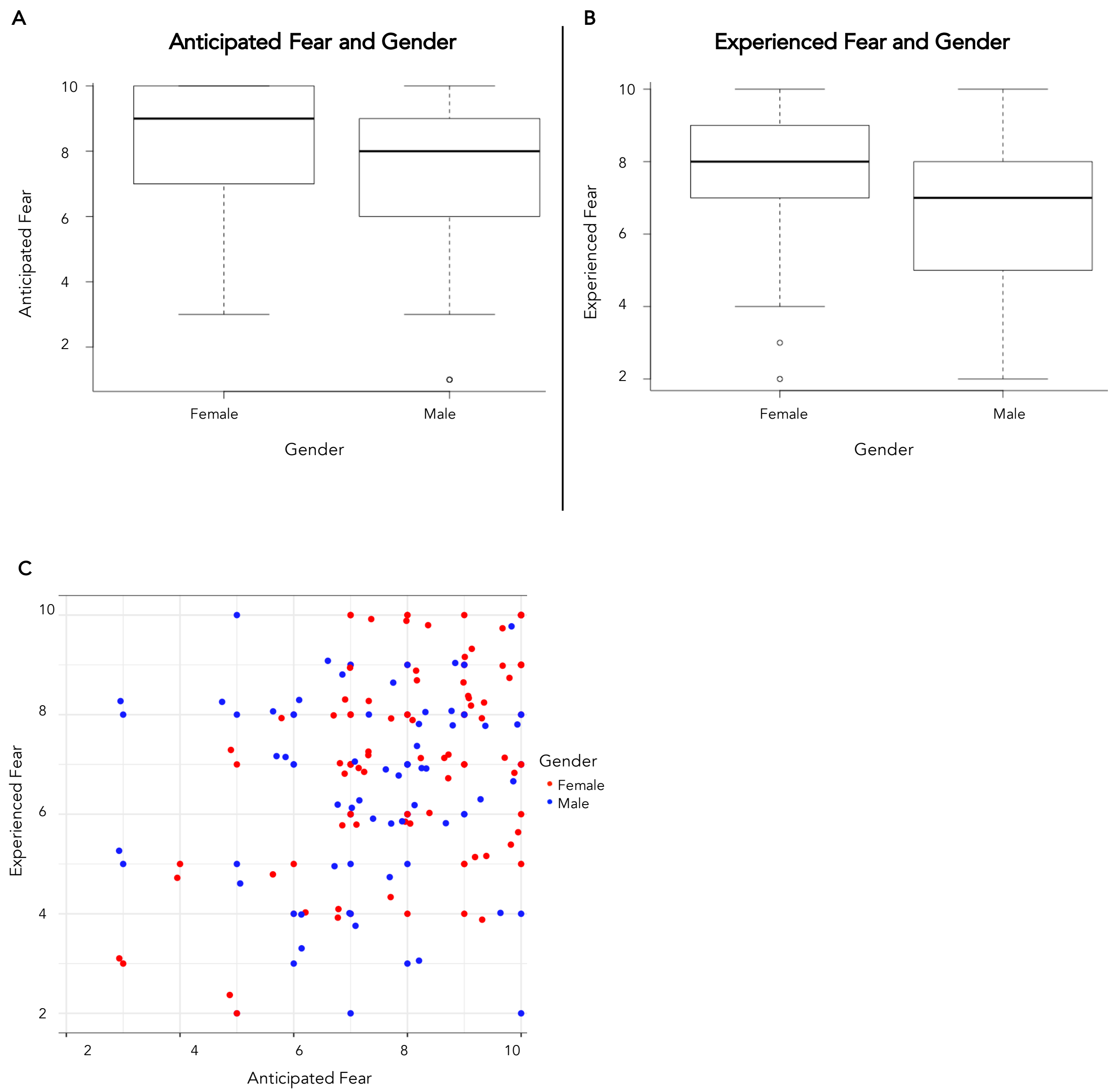


Fig. 2. Subjective fear and gender. **A.** Anticipated fear was higher for females than males. **B.** Experienced fear was higher for females than males. **C.** Anticipated and experienced fear were positively correlated in both genders.

Discussion

For humans, responses to threat encompass subjective emotional experiences of fear, physiological arousal, and defensive behavior. Most often these responses occur in the presence of others. Yet ethical restrictions on experimentation have impeded understanding of contextual and endogenous effects on fear-induced physiology in settings involving extreme threat. The current study leveraged advances in wearable technology to measure EDA during a real-world continuous haunted house threat manipulation, which was carefully designed to create intense fear experiences that are not actually dangerous (much as a horror writer or filmmaker does). The haunted house manipulation excluded performance demands common to the frequently used Trier Social Stress Test, included threats of greater intensity and variety than typical Pavlovian conditioning paradigms, and involved small social groups. Together these features increased the ecological validity of the haunted house fear-induction to understanding how humans process threats in dynamic contexts.

Increased tonic responding was associated with being among more friends and fewer strangers, a fear contagion effect. Although seemingly divergent to models of risk dilution, this finding highlights the importance of disaggregating physiological and behavioral responses to potential threat (LeDoux & Pine, 2016). The presence of social others can act to reduce actual danger, resulting in safe-state behaviors like foraging or mating. Simultaneously, social counterparts may amplify physiological responding because of social synchrony (Palumbo et al., 2017) and fear contagion (Gelder et al., 2004). In the current study prospective threats were highly likely, which reduced the ability of the social group to actually mitigate future danger through risk dilution or collective action. The effect of relationship type (friend versus stranger) is consistent with prior work demonstrating higher synchrony in both positive and negatively valenced interactions for individuals with closer relationship ties (Palumbo et al., 2017). It is possible that arousal projected by friends was more relevant than that of strangers (Ma et al., 2011). Additionally, friends may have up-regulated the excitement of the experience. Notably, tonic SCL represents a general state of preparatory hyperactivity to confront stress suggesting the presence of friends increases arousal in a nonspecific manner (as one would expect from phasic signals).

Individuals who reported greater subjective experiences of fear also demonstrated increased frequency of phasic responses, but did not show greater response magnitudes. This dissociation suggests the cognitive experience of fear may relate to distinct temporal aspects of the sympathetic nervous system. Heightened responsivity can aid learning about potential threats by orienting cognitive systems toward relevant stimuli (Yiend, 2010). Thus, reported experiences of fear may reflect conscious attention toward threat (Lau & Rosenthal, 2011). However, subjective fear may also reflect projection bias whereby participants undergoing increased physiological arousal recalled their experiences as more negative. Projection bias is associated with maladaptive emotion regulation and has deleterious effects on well-being (Chang et al., 2018). Despite that most aspects of acute responses are protective, fear-related biases may be incompatible with situational demands thereby contribute to damaging physiological response profiles observed in psychopathology.

Unexpected attacks elicited the largest phasic frequency and amplitude compared to expected attacks. Humans are highly motivated to reduce uncertainty. Heightened physiological responsivity to unexpected threats was most likely due to irreducible uncertainty – uncertainty that cannot be mitigated over time with learning. Heuristic decision-making required under conditions of irreducible uncertainty conceptually parallels panic behaviors observed in animals during circa-strike attacks. In those circa-strikes, panicked attempts to increase survival result in varied, non-strategic behaviors (Fanselow, 2018). Observed increases in SCR in this study may reflect physiological requirements associated with mounting highly variable defensive responding suited to confronting uncertainty.

Startle response had dissociable effects on later responding with faster habituated frequency of responding but increased amplitude sensitization. Lack of habituation to repeated threat exposure is linked to anxiety and may be an identifiable vulnerability factor (Campbell et al., 2014). SCR amplitude is thought to be more sensitive to peripheral factors like sweat gland density, which may account for the sensitization observed in this study. Few studies include both measures of phasic SCR, making interpretation of these conflicting patterns difficult. However, a prior large twin cohort study supports the assertion that these measures represent distinct phenotypes that are differentially linked to psychopathology risk (Isen et al., 2012). SCR should not be treated as a homogenous measure, but rather both frequency and amplitude may both be important for fully understanding links between physiology and psychopathology. These findings suggest that temporal and spatial dynamics of the physiological stress system respond differently to fear-induction.

Although the novel experimental context is a major strength of this study, it is possible that autonomic arousal observed was due to a multitude of emotional and cognitive experiences including excitement, nervousness, fear, anticipation, attention, and sensory inputs. Despite the inherent reduction in experimental control, the ecological validity of a continuous fear induction makes a substantial contribution to understanding how social context relates to physiological arousal under threat. Findings are interpreted in relation to fear given subjective reports of high anticipated and experienced of fear. Participants in this study self-selected to attend the haunted house experience and as such may be anomalous in seeking-out horror-related entertainment. Timing constraints limited the number of individual difference measures collected. However, this study provides an important proof of concept for further field experiments to continue probing real-world contextual contributors to fear responding.

The current study substantially furthers understanding of human psychological and physiological responses to real-world threats in social context. Foundational concepts in behavioral ecology motivated preregistered hypotheses regarding contextual and endogenous factors posited to influence physiological arousal. The presence of friends increased overall arousal whereas subjective fear experiences and unexpected attacks increased phasic responding. Spatial and temporal components differentially related to habituation after startle. These findings highlight the dynamic nature of autonomic nervous system response, and identifies potential contextually-dependent phenotypes of threat-related psychopathology. Insights from this work call for additional investigations to further detail social and meta-cognitive contributions to threat physiology.

Open Practices

The preregistration for this experiment filed on December 27, 2019 can be accessed at https://osf.io/bw69r/. Analyses and aims were preregistered after data were recorded and prior into any inspection of the data. De-identified data along with the data analysis scripts are also posted at https://osf.io/bw69r/.

Author Contributions

CFC and DM developed the study concept. VF, CFC, TM, and DM contributed to the study design. Data collection and preprocessing was performed by VF. Data analysis and interpretation was performed by SMT. SMT drafted the manuscript, and

CFC provided critical revisions. All authors provided manuscript input, and read and approved the final version.

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Supplemental Materials

Table S1. Room Descriptions as provided by 17th Door staff.

Room #	Room Description	Scare Description
1	Guests sit down and listen to a phone call while watching a video projection on a fog screen.	At the climax of the video, the metal grating on the center visitation window slides up and an actor swings through the opening, scaring the guests.
2	Guests watch the main character Paula get her parole denied. They watch the scene play out from behind security glass.	Towards the end of the scene a guard comes in to take Paula away using a tazor baton. The glass becomes frosted so you see them struggling behind the frosted glass. Then the guard suddenly shows up next to you and activates his tazor baton close to guests (he might shock people, but that would be very seldom).
3	Guests are led through a prison riot by Paula.	This is a "maze" walk through room with approximately 3-5 scares scattered throughout. The timing and intensity of these scares would not be consistent. These are jump scares from the side, 2 scares from behind, and 2 scares from overhead.

4	Prison shower scene.	This is not a typical scare room. It is more an actor interacting with guests. There is a mild scare at the end where the guests think they are going to get hit with water but instead are hit with air. When this happens, the wall opens up suddenly and becomes the exit to the room.
5	Prison workout room.	This is not a typical scare room. It is more an actor interacting with guests. There is a startling end to the scene where the lights turn off and it appears that the wall has been broken open with a loud crash.
6	Outside alley behind prison. This is a large room with a dumpsters at the end where the guests are, and a truck on the other end of the room.	Guests line up and kneel behind a guard rail on their knees. A truck at the other end of the room turns on its headlights, then starts its engine. The truck revs its engine for several seconds, then has a "burnout" sound effect as it begins racing towards the guests. When the truck stops abruptly about 18" from the guardrail it is timed with a large horn and also a large airblast.
7	A guards headquarters with video surveillance	You line up against the wall and the room begins spinning to the sound of a large cranking noise. As the

	monitors on wall. There are 3 clowns that work inside this room.	room continues to spin and disorient the guests, the clowns are jumping around the walls, etc. The overall scare lasts about 30 seconds.
8	This is an execution room done by firing squad.	Guests are lined up individually in metal bays at the end of a firing range. Guests cannot see who is across the room. They have black bags placed over their heads that block their vision and they are sentenced to death over the speakers. There is a countdown to build tension and then it calls out "fire!" at which point guests are shot with small nerf rival balls. These shots are somewhat painful and definitely uncomfortable. The shooting lasts for about 10 seconds.
9	Metal lockers themed as "isolation therapy".	Guests are split up and put into metal lockers 1 guest per locker. Once inside there are instructions over the speakers giving them basic instruction to prepare for their "therapy" A large light begins flashing inside the locker. The climax is a scare where the side panel of the locker drops down suddenly and there is a screaming head next to you that is shaking. At this

		point the back of the locker swings open and an actor pulls you out of the back.
10	Circular room with 8 chairs with restraints.	Guests are locked into chairs and play a game of 3 rounds. In each round they have a set amount of time to select someone else they would like to shock. If they don't select anyone then their chair will shock themselves. After each round of selections and before the shocks the guests get to see if they were selected and by whom.
11	A medical supply room with cabinets on both sides of a narrow aisle (40" wide).	The rooms begins dark and starts flashing lights for very brief amounts of time. An actor is stalking the guests with dubia cockroaches. Usually the guests don't know what is going on until about halfway through the scene. At that point the lights start staying on longer and the guests can see that the room is full of live cockroaches. Sometimes the actor with drop cockroaches on to people or put them down the back of their shirt, etc.
12	This is the other side of firing squad where the	This is not intended to be a scare room.

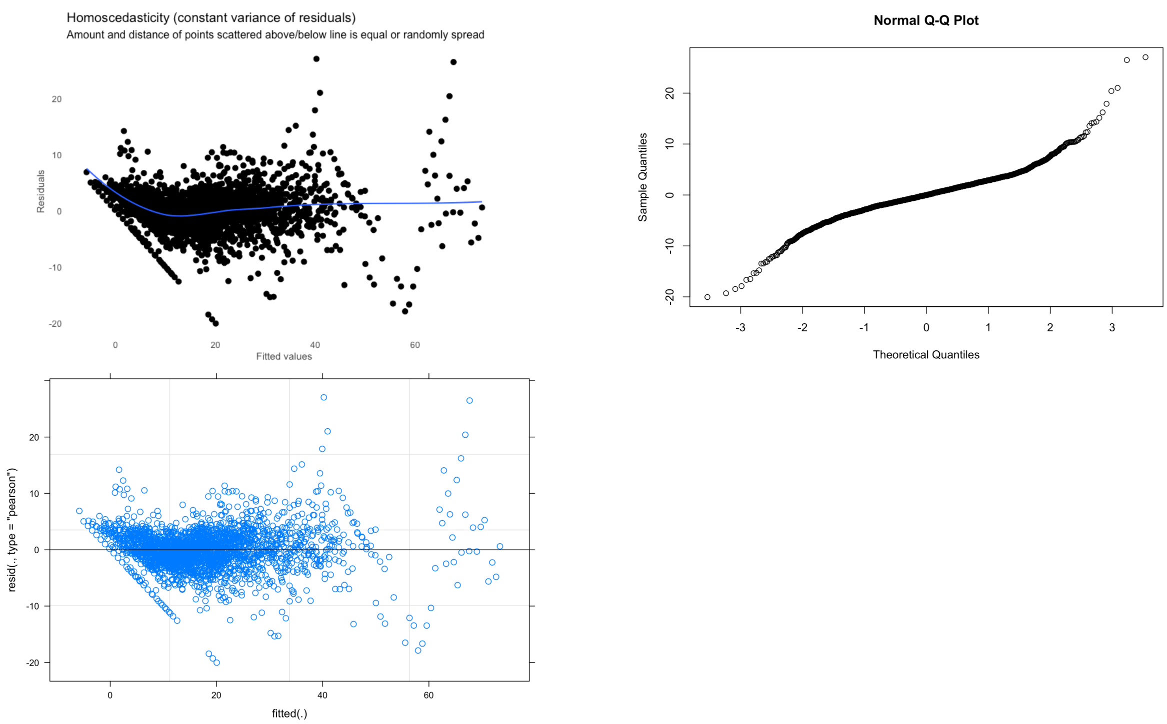
	guests get to shoot the guns.	
13	A room with latex rubber sheets hanging from the ceiling and blue strobing lights.	Guests are lined up with their backs against a wall. Bars come down from the ceiling that have latex rubber bands tied across them that lightly restrain the guests up against the wall. Suddenly the latex sheet overhead comes swinging down. Vacuums turn on inside the wall and suck the latex sheet tight against the wall. The guests are trapped in a tight seal against the wall with a lot of pressure and no ability to breath.
14	This is themed as the Warden's office.	there is no scare in here. There is a possibly uncomfortable scene that plays out where our lead character sexually assaults the Warden. This scene plays out through the use of backlit silhouette actors.
15	This is an industrial elevator.	Not really a scare room although there are some possible startling moments because the elevator jerks around a bit.
16	Metal lockers that are themed as a form of	Guests are split up and placed individually into small metal lockers with a small glass window on the front. The guard in the room sentences them to death at

	execution by gas chamber.	which point the chambers begin filling with fog and also begin leaning backwards. The chambers lean back about 70 degrees, then pause for about 2 seconds, before the back of the chambers suddenly open up which dumps the people out of the back. The guests fall into a "ballpit".
17	Prison common area.	Guests are watching TV when an alarm begins to sound and they are told its time to break out of the prison. They travel into another room where there are 3 holes in the wall that they are instructed to crawl into. Each of these holes is the start of an approximate 50 ft. low tunnel they crawl through. 2 of these tunnels have metal plates on the ground that shock the guests as they crawl over them. 1 of the tunnel is for mercy pendant holders and does not have shocks. All three tunnels have an overhead vinyl air bladder approx 12' long. When guests go under them , they inflate and will press the guests down into the floor. Usually the guests cannot move forward or back as they are held tight against the ground. It is also extremely dark in these tunnels.

Note. Description of experience: "We return once more to Perpetuum Penitentiary and the torturous story of our Paula. After accepting responsibility for the vicious murder of her son, Lincoln, Paula now seeks atonement for past sins. Even after months of intense labor, strengthening her body and mind, Paula has repeatedly failed in appealing to the Prison's sinister Warden for freedom. It's not enough. It's never enough. Her work must continue. At Perpetuum, a new circle of hell has taken root. Courtesy of Vixi Labs, and by the Warden's decree, all Prison treatment facilities will now be powered by revolutionary Vixi-technology. Operated by vile and sadistic engineers, their unorthodox methods for treating evils of humanity have hit new levels of depravity. They are enjoying every minute."

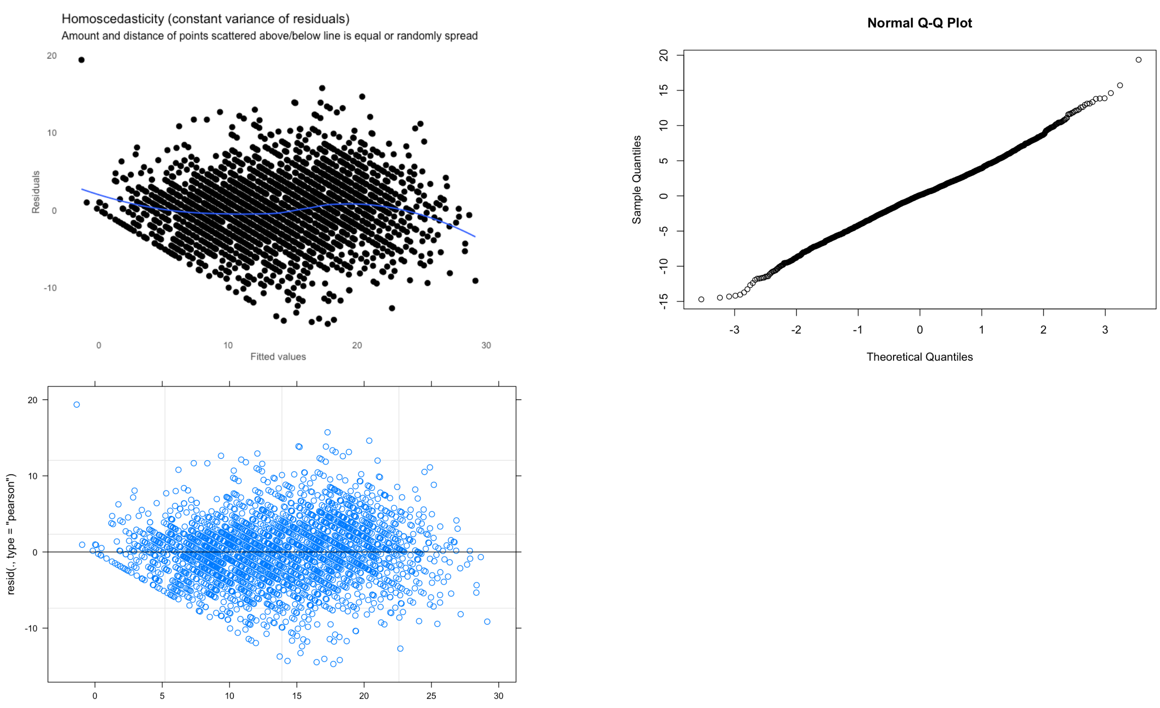
A

Tonic SCL ~ Time*Friends:Strangers



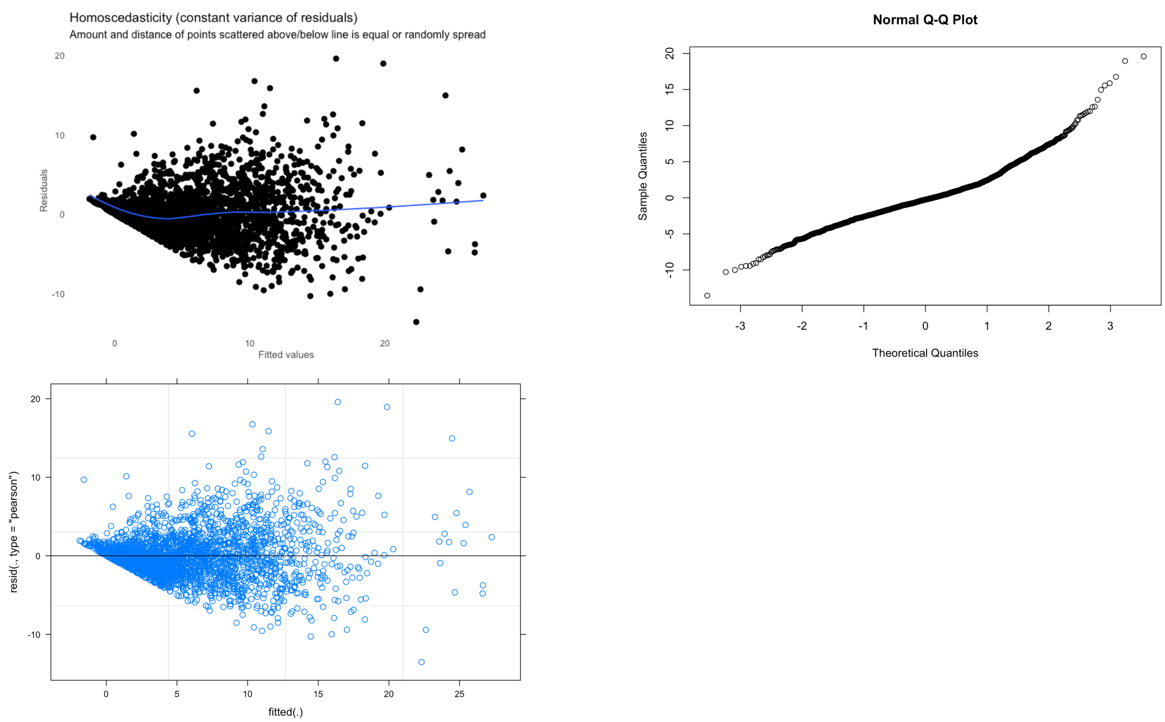
B

SCR Frequency ~ Time + Imminence^2



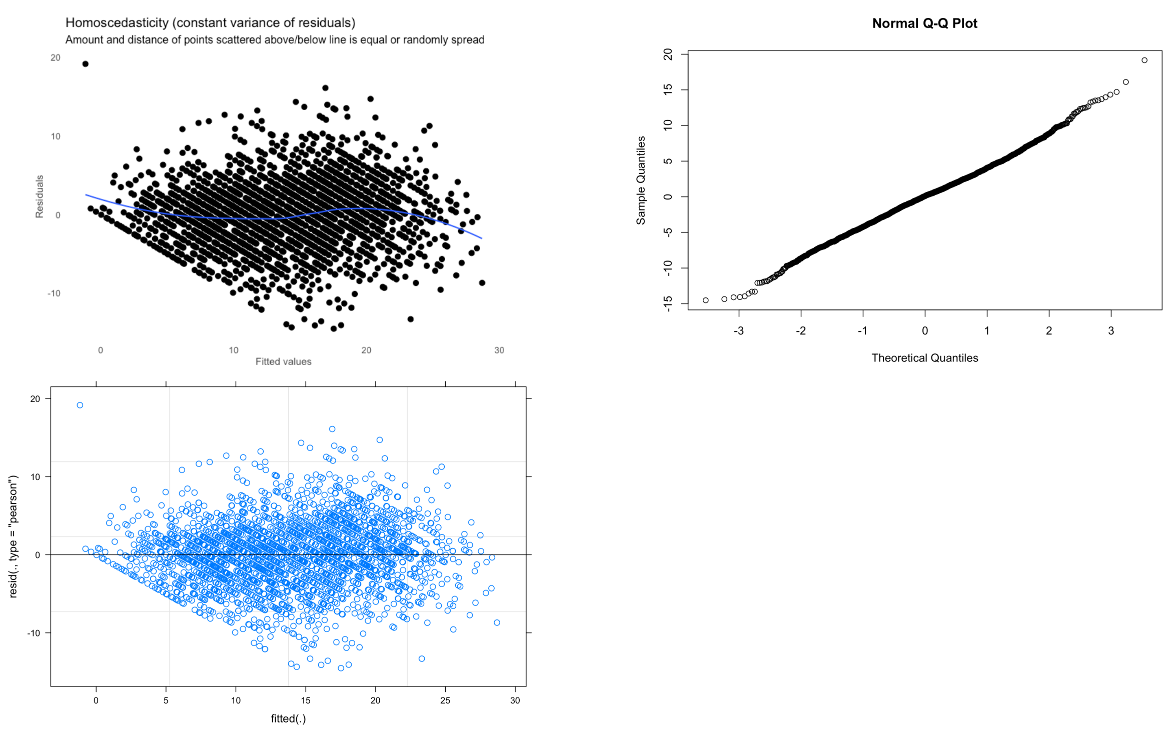
C

SCR Amplitude ~ Time + Imminence²



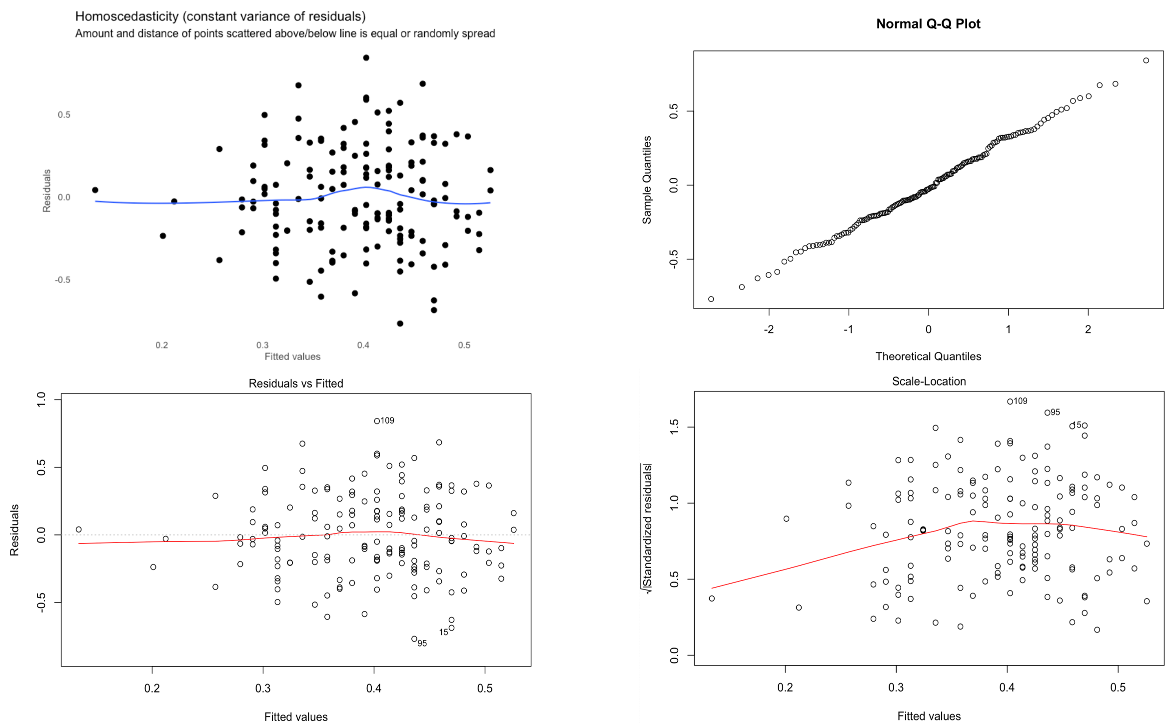
D

SCR Frequency ~ Time + Experienced Fear



E

SCR Frequency Habituation ~ SCR Frequency Startle



F

SCR Amplitude Sensitization ~ SCR Amplitude Startle

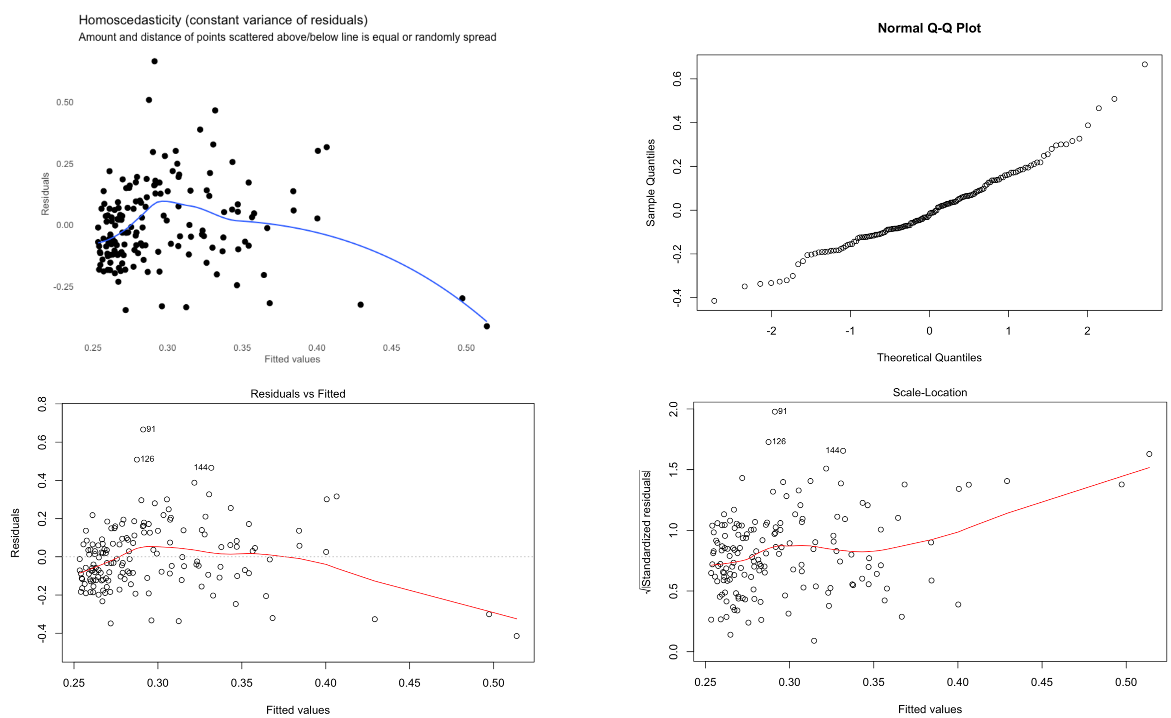


Fig. S1. Model diagnostics. **A.** Time and friend ratio interaction significantly associated with tonic SCL (Fig. 1A). **B.** Imminence quadratically associated with SCR frequency, controlling for time (Fig. 1B). **C.** Imminence quadratically associated with SCR amplitude, controlling for time (Fig. 1C). **D.** Experienced fear significantly associated with greater SCR frequency, controlling for time (Fig. 1D). **E.** SCR startle frequency significantly associated with faster SCR frequency habituation (Fig. 1E). **F.** SCR startle amplitude significantly associated with increased SCR amplitude sensitization (Fig. 1F).