Anger and Hostility; are they different? An Exploratory Analysis of Facial-Expressive
Differences, and Physiological and Facial-Emotional Responses

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Word Count: 11.654

This is a pre-print and will possibly differ from the accepted/published version

Abstract

Previous research has not empirically or conceptually explored whether faces expressing anger and hostility differ in respect to expressed facial characteristics, physiological and facial-emotional responses. In the current study, we make the case that hostility could differ from anger in the sense that it expresses higher intent for physical harm. Based on this exploratory hypothesis we tested whether there are expressive differences and discrete emotional responses between angry and hostile faces. We used participant assessment and computerised facial analysis to preselect faces. We found that using action unit analysis, faces labelled as angry and hostile revealed differences in expressive characteristics and that hostile faces were – as predicted – rated by the participants higher for the intent to inflict physical harm. Subsequently, we presented these faces, as well as fearful, sad and neutral faces, supraliminally and using masking and measured skin-conductance, heart-rate and facial-emotional responses. We found that in both conditions faces expressing hostility led to higher physiological arousal. We found that during supraliminal presentations, hostility elicited fearful facial-emotional responses while anger elicited mirroring responses. Our findings suggest that hostility is possibly a fear-eliciting sub-state of anger with distinguishable expressive characteristics.

Key words: anger, hostility, differences, expression, physiology

Introduction

Anger and hostility are two widely studied concepts in psychology (Berkley & Eckhardt, 2015). Anger is one of the six basic emotions that characterise human emotional expressions (Ekman, 1992) while hostility has its own wide research applications, ranging from international politics to forensic and medical research (Lin et al., 2015). It is not surprising, therefore, that anger and hostility have been approached using a variety of different perspectives. They have been explored in relation to whether they portray the intent for physical harm or verbal aggression (Yudofski et al., 1986). They have been addressed as social norms, such as situationally expected responses (Averill, 2012), as personality attitudes, such as instrumental-premeditated and impulsive-affective traits and as evolutionary concepts, such as defence and predatory mechanisms (Weinshenker & Siegel, 2002),

Anger is an emotion that has been described as state-anger, the transient experience of irritation, stress and frustration in response to an emotional elicitor, and as trait-anger, a more constant personality temperament that makes an individual experience more frequent and more intense state-anger responses even to innocuous and unprovocative cues (Ramirez & Andreu, 2006). Hostility, on the other hand, is considered an intention to overtly or covertly harm an individual and includes aggressive motor responses, as well as expressive characteristics that indicate potential intent for physical aggression, and assault, such as physically attacking an individual (Deffenbacher, 2000). Due to the intent to physically harm an individual portrayed in hostile expressions, hostility could potentially elicit different peripheral nervous system and facial-emotional responses (Houston & Stanford, 2005) compared to faces expressing anger (Fernandez, Day, & Boyle, 2015; see also Appendix 5.1 for a dedicated discussion concerning the physiological assessment methods used in the current studies).

Despite the multi-faceted aspects of anger and hostility-related models in psychological theory, the neural correlates (Fusar-Poli et al., 2009; Brooks et al., 2012) and the physiological

correlates (Ottaviani et al., 2016; van der Ploeg et al., 2017) that characterise the two expressions have been researched under the umbrella term of anger (see also Appendix 5.2 for a dedicated exploratory discussion concerning possible differences between anger and hostility). For example, studies assessing responses to supraliminal emotional faces (Banks, Bellerose & Douglas, 2012) have focused on the exploration of skin conductance and heart rate responses to anger as a basic emotion (Ekman, 1992). In the same manner, studies relating to masked presentations and physiological responses (van der Ploeg et al., 2017), have included prototypical angry faces (Bornemann et al., 2012; Chatelain & Gendolla, 2015) from a variety of pre-existing datasets (Axelrod, Bar, & Rees, 2015) but have not explored physiological and facial-emotional responses to perceived hostility.

This approach could be problematic because several of these studies explore whether we can experience automatic and involuntary arousal in response to environmental signals of danger using angry faces (van der Ploeg et al., 2017). It is unclear, nonetheless, if anger is an appropriate stimulus for eliciting responses to danger (Hess & Fischer, 2012) or whether evolutionary-biological preparedness should be explored using stimuli that could indicate higher expressive intent for physical harm, such as faces labelled as hostile (Averill, 2012). Additionally, if we keep in mind that hostility could differ from anger in the sense that it portrays expressive characteristics that indicate the intent to inflict physical harm, providing empirical evidence that could support that there are distinguishing characteristics between these two expressions could function as a starting point for developing response strategies that could inform and improve the professional practise of police, orderly and medical personnel (Novaco, 1994; Rippon, 2000).

The exploratory hypothesis that guided the current research was that hostile expressions could indicate higher intent for physical harm compared to angry expressions. In the current experiments we tested whether angry and hostile expressions elicit differential patterns of skin

conductance and heart rate responses, as well as whether they are associated with different facial-emotional characteristics and elicit different facial-emotional responses. Due to the lack of a dataset including separate labels for angry and hostile expressions, we assigned a forced categorisation task during a pilot stage, selected and assessed, using participant recruitment and automatic facial action unit recognition software, angry and hostile faces from an existing database (Gur et al., 2002). Subsequently we presented these faces, as well as fearful, sad and neutral faces overtly for one second and for brief durations (34.72 ms) with backwards masking to a black and white pattern (125 ms), and measured skin conductance, heart rate and facial-emotional changes.

Stage One: Stimulus Preselection

Phase One:

Aims: The aims of this phase of stage one were to preselect faces expressing anger or hostility from an existing dataset and assess with automatic facial recognition software whether these faces display differences in action units for the expression of emotion. Our hypothesis for this phase was that due to the possibility that hostile faces indicate higher intent for physical harm we would be able to record distinct expressive differences between faces labelled as angry and faces labelled as hostile.

Participants: A power calculation based on medium effect sizes (partial eta-squared = .06; $f = .25$) and within-subject experimental trial repetitions was performed. The result revealed that twenty-two participants would be required for $P_{(1-\beta)} \geq .8$ (Faul et al., 2009). Twenty-seven volunteers participated in this phase. The exclusion criteria were current or previous DSM Axis I or II diagnosis (Dalili, Penton-Voak, Harmer & Munafò, 2015), having a criminal record (Robertson, Daffern & Bucks, 2015) and suffering or having suffered abuse in one's personal life (Pollak, Cicchetti, Hornung & Reed, 2000) through self-report. The participants were screened with the Somatic and Psychological Health Report Questionnaire (Berryman,

McAuley & Moseley, 2012), an on-line alexithymia questionnaire (Alexithymia, 2018) and the Aggression Questionnaire (McKay, Perry & Harvey, 2016). One participant was excluded from the analysis due to possible alexithymic traits. The final population sample consisted of twenty-six participants (thirteen female) with mean age 31.08 (SD = 7.19). The experiment was approved by the Ethics Committee of the School of Psychology of the University of Nottingham.

Facial stimuli: The facial stimuli used were taken from the dataset created by Gur and colleagues (2002; see Appendix 3 for stimulus validation summary). All the stimuli were adjusted for interpupillary distance, transformed to grey scale and resized to a standard 1024 × 768 pixels resolution. Their luminescence was averaged in SHINE, MATLAB Toolbox and finally the faces were spatially aligned and framed into pure white within a cropped circle (Height: 6 cm, Width: 4 cm).

Participant Assessment: All stimuli were presented on a high frequency LED monitor set at 144 Hz (6.94 ms) and the presentation was created in the Builder and Coder components of PsychoPy v.1.90.02 (Peirce, 2007). Two-hundred faces labelled as angry from fifty actors (twenty-five female) were presented. The session started with a training stage during which participants familiarised themselves with the keyboard and mouse response components of the experiment. The main experiment started with a fixation cross for two seconds ($\pm$ one-second). After the fixation cross, in random order, a single face was presented at fixation for one second followed by a black-and-white pattern mask for one second. A blank screen interval was then presented for two seconds. After the interval participants were asked “What label best describes the presented face?”. They were asked to choose from an on-screen list using the keyboard. The options included (a) angry, (s) hostile, (d) both and (f) none; the key assignment and the order of the list was randomised in each trial and the participants were briefed during the training session that they can base their responses on subjective emotional criteria. After the

labelling response participants were asked to use the mouse to rate from one (extremely low) to ten (extremely high) the intensity of the emotional expression and press OK to confirm their choice. Following this response, the participants were asked to use the mouse to rate from one (extremely low) to ten (extremely high) the emotional expression in four Likert scales, each presented in one quadrant of the screen. The emotional expression was rated for frustration, stress, anger and hostility (Ramirez & Andreu, 2006); the assignment of scales to quadrants was randomised on each trial. Participants were asked to press OK to confirm their choice. A three-second blank screen was presented before the next trial.

Stimulus Preselection: All faces which participants rated with 100% agreement for expressing anger or hostility were initially selected. The set included forty-one faces from twenty-seven actors. These faces were further selected to avoid actor repetition and to include an equal number of males and female. To this end, ten faces showing anger and ten faces showing hostility from twenty different actors (including five different female and male actors for each category) were chosen using a pseudo-randomisation function implemented in Python.

Facial Recognition Software: Computer-based analysis of the resulting pool of images was conducted using Noldus FaceReader 7.1. The analysis employed the Viola-Jones cascaded algorithm and an active appearance model (AAM) to eliminate static identification variability. The analysis included the in-built emotional categorization labels included in Noldus (anger, fear, surprise, happiness, sadness and neutral), an assessment of whether facial action units were innervated and a percentage metric for the identification of facial action unit innervation that indicated how pronounced the specific action unit was in the assessed face.

Results and Discussion: The analysis was performed using frequentist and Bayesian statistics. For every non-significant finding, a Bayes factor was calculated using the Dienes Calculator. Sensitivity for the null was defined at $B \leq .33$, given that the mean for hostility, for any reported assessment, was within $\pm$ one standard deviations of the mean of the expression it was

compared against (Dienes, 2016). The final subset of faces did not reveal significant differences in Emotional Intensity ratings between hostility ($M = 8.23$; $SD = .74$) and anger ($M = 8.16$; $SD = .8$; $p = .74$; $d = .1$; $S.E. = .14$; $B = .85$). To explore whether the final subset of angry and hostile faces included substantial differences in emotion characteristics, the selected stimuli were tested for differences in frustration, stress, anger and hostility ratings. A repeated measures ANOVA revealed that there were significant differences between anger and hostility ($F(1, 25) = 4.65$; $p = .041$; $\eta^2 = .16$). Bonferoni corrected pairwise comparisons revealed that anger ($M = 8.27$, $SD = 1.05$) lead to higher ratings for stress compared to hostility ($M = 7.36$, $SD = .84$; $p < .001$; $d = .96$). Anger ($M = 8.19$, $SD = 1.39$) also revealed a trend for higher frustration ratings compared to hostility ($M = 7.63$, $SD = .76$; $p = .08$; $d = .49$). Hostile expressions ($M = 8.91$, $SD = .64$) were rated higher for hostility compared to angry expressions ($M = 6.35$, $SD = 1.14$; $p < .001$; $d = 2.77$). Ratings for anger were not significantly different between anger ($M = 8.1$, $SD = 1.26$) and hostility ($M = 8.29$, $SD = 1.21$; $p = .59$; $d = .08$) and showed a trend for Bayesian sensitivity for the null ($S.E. = .33$; $B = .45$). The computer-based assessment identified all images as expressing anger (as opposed to fear, surprise, happiness, sadness or being neutral). Further quantitative analysis for the percentage metric for the identification of facial action unit innervation differences between anger and hostility revealed significant differences ($F(1, 9) = 16.11$; $p < .01$; $\eta^2 = .64$) and showed that hostility included more pronounced head and gaze participant-oriented characteristics (see Table 1; see also Appendix 3: Stimulus Set Selection for actor gender analysis).

Table 1: Pairwise Comparison between Anger and Hostility

	Anger		Hostility		Cohen's d
	Mean (%)	S.D (%)	Mean (%)	S.D. (%)	
4. Brow Lowerer	91.34	3.45	92.45	2.17	-.4*
5. Upper Lid Raiser	86.71	5.15	96.17	3.43	-2.21**
9. Nose Wrinkler	14.45	7.48	34.21	9.14	-2.38**
17. Chin Raiser	24.56	8.12	46.76	8.15	-2.73**
24. Lip Presser	31.45	11.08	68.31	9.92	-3.51**
25. Lips Part	78.98	2.98	42.98	15.67	3.86**
57. Head Forward	79.15	4.58	92.49	3.67	-3.23**
M69 (Direct Gaze)	68.45	4.55	82.81	9.01	-2.12**

Note: Percentage metric for the identification of facial action unit innervation between hostility and anger. One asterisk (*) indicates Bonferroni-corrected significance at $p \leq .01$. Two asterisks (**) indicate Bonferroni-corrected significance at $p \leq .001$.

Phase Two:

Aims: The aim of this phase of stage one was to rate and compare the final subset of angry and hostile expressions for the intent to physically harm an individual. Our hypothesis for this phase was that the expressive differences between faces labelled as angry and faces labelled as hostile in the previous phase could be partly due to expressive characteristics in hostile faces that could associate with higher intent for physical harm and that hostile faces will be associated with higher ratings for the intent to inflict physical harm.

Participants: A power calculation based on medium effect sizes ($d = .5$) and within-subject experimental trial repetitions was performed. The result revealed that twenty-seven participants would be required for $P_{(1-\beta)} \geq .8$ (Faul et al., 2009). Forty-three volunteers who were not part of Phase One participated in this phase. The exclusion criteria were current or previous DSM Axis I or II diagnosis, having a criminal record and suffering or having suffered abuse in one's personal life through self-report. The participants were screened with the Somatic and Psychological Health Report Questionnaire, an on-line alexithymia questionnaire and the Aggression Questionnaire. Data from one participant were excluded from the analysis due to a possible mental health diagnosis (SPHERE-12). The final population sample consisted of forty-

two participants (twenty female) with mean age 29.28 (SD = 4.29). The experiment was approved by the Ethics Committee of the School of Psychology of the University of Nottingham.

Methods: All stimuli were presented on a high frequency LED monitor set at 144 Hz (6.94 ms) and the presentation was created in the Builder and Coder components of PsychoPy v.1.90.02. Twenty faces from twenty actors were presented. Ten faces that were labelled as angry and ten faces that were labelled as hostile in the previous phase were presented. The session started with a training stage during which participants familiarised themselves with the keyboard and mouse response components of the experiment. The main experiment started with a fixation cross for two seconds ($\pm$ one-second). After the fixation cross, in random order, a single face was presented at fixation for one second followed by a black-and-white pattern mask for one second. A blank screen interval was then presented for two seconds. After the interval participants were asked “Please rate how likely you consider this expression to indicate intentions to physically harm an individual?”. Participants were asked to use the mouse to rate from one (extremely low) to ten (extremely high) each expression and press OK to confirm their choice. A three-second blank screen was presented before the next trial.

Results and Discussion: Hostile faces ($M = 8.31$, $SD = .62$) were rated higher for the likelihood to inflict physical harm compared to angry faces ($M = 7.75$, $SD = .49$; $t(41) = 5.49$, $p < .001$; $d = 1.01$) suggesting that hostile expressions included more pronounced physical-threat-related characteristics compared to angry faces. No differences were found between male and female actors for the intent to inflict physical harm ($t(41) = 1.03$, $p = .31$; $d = .21$; $S.E. = .33$; $B = 1.02$)

Stage Two: Supraliminal Assessment

Aims: The aim of this stage was to present angry, hostile, fearful, sad and neutral expressions for one second and measure skin-conductance, heart-rate and facial-emotional responses. Our

hypothesis for this stage was that due to expressive characteristics in hostile faces that indicate higher intent for physical harm, hostile faces will elicit higher physiological arousal than angry faces and that they will elicit fearful facial-emotional responses. As an exploratory hypothesis we expected angry faces to be processed as communicating social cues that relate to frustration and experienced stress and elicit, mirroring, anger-related facial emotional responses.

Participants: A power calculation based on medium effect sizes (partial eta-squared = .06; $f = .25$) and within-subject experimental trial repetitions was performed. The result revealed that twenty-eight participants would be required for $P_{(1-\beta)} \geq .8$ (Faul et al., 2009). Twenty-nine volunteers that were not part of Stage One participated in the current stage. The exclusion criteria were current or previous DSM Axis I or II diagnosis, having a criminal record and suffering or having suffered abuse in one's personal life through self-report. The participants were screened with the Somatic and Psychological Health Report Questionnaire, an on-line alexithymia questionnaire and the Aggression Questionnaire. No participants were excluded. The final population sample consisted of twenty-nine (thirteen female) participants with mean age 31.82 (SD = 8.25). The experiment was approved by the Ethics Committee of the School of Psychology of the University of Nottingham.

Facial stimuli: The facial stimuli used were taken from the dataset created by Gur and colleagues (2002). Ten different faces from different actors expressing anger, hostility, fear, sadness and neutral emotions were used. Fifty non-facial blurs were also used. These were generated from black and white pattern stimuli and scrambled using pseudo-randomised pixel permutation in MATLAB. All stimuli were adjusted for interpupillary distance, transformed to grey scale and resized to a standard 1024×768 pixels resolution. Their luminescence was averaged in SHINE, MATLAB Toolbox and finally the faces were spatially aligned and framed into pure white within a cropped circle (Height: 6 cm, Width: 4 cm). The included stimuli were validated for emotional discrimination with face-reader software (Noldus, 2018) and

participant assessment, they were controlled for low-level visual features, such as spatial frequency and gradient orientation differences, and the black and white pattern blurs were also separately adjusted for luminance contrast with the presented faces (see Tsikandilakis & Chapman, 2018; Tsikandilakis, Peirce & Chapman, 2018; Tsikandilakis, Bali & Chapman, 2018).

Physiological Assessment: Skin conductance and heart rate were used to assess physiological responses. Skin-conductance responses were measured from the left hand (index/first and middle/second fingers) of each participant using disposable Ag/AgCl gelled electrodes. The signals were received by a BIOPAC System, EDA100C in units of microsiemens (μS) and recorded in AcqKnowledge (Braithwaite, Watson, Jones, & Rowe, 2013). Heart rate was measured via a single finger sensor from the left hand (ring/third finger). The signal was measured by a BIOPAC System, PPG100C using infra-red photoplethysmography of blood flow fluctuations and converted and recorded in beats per minute (bpm) in AcqKnowledge. The presence of a phasic skin-conductance response was defined as an unambiguous increase with respect to each pre-target skin-conductance score occurring up to three seconds post stimuli offset (van der Ploeg et al., 2017). The presence of a heart-rate response was defined as an event-related heart rate peak in beats per minute with respect to each pre-target heart-rate score occurring up to five seconds post stimuli offset.

Facial Recognition Software: Computer-based analysis of the resulting pool of images was conducted using Noldus FaceReader 7.1 using an HD camera mounted on the bottom of the presenting screen and centred on the participant's face. The analysis was run using the maximum video capture frames per second allowed by the face-reader equipment (thirty fps). The analysis was run using the Viola-Jones cascaded algorithm and an active appearance model (AAM) that employed a 500-point Euclidean transformation to eliminate static identification variability for image quality, lighting, background variation and orientation (Lewinski et al.,

2014). Each participant was evaluated in respect to the expressed emotion after controlling for the influence of action units that were present in their own neutral expressions using the participant calibration module (Noldus, 2018). The analysis included the in-built emotional categorization labels included in Noldus (anger, fear, surprise, happiness, sadness and neutral). Facial-emotional recognition of an emotion was defined as a categorical classification of an emotional response up to five seconds post-stimuli offset. Participants were aware that their facial expressions were recorded.

Main Experiment: All stimuli were presented on a high frequency LED monitor set at 144 Hz (6.94 ms) and the presentation was created in the Builder and Coder components of PsychoPy v.1.90.02. A total of fifty faces and fifty non-facial pattern blurs were presented during this experiment. The session started with a training stage during which participants familiarised themselves with the keyboard and mouse response components of the experiment. The main experiment started with a fixation cross for two seconds ($\pm$ one-second). After the fixation cross, in random order, a single angry or hostile or fearful or sad or neutral face, or a non-facial pattern blur was presented at fixation for one second followed by a black-and-white pattern mask for one second (see Figure 2). A blank screen interval was then presented for seven seconds. After the interval participants were assigned a gender recognition engagement task. They were asked to choose from an on-screen list the gender of the presented face using the keyboard. The options included (a) male, (s) female and (d) unsure; the key assignment and the order of the list was randomised in each trial. The aim of the engagement task was to ensure stimulus attendance and the responses were not analysed further. After the engagement task a five-second blank screen was presented before the next trial (Cacioppo, Tassinary & Berntson, 2017, p. 165).

Results and Discussion: To explore whether there were significant differences in arousal between different emotional expressions, a repeated measures ANOVA was ran with

independent variable Expression (anger, hostility, fear, sadness and neutral) and dependent variable skin conductance responses. The analysis revealed a significant effect ($F(3.01, 84.36) = 56.12$; $p < .001$; $\eta^2 = .67$; Greenhouse-Geisser corrected). Hostility ($M = .62$, $SD = .19$) was significantly higher for skin conductance arousal compared to angry ($M = .48$, $SD = .19$; $p < .01$; $d = .73$), sad ($M = .25$, $SD = .05$; $p < .001$; $d = .2.66$) and neutral expressions ($M = .21$, $SD = .15$; $p < .001$; $d = 2.39$). No significant differences were revealed between hostility and fear ($M = .66$, $SD = .13$; $p = .345$; $d = .36$; $S.E. = .02$; $B = .65$). The same pattern of results was revealed for heart rate responses ($F(2.17, 60.76) = 79.42$; $p < .001$; $\eta^2 = .74$; Greenhouse-Geisser corrected; see Figure 1). An analysis of variance with independent variables Expression Type (Anger and Hostility) and Emotional Response (anger, fear, happiness, sadness, surprise, disgust and neutral) was run to determine if expressions of anger and hostility elicited different facial-emotional responses during the presentation. The analysis revealed a significant effect of Emotional Response ($F(2.72, 76.21) = 84.65$; $p < .001$; $\eta^2 = .75$; Greenhouse-Geisser corrected) and a significant interaction ($F(2.31, 64.54) = 10.94$; $p < .001$; $\eta^2 = .28$; Greenhouse-Geisser corrected). Expressions of hostility elicited significantly higher facial-emotional responses for fear compared to angry expressions ($p < .001$; $d = 2.14$). Expressions of anger elicited significantly higher facial-emotional response for anger ($p < .001$; $d = 1.16$; see Figure 1). No differences were found between male and female actors for skin conductance ($t(28) = 1.05$; $p = .3$; $d = .01$; $S.E. = .01$; $B = .91$), heart rate ($t(28) = 1.38$; $p = .18$; $d = .04$; $S.E. = .27$; $B = .99$) and facial-emotional responses ($t(28) = .42$; $p = .68$; $d = .01$; $S.E. = .24\%$; $B = 2.97$). These results suggested that hostile faces were more effective elicitors of physiological arousal and elicited more instances of fearful facial-emotional responses compared to faces expressing anger.

Figure 1: Skin Conductance (A.), Heart Rate (B.) and Facial-Emotional Responses (C.)

Note: In A. and B. mean and standard error for skin conductance and heart rate for each presented emotion. In C. the percentage of recognition for anger and hostility as each emotional category included in Noldus, including Bonferoni corrected p-values and Cohen's d per emotional response. A single asterisk (*) indicates significance at $p \leq .001$; see Appendix 2.1.

Stage Three: Masked Assessment

Aims: The aim of this stage was to present angry, hostile, fearful, sad and neutral expressions for 34.72 ms with backwards masking to a black-and-white pattern for 125 ms and measure physiological and facial-emotional responses. Our hypothesis for this stage was that due to expressive characteristics in hostile faces that indicate higher intent to inflict physical harm, hostile faces will elicit higher physiological arousal than angry faces under conditions of visual suppression. Since the assessment of hostile faces and facial-emotional response analysis using computerised face-reading methods had not been previously undertaken under conditions of backwards masking, two secondary questions we explored, in the current stage, were whether

we could report evidence for subliminal processing for hostile, and other emotional faces, and whether facial-emotional responses to emotional faces could be reported when using backwards masking.

Participants: A power calculation based on medium effect sizes (partial eta-squared = .06; $f = .25$) and within-subject experimental trial repetitions was performed. The result revealed that twenty-seven participants would be required for $P_{(1-\beta)} \geq .8$ (Faul et al., 2009). Thirty volunteers who were not part of Stages One and Two participated in the current stage. The exclusion criteria were current or previous DSM Axis I or II diagnosis, having a criminal record and suffering or having suffered abuse in one's personal life through self-report. The participants were screened with the Somatic and Psychological Health Report Questionnaire, an on-line alexithymia questionnaire and the Aggression Questionnaire. No participants were excluded. The final population sample consisted of thirty participants (fifteen female) with mean age 32.9 (SD = 9.16). The experiment was approved by the Ethics Committee of the School of Psychology of the University of Nottingham.

Procedure: The equipment and the assessment of physiological and facial-emotional responses were identical to Stage Two. All stimuli were presented on a high frequency LED monitor set at 144 Hz (6.94 ms) and the presentation was created in the Builder and Coder components of PsychoPy v.1.90.02. To ensure that brief stimuli would be appropriately presented during the main experiment an IPAD PRO camera with 240 Hz refresh rate (4.17 ms) recorded two pilot runs of the experiment and the stimuli presentation was assessed frame by frame; no instances of dropped frames were detected. A self-developed dropped frame report script with one frame (6.94 ms) tolerance threshold was coded in Python and two pilot experimental diagnostic sessions were run. The presenting monitor reported no dropped frames; prognostic dropped frame rate was estimated at 1/5000 trials. Experimental stages were, subsequently, run using

dropped frames diagnostics and per stimuli presentation frame rate performance of the stimuli presenting monitor; no instances of dropped frames were reported.

Main Experiment: A total of fifty faces and fifty non-facial pattern blurs were presented during this experiment. The session started with a training stage during which participants familiarised themselves with the keyboard and mouse response components of the experiment. The main experiment started with a fixation cross for two seconds ($\pm$ one-second). After the fixation cross, in random order, a single angry or hostile or fearful or sad or neutral face, or a non-facial pattern blur was presented at fixation for 34.72 ms followed by a black-and-white pattern mask for 125 ms (see Figure 2). A blank-screen interval was then presented for seven seconds. After the interval participants were assigned a signal detection engagement task. They were asked by an on-screen message to reply using the keyboard whether they saw a face during the presentation from an on-screen list. The options included (a) yes and (s) no; the key assignment and the order of the list was randomised in each trial. After this task the participants were asked to rate the confidence of their reply from one (not confident at all) to ten (extremely confident) using the mouse and press OK to confirm their choice. After the engagement tasks a five-second blank screen was presented before the next trial (Cacioppo, Tassinary & Berntson, 2017, p. 165).

Figure 2: Examples of Experimental Stimuli Sequence

Note: Example of experimental sequence with male face expressing hostility and male face expressing anger; only one target stimuli (angry or hostile or fearful or sad or neutral face or non-facial blur) was shown in each trial; two faces are presented here for illustration purposes. During Stage Two the target stimuli was presented for one second with the pattern mask presented also for one second. During Stage Three the target stimuli faces was presented for 34.72 ms with the pattern mask presented for 125 ms.

Results and Discussion: To explore whether there were significant differences in arousal between different emotional expressions, a repeated measures ANOVA was run with independent variable Expression (anger, hostility, fear, sadness and neutral) and dependent variable skin conductance responses. The analysis revealed significant results ($F(2.11, 61.09) = 41.05$; $p < .001$; $\eta^2 = .59$; Greenhouse-Geisser corrected). Hostility ($M = .13$, $SD = .07$) was significantly higher for skin conductance arousal compared to sad ($M = .04$, $SD = .01$; $p < .001$; $d = 2.1$) and neutral faces ($M = .02$, $SD = .01$; $p < .001$; $d = 2.3$). A trend was revealed for higher skin conductance for hostility compared to anger ($M = .09$, $SD = .04$; $p = .017$; $d = .7$). Hostility and fear ($M = .15$, $SD = .05$; $p = 1$; $d = .3$; $S.E. = .01$; $B = 1.16$) were not significantly different. The same pattern of results was revealed for heart rate responses ($F(2.43, 70.57) = 60.89$; $p < .001$; $\eta^2 = .68$; Greenhouse-Geisser corrected; see Figure 3). The facial-emotional assessment did not provide significant differences between emotional types ($F(1, 29) = .39$; $p = .53$; $\eta^2 = .01$), suggesting that the reduction in signal strength under conditions of backwards

masking causes a reduction in changes in facial-emotional responses when using automatic facial-recognition software. No differences were found between male and female actors for skin conductance ($t(29) = 1.08$; $p = .29$; $d = .04$; S.E. = .01; $B = 1$), heart rate ($t(29) = 1.54$; $p = .14$; $d = .16$; S.E. = .52; $B = 1.05$) and facial-emotional responses ($t(29) = .17$; $p = .87$; $d = .02$; S.E. = .26%; $B = 1.75$).

Figure 3: Skin Conductance and Heart Rate Responses

Note: Mean and standard error for skin conductance and heart rate for each presented emotion during Stage Three. Asterisk (*) indicates significance at $p \leq .001$; see Appendix 2.2 for full table of pairwise comparisons. Skin conductance was significantly higher for hostile and fearful faces compared to other types of expression.

Results and Discussion, Subliminality: As an exploratory addendum to the main analysis in the current stage we also explored whether we could report evidence for subliminal processing. Hit rate performance per stimulus type was transformed to non-parametric sensitivity index A. A Bayesian analysis with corrected degrees of freedom (Berry, 1996) was run using the Dienes calculator (2015) to assess chance-level processing, with substantial evidence for the null hypothesis defined as a Bayes factor B below 1/3 (chance-level performance) and evidence for the alternate defined as a Bayes factor B above 3 (different to chance-level performance). The intervals were conservatively defined at $-.05$ (.45; lower bound) and $.05$ (.55; higher bound) with 0 ($A = .5$) representing chance level performance. Discrimination performance using non-parametric receiver operating characteristics was overall above chance ($M. = .6694$; S.D. = .0134; S.E. = .0024; $B > 3$; for individual stimulus type scores see Figure 4).

Further miss versus hits analysis reported that although hit responses showed highly significant differences between stimulus types for SCR ($F(2.48, 65.19) = 228.42$; $p < .001$; $\eta^2 = .89$; Greenhouse-Geisser corrected) and heart-rate ($F(4, 116) = 160.24$; $p < .001$; $\eta^2 = .85$; Greenhouse-Geisser corrected), misses for detection did not show significant differences and showed insensitivity for the null for SCR ($F(4, 116) = 1.02$; $p = .4$; $\eta^2 = .34$; Greenhouse-Geisser corrected; S.E.M. = .08; $B = 1.37$) and heart rate responses ($F(4, 116) = .41$; $p = .8$; $\eta^2 = .03$; Greenhouse-Geisser corrected; S.E.M. = .13; $B = 1.98$; see Figure 4).

Figure 4: Signal Detection (A.) and Hits versus Misses Performance (B.) in Stage Three

Note: In A. non-parametric sensitivity index A (Zhang & Mueller, 2005) and hit rates performance. In B. Skin conductance and heart scores for reach stimulus type and standardised Cohen's d (measured in units of standard deviation from the overall mean of the presented stimulus types. * Asterisk indicates Bonferonni corrected significance at .001. Facial responses were not different for hits and misses in the current stage; see Appendix 2.2 for full table of pairwise comparisons.

Discussion

In the current studies, we initially used a forced categorization task to identify faces expressing anger or hostility. We then assessed the emotional intensity of these expressions, as well as sub-features of these expressions such as frustration, stress, levels of anger and levels of hostility. While we found that anger and hostility were not different in terms of emotional intensity and perceived anger, angry expressions were rated higher for frustration and tended to be rated higher for stress compared to hostile expressions. On the other hand, hostile expressions were rated higher for hostility. We also found that hostile faces were rated higher for the intent to inflict physical harm. Using computer-based analysis of facial expressions, we found that hostility and anger differed in the expression of facial action units and that hostility included more pronounced head and gaze participant-oriented characteristics. When presenting angry, hostile, fearful, sad and neutral faces both supraliminally and using backwards masking, we found higher physiological arousal (skin conductance, heart rate) in response to faces expressing hostility compared to faces expressing anger. We also found that hostility elicited fearful facial-emotional responses, while anger elicited angry facial-emotional responses.

Previous psychological models have proposed a distinction between state-anger, the response to emotional elicitors that could cause irritation, frustration and anger-related responses, and trait-anger, a more permanent personality characteristic that could lead to more intense and more frequent anger-related responses, even to innocuous cue. Previous models have also suggested that hostility is an overt or covert intention to physically harm an individual (Deffenbacher, 2000). Due to these differences, hostile expressions could elicit discrete physiological and facial-emotional responses (Vella & Friedman, 2007). In the current study we found that hostility and anger do elicit different physiological-emotional responses and particularly that hostility is a more efficient elicitor for fear and physiological arousal compared to anger.

The differences we found between anger and hostility have implications for psychological theory and applied science. A substantial number of previous studies tested the biological preparedness model – the concept that we respond automatically and involuntarily to environmental danger – using angry faces (Brooks et al., 2012). The current results suggest that, due to the inclusion of possibly familiar sub-characteristics such as stress and frustration, angry faces could elicit empathetic-mimicking responses, and that they are not necessarily suitable stimuli for the exploration of responses to environmental danger. Hostile faces, on the other hand, were more likely to be emotionally processed as an indication of threat and lead to fear-related emotional responses. Thus they should be considered as a more suitable candidate for studies that intent to examine automatic and involuntary responses to threat (van der Ploeg et al., 2017).

During Stage One, we were able to show that hostility and anger do not simply differ quantitatively concerning the level of emotionality of the presented faces. Participants did not rate the two expressions differently for emotional intensity, they rated anger higher for frustration and stress, and critically we found that, whereas anger is an integral part of hostility, hostility is not necessarily an integral part of anger. These results suggest that hostility is a sub-state of the basic expression of anger; and not vice versa. This interpretation is also supported by the report that hostility included differences in the expression of facial action units, such as head and gaze participant-oriented characteristics. It is possible that hostility and anger belong to the same basic emotional expression category (Ekman, 1992). However, the current findings point towards the possibility that hostility elicits higher physiological arousal and fear-related facial-emotional responses possibly due to expressive characteristics that signify potential intent for physical harm. These findings should not be misinterpreted to confer the message that anger is a categorically harmless – in terms of intent – expression of emotion. Instead, our findings should be interpreted to suggest that there are qualitative and quantitative differences

in sub-characteristics in expressions – originally labelled under the basic emotion umbrella of anger – that could indicate whether a face is expressing sufficient hostility-related features to be emotionally appraised as an indication of threat (Ramirez & Andreu, 2006).

From an applied science perspective the current findings could have applications for the development of interpersonal communication strategies and the training of critical-decision-making professionals. The current findings could potentially serve as a starting point for further research exploring the applicability and usefulness of evaluating anger and hostility in professional premises to help critical-decision-making professionals to respond appropriately in interpersonal encounters based on whether – and to what extent – an encounter indicates the intention for physical harm against an individual (Rippon, 2000).

These findings are important and have important implications, nevertheless, they should be considered as the beginning of a hopefully wider effort to explore if the currently reported effects can be replicated and extended. For example, we were not able to report gender differences in the current studies. This could be due to extensive and rigorous gender controls implemented in previous (see for example Tsikandilakis & Chapman, 2018; Tsikandilakis, Chapman & Peirce, 2018) and the current studies (see also Appendix 3) in this facial dataset and could reflect these controls, and not *per se* a lack of an effect should the current experimental conditions are replicated with a different dataset. Along the same lines, we opted to use the current dataset in the current studies because the actors were allowed to express emotion freely. They were instructed to produce subjective expressions associated with each emotional label (Gur et al., 2002). Future research could benefit from a replication of the current design using additional facial stimuli sets and particularly, the exploration of whether facial stimuli sets that include action units instructed expressions offer instances of faces that will be labelled as expressing hostility (see for example Ekman, 2007; Tottenham et al., 2009; van der Schalk et al., 2011), or whether the need for the development of a facial stimulus set

including a separate “Hostility” label is necessitated to further advance the current research (Staugaard. 2010). Finally, additional methods such as the eye-blink paradigm (Blumenthal et al., 2005; see also Appendix 5.2) as well as neural assessment of responses to angry and hostile faces could shed additional light in the behavioural and cognitive workings of the novel emotional distinction that the current exploratory research has provide evidence for.

Conclusions

In the current studies we explored whether angry and hostile faces differ in terms of physiological and facial-emotional responses. We found that hostility elicits higher physiological arousal than anger. We also found that hostile faces elicit fear-related responses while angry faces elicit mirroring responses. Our findings suggest that hostility and anger are not equivalent emotional elicitors and that hostility is possibly a more suitable stimulus for inclusion in studies that explore biological preparedness and responses to threat possibly because it includes expressive indications for physical harm. The current findings could be potentially useful to critical-decision-making professionals – within the context of developing discrimination of intent training sessions – to help them to provide a strategically appropriate response based on whether – and to what extend – an encounter indicates the intention for physical harm against an individual. The current findings should be considered as the first exploratory step for additional replication including additional facial stimuli sets and additional behavioural and neural assessment methods.

Acknowledgements

The current study has no conflicts of interest. The current study was supported by a research grant awarded to the first authors by the Economic and Social Research Council of the University of Nottingham. The primary author would like to thank Zoltan Dienes, Alison Mostyn, Talis Bachmann and Alan Williams for their friendly support. Raw material, code and data for the current study have been made open access in <https://osf.io/5pmj6/>.

References

- Alexithymia. (2019, January 19). *Alexithymia: Emotional blindness*. Retrieved from <https://www.alexithymia.us/alexithymia-questionnaire-online-test>.
- Averill, J. R. (2012). *Anger and aggression: An essay on emotion*. Springer Science & Business Media.
- Axelrod, V., Bar, M., & Rees, G. (2015). Exploring the unconscious using faces. *Trends in cognitive sciences*, 19(1), 35-45.
- Banks, S. J., Bellerose, J., Douglas, D., & Jones-Gotman, M. (2012). Bilateral skin conductance responses to emotional faces. *Applied psychophysiology and biofeedback*, 37(3), 145-152.
- Birkley, E. L., & Eckhardt, C. I. (2015). Anger, hostility, internalizing negative emotions, and intimate partner violence perpetration: A meta-analytic review. *Clinical psychology review*, 37, 40-56.
- Berryman, C., McAuley, J. H., & Moseley, L. G. (2012). Sphere 12 screening questionnaire. *Journal of physiotherapy*, 58(4), 273.
- Blumenthal, T. D., Cuthbert, B. N., Filion, D. L., Hackley, S., Lipp, O. V., & Van Boxtel, A. (2005). Committee report: Guidelines for human startle eyeblink electromyographic studies. *Psychophysiology*, 42(1), 1-15.
- Bornemann, B., Winkielman, P., & van der Meer, E. (2012). Can you feel what you do not see? Using internal feedback to detect briefly presented emotional stimuli. *International Journal of Psychophysiology*, 85(1), 116-124.
- Braithwaite, J. J., Watson, D. G., Jones, R., & Rowe, M. (2013). A guide for analysing electrodermal activity (EDA) & skin conductance responses (SCRs) for psychological experiments. *Psychophysiology*, 49(1), 1017-1034.
- Brooks, S. J., Savov, V., Allzén, E., Benedict, C., Fredriksson, R., & Schiöth, H. B. (2012). Exposure to subliminal arousing stimuli induces robust activation in the amygdala, hippocampus, anterior cingulate, insular cortex and primary visual cortex: a systematic meta-analysis of fMRI studies. *NeuroImage*, 59(3), 2962-2973.
- Buss, A. H., & Perry, M. (1992). The aggression questionnaire. *Journal of personality and social psychology*, 63(3), 452.
- Chatelain, M., & Gendolla, G. H. (2015). Implicit fear and effort-related cardiac response. *Biological psychology*, 111, 73-82.
- Cootes, T. F., Edwards, G. J., & Taylor, C. J. (2001). Active appearance models. *IEEE Transactions on Pattern Analysis & Machine Intelligence*, 6, 681-685.

- Dalili, M. N., Penton-Voak, I. S., Harmer, C. J., & Munafò, M. R. (2015). Meta-analysis of emotion recognition deficits in major depressive disorder. *Psychological medicine*, 45(6), 1135-1144.
- Deffenbacher, J. L. (2000). Prisoners of hate: The cognitive basis of anger, hostility and violence. *Journal of Cognitive Psychotherapy*, 14(2), 201.
- Dienes, Z. (2016). How Bayes factors change scientific practice. *Journal of Mathematical Psychology*, 72, 78-89.
- Ekman, P. (1992). An argument for basic emotions. *Cognition & emotion*, 6(3-4), 169-200.
- Ekman, P. (2007). *Emotions revealed: Recognizing faces and feelings to improve communication and emotional life*. Macmillan.
- Faul, F., Erdfelder, E., Buchner, A., & Lang, A. G. (2009). Statistical power analyses using G*Power 3.1: Tests for correlation and regression analyses. *Behavior research methods*, 41(4), 1149-1160.
- Fernandez, E., Day, A., & Boyle, G. J. (2015). Measures of anger and hostility in adults. In *Measures of personality and social psychological constructs*. 8, 74-100.
- Fusar-Poli, P., Placentino, A., Carletti, F., Landi, P., Allen, P., Surguladze, S., ... & Perez, J. (2009). Functional atlas of emotional faces processing: a voxel-based meta-analysis of 105 functional magnetic resonance imaging studies. *Journal of psychiatry & neuroscience*. 7, 121-139.
- Gur, R.C., Sara, R., Hagendoorn, M., Marom, O., Hughett, P., Macy, L., Turner, T., Bajcsy, R., Posner, A. & Gur, R.E. (2002). A method for obtaining 3-dimensional facial expressions and its standardization for use in neurocognitive studies. *Journal of neuroscience methods*, 115(2), 137-143.
- Hess, U., & Fischer, A. (2013). Emotional mimicry as social regulation. *Personality and social psychology review*, 17(2), 142-157.
- Houston, R. J., & Stanford, M. S. (2005). Characterization of aggressive behaviour and phenytoin response. *Aggressive Behaviour: Official Journal of the International Society for Research on Aggression*, 32(1), 38-43.
- Keltner, D., & Cordaro, D. T. (2015). Understanding multimodal emotional expressions: Recent advances in basic emotion theory. *Emotion Researcher*, 1-17.
- Lewinski, P., den Uyl, T. M., & Butler, C. (2014). Automated facial coding: Validation of basic emotions and FACS AUs in FaceReader. *Journal of Neuroscience, Psychology, and Economics*, 7(4), 227.

- Liddell, B. J., Brown, K. J., Kemp, A. H., Barton, M. J., Das, P., Peduto, A., ... & Williams, L. M. (2005). A direct brainstem–amygdala–cortical ‘alarm’ system for subliminal signals of fear. *Neuroimage*, 24(1), 235-243.
- Lin, I. M., Fan, S. Y., Lu, H. C., Lin, T. H., Chu, C. S., Kuo, H. F., ... & Lu, Y. H. (2015). Randomized controlled trial of heart rate variability biofeedback in cardiac autonomic and hostility among patients with coronary artery disease. *Behaviour research and therapy*, 70, 38-46.
- McKay, M. T., Perry, J. L., & Harvey, S. A. (2016). The factorial validity and reliability of three versions of the Aggression Questionnaire using Confirmatory Factor Analysis and Exploratory Structural Equation Modelling. *Personality and Individual Differences*, 90, 12-15.
- Miller, T. Q., Smith, T. W., Turner, C. W., Guijarro, M. L., & Hallet, A. J. (1996). Meta-analytic review of research on hostility and physical health. *Psychological bulletin*, 119(2), 322.
- Noldus. (2018, March 21). Reference manual. <http://www.noldus.com/human-behavior-research/products/facereader>
- Novaco, R. W. (1994). Anger as a risk factor for violence among the mentally disordered. Violence and mental disorder: *Developments in risk assessment*, 21, 59.
- Ottaviani C., Thayer J.F., Verkuil B., et al. (2016). Physiological concomitants of perseverative cognition: a systematic review and meta-analysis. *Psychological Bulletin* 142, 231–59.
- Peirce, J. W. (2007). PsychoPy—psychophysics software in Python. *Journal of neuroscience methods*, 162(1-2), 8-13.
- Pollak, S. D., Cicchetti, D., Hornung, K., & Reed, A. (2000). Recognizing emotion in faces: developmental effects of child abuse and neglect. *Developmental psychology*, 36(5), 679.
- Ramirez, J. M., & Andreu, J. M. (2003). Aggression's typologies. *Revue internationale de psychologie sociale*, 16(3), 145-161.
- Ramirez, J. M., & Andreu, J. M. (2006). Aggression, and some related psychological constructs (anger, hostility, and impulsivity) Some comments from a research project. *Neuroscience & Biobehavioral Reviews*, 30(3), 276-291.
- Ramirez, J. M., Alvarado, J. M., & Santisteban, C. (2004). Individual differences in anger reaction to noise. *Individual Differences Research*, 2(2), 125-136.
- Roberton, T., Daffern, M., & Bucks, R. S. (2015). Beyond anger control: Difficulty attending to emotions also predicts aggression in offenders. *Psychology of Violence*, 5(1), 74.
- Rippon, T. J. (2000). Aggression and violence in health care professions. *Journal of advanced nursing*, 31(2), 452-460.

Staugaard, S. R. (2010). Threatening faces and social anxiety: a literature review. *Clinical psychology review*, 30(6), 669-690.

Tottenham, N., Tanaka, J. W., Leon, A. C., McCarry, T., Nurse, M., Hare, T. A., ... & Nelson, C. (2009). The NimStim set of facial expressions: judgments from untrained research participants. *Psychiatry research*, 168(3), 242-249

Tsikandilakis, M., & Chapman, P. (2018). Skin conductance responses to masked emotional faces are modulated by hit rate but not signal detection theory adjustments for subjective differences in the detection threshold. *Perception*, 47(4), 432-450.

Tsikandilakis, M., Bali, P., & Chapman, P. (2018a). Beauty *is* in the eye of the Beholder: Self-Reports for Attractiveness Ratings require Conscious Face-Detection of a Presented Faces. *Perception*.

Tsikandilakis, M., Bali, P., & Chapman, P. (2018b). "I can see you": Perception and miss-Perception of Subliminal Emotional Faces and their effect in Human Physiology. *Journal of Experimental Psychology: General*.

van der Ploeg, M. M., Brosschot, J. F., Versluis, A., & Verkuil, B. (2017). Peripheral physiological responses to subliminally presented negative affective stimuli: A systematic review. *Biological psychology*, 129, 131-153.

Vella, E. J., & Friedman, B. H. (2007). Autonomic characteristics of defensive hostility: Reactivity and recovery to active and passive stressors. *International Journal of Psychophysiology*, 66(2), 95-101.

van der Ploeg, M. M., Brosschot, J. F., Versluis, A., & Verkuil, B. (2017). Peripheral physiological responses to subliminally presented negative affective stimuli: A systematic review. *Biological psychology*, 129, 131-153.

van der Schalk, Job, et al. "Moving faces, looking places: validation of the Amsterdam Dynamic Facial Expression Set (ADFES)." *Emotion* 11.4 (2011): 907.

Viola, P., & Jones, M. J. (2004). Robust real-time face detection. *International journal of computer vision*, 57(2), 137-154.

Weinshenker, N. J., & Siegel, A. (2002). Bimodal classification of aggression: Affective defense and predatory attack. *Aggression and Violent Behavior*, 7(3), 237-250.

Yudofsky, S. C., Silver, J. M., Jackson, W., Endicott, J., & Williams, D. (1986). The Overt Aggression Scale for the objective rating of verbal and physical aggression. *The American journal of psychiatry*. 8 (2), 211-241.

Zhang, J., & Mueller, S. T. (2005). A note on ROC analysis and non-parametric estimate of sensitivity. *Psychometrika*, 70(1), 203-212.

Appendix

1. Signal Detection Analysis (adjusted ROC curve as per Zhang & Mueller, 2005; p. 205-209)

ROC analysis was not a primary aim of the current experimental studies. To offer a pilot exploration of differences in signal detection performance between anger and hostility, and other emotional types under conditions of backwards masking we provide Bayesian analysis below:

Bayesian Comparison of Signal Detection Performance

	Anger	Fearful	Sadness	Neutral
Hostility	.51	.1	NaN (+∞)	NaN (+∞)
Anger		.07	.06	NaN (+∞)
Fearful			.024	NaN (+∞)

Note that we did not assess the participants for previous experimental participation in emotional assessment experiments including emotional faces. Part of the current results – if the participants had previous experience – could be due to the novelty of the presentation of hostile faces and future research should take that into consideration in dedicated attempts to explore signal detection performance for hostile, angry and other facial emotional types.

2. Pairwise Comparisons

2.1: Stage Two

	Mean	Std. Deviation
AngSCR	.484263	.1975315
HosSCR	.624915	.1976198
FearSCR	.660627	.1279978
SadSCR	.254655	.0535512
NeuSCR	.206088	.1544950

(I) Emotion	(J) Emotion	Mean Difference (I-J)	Std. Error	Sig. ^b	95% Confidence Interval for Difference ^b	
					Lower Bound	Upper Bound
1	2	-.141 [*]	.048	.007	-.240	-.041
	3	-.176 [*]	.046	.001	-.270	-.083
	4	.230 [*]	.040	.000	.147	.312
	5	.278 [*]	.051	.000	.174	.383
2	1	.141 [*]	.048	.007	.041	.240
	3	-.036	.037	.345	-.112	.040
	4	.370 [*]	.038	.000	.293	.447
	5	.419 [*]	.036	.000	.345	.492
3	1	.176 [*]	.046	.001	.083	.270
	2	.036	.037	.345	-.040	.112
	4	.406 [*]	.027	.000	.351	.461
	5	.455 [*]	.033	.000	.387	.522
4	1	-.230 [*]	.040	.000	-.312	-.147
	2	-.370 [*]	.038	.000	-.447	-.293
	3	-.406 [*]	.027	.000	-.461	-.351
	5	.049	.031	.126	-.014	.112
5	1	-.278 [*]	.051	.000	-.383	-.174
	2	-.419 [*]	.036	.000	-.492	-.345
	3	-.455 [*]	.033	.000	-.522	-.387
	4	-.049	.031	.126	-.112	.014

	Mean	Std. Deviation
AngHeartRate	6.978723	2.2837888
HosHeartRate	9.951934	2.1125628
FearHeartRate	9.792414	3.2111630
SadHeartRate	3.636897	.8804914
NeuHeartRate	2.628276	.8643167

(I) Emotion	(J) Emotion	Mean Difference (I-J)	Std. Error	Sig. ^b	95% Confidence Interval for Difference ^b	
					Lower Bound	Upper Bound
1	2	-2.973 [*]	.624	.000	-4.252	-1.695
	3	-2.814 [*]	.830	.002	-4.514	-1.114
	4	3.342 [*]	.448	.000	2.424	4.259
	5	4.350 [*]	.466	.000	3.396	5.305
2	1	2.973 [*]	.624	.000	1.695	4.252
	3	.160	.519	.761	-.905	1.224
	4	6.315 [*]	.413	.000	5.469	7.161
	5	7.324 [*]	.396	.000	6.513	8.134
3	1	2.814 [*]	.830	.002	1.114	4.514
	2	-.160	.519	.761	-1.224	.905
	4	6.156 [*]	.612	.000	4.902	7.409
	5	7.164 [*]	.609	.000	5.917	8.412
4	1	-3.342 [*]	.448	.000	-4.259	-2.424
	2	-6.315 [*]	.413	.000	-7.161	-5.469
	3	-6.156 [*]	.612	.000	-7.409	-4.902
	5	1.009 [*]	.256	.000	.485	1.533
5	1	-4.350 [*]	.466	.000	-5.305	-3.396
	2	-7.324 [*]	.396	.000	-8.134	-6.513
	3	-7.164 [*]	.609	.000	-8.412	-5.917
	4	-1.009 [*]	.256	.000	-1.533	-.485

2.2 Stage Three

	Mean	Std. Deviation
AngSCR	.089014	.0387238
HosSCR	.132087	.0699359
FearSCR	.146227	.0516764
SadSCR	.040895	.0124371
NeuSCR	.024562	.0146107

(I) Emotion	(J) Emotion	Mean Difference (I-J)	Std. Error	Sig. ^b	95% Confidence Interval for Difference ^b	
					Lower Bound	Upper Bound
1	2	-.043 [*]	.017	.017	-.078	-.008
	3	-.057 [*]	.012	.000	-.082	-.033
	4	.048 [*]	.008	.000	.033	.064
	5	.064 [*]	.008	.000	.049	.080
2	1	.043 [*]	.017	.017	.008	.078
	3	-.014	.017	.426	-.050	.022
	4	.091 [*]	.013	.000	.064	.119
	5	.108 [*]	.013	.000	.080	.135
3	1	.057 [*]	.012	.000	.033	.082
	2	.014	.017	.426	-.022	.050
	4	.105 [*]	.009	.000	.087	.124
	5	.122 [*]	.010	.000	.101	.142
4	1	-.048 [*]	.008	.000	-.064	-.033
	2	-.091 [*]	.013	.000	-.119	-.064
	3	-.105 [*]	.009	.000	-.124	-.087
	5	.016 [*]	.004	.000	.008	.024
5	1	-.064 [*]	.008	.000	-.080	-.049
	2	-.108 [*]	.013	.000	-.135	-.080
	3	-.122 [*]	.010	.000	-.142	-.101
	4	-.016 [*]	.004	.000	-.024	-.008

	Mean	Std. Deviation
AngHeartRate	2.831633	1.5525523
HosHeartRate	5.376190	1.6317154
FearHeartRate	5.05136	1.535761
SadHeartRate	2.065646	.3332749
NeuHeartRate	1.628571	.2045315

(I) Emotion	(J) Emotion	Mean Difference (I-J)	Std. Error	Sig. ^b	95% Confidence Interval for Difference ^b	
					Lower Bound	Upper Bound
1	2	-2.545 [*]	.456	.000	-3.477	-1.612
	3	-2.220 [*]	.399	.000	-3.036	-1.403
	4	.766 [*]	.294	.014	.165	1.367
	5	1.203 [*]	.284	.000	.622	1.784
2	1	2.545 [*]	.456	.000	1.612	3.477
	3	.325	.329	.332	-.348	.998
	4	3.311 [*]	.306	.000	2.685	3.936
	5	3.748 [*]	.292	.000	3.150	4.345
3	1	2.220 [*]	.399	.000	1.403	3.036
	2	-.325	.329	.332	-.998	.348
	4	2.986 [*]	.279	.000	2.414	3.557
	5	3.423 [*]	.266	.000	2.880	3.966
4	1	-.766 [*]	.294	.014	-1.367	-.165
	2	-3.311 [*]	.306	.000	-3.936	-2.685
	3	-2.986 [*]	.279	.000	-3.557	-2.414
	5	.437 [*]	.069	.000	.296	.578
5	1	-1.203 [*]	.284	.000	-1.784	-.622
	2	-3.748 [*]	.292	.000	-4.345	-3.150
	3	-3.423 [*]	.266	.000	-3.966	-2.880
	4	-.437 [*]	.069	.000	-.578	-.296

3. Stimulus Set Selection Summary

Accuracy (%)	Session					
	A (type):		B (experience)			
	Mean (S.D.)		Mean (S.D.)			
	Group AB	Group BA	Group AB	Group BA	Overall Session A	Overall Session B
Angry*	71.97 (9.97)	80.55 (5.27)	46.35 (11.25)	44.44 (8.07)	76.47 (8.79)	45.29 (9.43)
Fearful	75 (8.01)	77.22 (6.66)	53.12 (7.98)	57.22 (11.48)	76.17 (7.18)	55.29 (9.91)
Disgusted	73.12 (10.66)	67.77 (8.7)	45 (8.45)	40.55 (7.26)	70.29 (9.75)	42.64 (7.92)
Happy	81.25 (9.54)	81.11 (10.24)	60 (11.95)	66.66 (12.74)	81.17 (9.6)	63.52 (12.47)
Sad	85.62 (5.62)	80 (9.35)	54.37 (8.63)	57.55 (7.94)	82.64 (8.12)	56.17 (8.2)
Neutral	88.75 (4.43)	85.55 (8.45)	66.9 (4.58)	70 (16.95)	87.05 (6.85)	68.52 (12.47)
Intensity (1 - 10)						
Angry	6.3 (.89)	6.02 (1.32)	7.35 (1.09)	7.13 (1.69)	6.15 (1.11)	7.23 (1.4)
Fearful	5.91 (.46)	5.48 (.63)	7.06 (.35)	6.71 (1.14)	5.68 (.58)	6.88 (.86)
Disgusted	5.46 (.34)	5.88 (.67)	6.43 (.26)	6.92 (1.01)	5.68 (.56)	6.69 (.77)
Happy	5.96 (.59)	5.87 (.45)	7.51 (1.01)	7.42 (.64)	5.91 (.5)	7.46 (.81)
Sad	4.88 (.48)	4.81 (.59)	5.06 (1.15)	5.26 (.77)	4.84 (.52)	5.16 (.94)
Ambiguity (1 - 10)**						
Angry	5.62 (1.02)	5.66 (1.34)	4.63 (1.29)	3.5 (1.07)	5.64 (1.16)	4.03 (1.28)
Fearful	5.24 (1.13)	5.16 (.81)	4.19 (.73)	4.05 (1)	5.19 (.94)	4.12 (.86)
Disgusted	6.23 (.58)	5.29 (.51)	4.98 (.85)	4.49 (.32)	5.74 (.71)	4.72 (.65)
Happy	5.28 (.48)	5.2 (.56)	3.69 (.66)	3.61 (.55)	5.24 (.51)	3.64 (.59)
Sad	5.61 (.58)	5.52 (.48)	3.79 (.75)	3.96 (.65)	5.56 (.51)	3.88 (.68)
Neutral	4.38 (.6)	4.93 (.84)	2.93 (.96)	3.26 (.96)	4.67 (.77)	3.1 (.94)
Accuracy Analysis (p values)						
(AT Task)						
(AE Task)	Angry	Fearful	Disgusted	Happy	Sad	Neutral
Angry*	.00***	.138	.365	.016	.005	.00
Fearful	.	.00***	.003	.65	1	.007
Disgusted	.	.	.00***	.003	.00	.00
Happy	.	.	.	.00***	1	1
Sad	.	.	.	.	.00***	.001
Neutral	.	.	.	.	.	.00***

$$IF (\%) = \left(\left(\frac{(10 - Amb.) + (Int.)}{2} \right) * 50 \right) + \left(\left(\frac{SCR \text{ Maximum Deferral}}{\text{Max}[SCR \text{ Maximum Deferral Stimuli Type}]} \right) * 25 \right) + \left(\left(\frac{HR \text{ Maximum Deferral}}{\text{Max}[HR \text{ Maximum Deferral Stimuli Type}]} \right) * 25 \right)$$

Ambiguity using a one (not at all) to ten (extremely) scale. This item is reversed (10 - x).

Intensity using a one (not at all) to ten (extremely) scale.

Highest unambiguous increase of a phasic skin conductance response three seconds post stimulus offset with respect to pretarget baseline for the specific stimuli.

The score for the stimuli with the highest unambiguous increase in phasic skin conductance response three seconds post stimulus offset with respect to pretarget baseline for the specific emotional stimuli category.

Highest unambiguous increase of a phasic heart rate response four seconds post stimulus offset with respect to pretarget baseline for the specific stimuli.

The score for the stimuli with the highest unambiguous increase in phasic heart rate four seconds post stimulus offset with respect to pretarget baseline for the specific emotional stimuli category.

Descriptive Statistics

	N	Range	Minimum	Maximum	Sum	Mean	Std. Deviation	Variance
	Statistic	Statistic	Statistic	Statistic	Statistic	Statistic	Statistic	Statistic
Face	17	3.75	1.10	4.85	38.05	2.2382	0.26725	1.10192
NoFace	17	3.80	1.15	4.95	37.35	2.1971	0.26211	1.08072
Angry	17	4.00	1.20	5.20	38.40	2.2588	0.28787	1.18694
Fear	17	4.00	1.20	5.20	40.40	2.3765	0.30384	1.25276
Sad	17	3.80	1.00	4.80	37.80	2.2235	0.26172	1.07908
Neutral	17	3.20	1.00	4.20	35.00	2.0588	0.23374	0.96375
Valid N (listwise)	17							

Gender Analysis

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
					Lower	Upper			
1	Stress_Male - Stress_Female	.23077	2.00614	.39344	-.57953	1.04107	.587	25	.563
2	Frustration_Male - Frustration_Female	-.30769	2.69472	.52848	-1.39611	.78073	-.582	25	.566
3	Hostility_Male - Hostility_Female	.96154	2.64546	.51882	-.10699	2.03006	1.853	25	.076

Male and Female Examples of Hostility and Anger

In the interest of replication of the AU analysis the faces are presented here unprocessed as originally included in the facial dataset. Note that the actors were asked to provide multiple expressions for each emotion freely and without further instructions and the dataset includes approximately sixty to seventy emotional pictures per actor. During the experiment the participants rated the processed and not the current versions of the emotional expressions; see stage one.

Hostility:

Anger:

4. Angry and Hostile Facial Expressions

Hostile Faces Set Codes: 03_2, 09_1, 28_1, 96_2, 102_1, 103_1, 108_1, 137_2, 144_1, 192_1

Angry Faces Set Codes: 04_1, 12_1 (2), 22_1, 23_1, 55_1, 59_1, 69_2, 97_1, 101_1, 182_2

Hostile Faces

Common Action Units:

- 2. Outer Brow Lowered
- 4. Brow Lowered
- 5. Upper Lid Raiser\
- 6. Cheek Raiser
- 9. Nose Wrinkled
- 17. Chin Raiser
- 24. Lip Presser
- 57. Head Forward
- M69. Direct Gaze

Angry Faces

Common Action Units:

- 2. Outer Brow Raiser
- 4. Brow Lowered
- 6. Cheek Raiser
- 9. Nose Wrinkled\
- 10. Upper Lip Raiser
- 17. Chin Raiser
- 25. Lips Part
- 26. Jaw Drop

Emotional Morphing

5.1. Physiological Assessment methods

Skin conductance responses (SCR) were used to assess responses to angry and hostile faces. SCR is a measure of subcutaneous sweating and therefore, of sympathetic autonomic nervous system arousal (Carlson, 2014) that can record physiological responses that are automatic and involuntary and also not necessarily under conscious regulation (Öhman, 2005), such as fight or flight responses (Flykt et al., 2007). SCR is also relatively impenetrable to parasympathetic nervous system arousal artefacts, such as indigestion, respiratory and circulatory arrhythmias (Cacioppo, Tassinary & Berntson, 2017; p. 159-179). Variations in amplitude for SCR scores are a reliable measure of experienced arousal in response to visual-emotional stimuli and has been previously employed by several studies that assess arousal responses to emotional elicitors (Braithwaite et al., 2013). We also employ heart-rate assessment for responses to angry and hostile faces (Garfinkel & Critchley, 2016). Heart-rate has also being suggested as a reliable assessment of peripheral nervous system arousal (Critchley et al., 2005; see also Cacioppo, Tassinary & Berntson, 2017; p. 182-209) and has been previously employed by several studies that assessed emotional responses to emotional faces to explore experienced arousal to various emotional stimulus types (see van der Ploeg et al., 2017). We implement the first instance of parallel physiological and facial-emotional expressive responses, using Noldus, FaceReader 7.1 for facial-emotional response assessment (Lewinski et al., 2014), and also undertook an Action Units (AUs) analysis to explore differences in expressive characteristics between angry and hostile emotional expressions (see Keltner & Cordaro, 2015).

5.2. Anger and Hostility

The assessment of the differences between anger and hostility acquires further interest when we consider that both empirical research and a dedicated conceptual framework that

could account for the differences between these expressions are limited in previous studies. For example, anger and hostility have been separately explored in driving studies (Galovski, Malta, & Blanchard, 2006; Demir, Demir & Özkan, 2016), clinical studies (Harty, Miller, Newcorn, J. & Halperin, 2009; Painuly, Sharan, & Mattoo, 2005), psycho-therapeutic studies (Lee & DiGiuseppe, 2018; Berkout, Tinsley & Flynn, 2018), domestic violence studies (Birkley & Eckhardt, 2015), military (Heesink, Rademaker, Vermetten, Geuze, & Kleber, 2015) orderly and medical personnel studies (Tema, Poggenpoel & Myburgh, 2011) facial expression classifying algorithm studies (Larkin, Martin & McClain, 2002; Herridge, Harrison, Mollet & Shenal, 2004) sociological and political studies (Lyman, 2004; Holmes, 2004), and questionnaire assessment review studies (Fernandez, Day & Boy, 2015; Eckhardt, Norlander, & Deffenbacher, 2002).

Nevertheless, the theoretical definition of anger and hostility outside these applied areas and within the context of a more global emotional framework, that could contribute as to why these expressions could be addressed as separate concepts, is missing (Lemerise & Dodge, 2008). The possibility that hostility and anger could elicit different responses is under-addressed in previous research, and an explicit account associated with the exploration of the context in which these expressions could manifest and the social dynamics, behavioural motivations, and emotional and cognitive processes that could underlie these expressions is not explicitly and thoroughly provided in previous psychological studies (Eckhardt, Norlander & Deffenbacher, 2004; Fernandez, Day & Boy, 2015).

For example, anger has been defined as a complex emotional state ranging from mild irritation to fury and rage, and hostility has been defined as a complex set of emotions and attitudes that motivate vindictive and aggressive behaviours (Eckhardt, Norlander & Deffenbacher, 2004; p. 19-21). Along the same lines, if we examine the numerous questionnaires that have been developed for the assessment of anger and hostility (for a

comprehensive review see Fernandez, Day & Boyle, 2015) we can see that physical aggression is most commonly considered as a part of hostility, while verbal aggression and personal frustration are most commonly associated with anger. As Eckhardt, Norlander and Deffenbacher (2004) correctly note, the association of these variables with anger and hostility is predominantly driven by classical and exploratory theoretical contributions (for a comprehensive literature review see Averill, 2012) and do not provide the necessary framework for a distinction concerning how these two emotional states manifest, what type of eliciting stimuli they are associated with and what type of behavioural output should be expected as a result of encountering each expression.

In the current manuscript we propose a simple and testable hypothesis. Namely we propose that hostility could indicate higher intent for physical harm. This is an exploratory hypothesis that is addressed in the introduction and discussion of the main text and constitutes the basis of our experimental testing, our basic hypotheses and the basis for subsequent statistical analysis. In the current addendum, we can add, as further exploratory themes, that hostility is an expression that portrays high arousal and negative valence (Fernandez, Day & Boyle, 2015), an expression that includes more pronounced characteristics for the intent to inflict physical harm but also an expression that has not yet formed into a fully manifest behavioural response (see for example Emotional Morphing in Appendix 4). Therefore, it could confer anticipatory stress and uncertainty-avoidance arousal relating to the level of contentiousness and further emotional (verbal and predominantly physical) consequences that can occur as a result of the hostile social transaction (Whalen, 2007). It is possible that a certain amount of unpredictability in relation to the subsequent social, behavioural verbal and behavioural physical outcomes that take place as a result of encountering a hostile expression could contribute to the discrimination of hostility and anger. Conversely, anger could indicate, a mild to extreme (depending on circumstance), emotional end-result with fully manifest

intentional characteristics and could arguably be suggested to elicit automatic and involuntary fight-or-flight responses (Brooks et al., 2012). The difference with hostility, in this respect, could be that anger does not require intricate decision making processing relating to the intentions of the social transaction and it does not elicit cognitive and emotional uncertainty as to the selection of the appropriate coping mechanism and/or emotional strategy for a response (Greco & Roger, 2001). Along the same lines, it is possible that hostility communicates highly negative but pending emotional behaviour while anger communicates negative but expressed emotional affect. In this manner, hostility could expressively inform the emotional recipient that their reaction, such as an also hostile or a submissive response (Dodge et al., 2015), will be processed as a trigger that will regulate the level of the forthcoming emotional escalation.

This possibility is also exploratory and is presented here as a possible correlate of the distinction between the two expressions as a result of the action unit differences (e.g. hostility includes more pronounced forward head movement and direct eye-gaze) and emotional morphing techniques used to explore anger and hostility (again see Appendix 4: Emotional Morphing). These possibilities could be addressed using a replication of the current design with the eye-blink startle paradigm (Blumenthal et al., 2005). For example, a negative emotionally modulating stimulus (C+) could be used to explore whether anticipatory stress and uncertainty-avoidance play an important part in physiological and behavioural responses to hostile faces and elicit patterns of behaviour with higher indications for startle and anticipatory stress responses as compared to anger. Conversely exploring the neural correlates associated with anger and hostility could shed additional light to the differences between the two expressions (Heesink et al., 2018).

Supplementary Bibliography

Averill, J. R. (2012). *Anger and aggression: An essay on emotion*. Springer Science & Business Media.

- Barlow, D. H. (Ed.). (2014). *Clinical handbook of psychological disorders: A step-by-step treatment manual*. Guilford publications.
- Berkout, O. V., Tinsley, D., & Flynn, M. K. (2018). A Review of Anger, Hostility, and Aggression from an ACT Perspective. *Journal of Contextual Behavioral Science*.
- Berntson, G. G., Cacioppo, J. T., & Tassinary, L. G. (Eds.). (2017). *Handbook of psychophysiology*. Cambridge University Press.
- Braithwaite, J. J., Watson, D. G., Jones, R., & Rowe, M. (2013). A guide for analysing electrodermal activity (EDA) & skin conductance responses (SCRs) for psychological experiments. *Psychophysiology*, 49(1), 1017-1034.
- Brooks, S. J., Savov, V., Allzén, E., Benedict, C., Fredriksson, R., & Schiöth, H. B. (2012). Exposure to subliminal arousing stimuli induces robust activation in the amygdala, hippocampus, anterior cingulate, insular cortex and primary visual cortex: a systematic meta-analysis of fMRI studies. *NeuroImage*, 59(3), 2962-2973.
- Blumenthal, T. D., Cuthbert, B. N., Fillion, D. L., Hackley, S., Lipp, O. V., & Van Boxtel, A. (2005). Committee report: Guidelines for human startle eyeblink electromyographic studies. *Psychophysiology*, 42(1), 1-15.
- Birkley, E. L., & Eckhardt, C. I. (2015). Anger, hostility, internalizing negative emotions, and intimate partner violence perpetration: A meta-analytic review. *Clinical psychology review*, 37, 40-56.
- Demir, B., Demir, S., & Özkan, T. (2016). A contextual model of driving anger: a meta-analysis. *Transportation research part F: traffic psychology and behaviour*, 42, 332-349.
- Dodge, K. A., Malone, P. S., Lansford, J. E., Sorbring, E., Skinner, A. T., Tapanya, S., ... & Bacchini, D. (2015). Hostile attributional bias and aggressive behavior in global context. *Proceedings of the National Academy of Sciences*, 112(30), 9310-9315.
- Eckhardt, C., Norlander, B., & Deffenbacher, J. (2004). The assessment of anger and hostility: A critical review. *Aggression and Violent Behavior*, 9(1), 17-43.
- Eilenberg, S., & MacLane, S. (1945). General theory of natural equivalences. *Transactions of the American Mathematical Society*, 58(2), 231-294.
- Ekman, P. (2007). *Emotions revealed: Recognizing faces and feelings to improve communication and emotional life*. Macmillan.
- Faul, F., Erdfelder, E., Buchner, A., & Lang, A. G. (2009). Statistical power analyses using G*Power 3.1: Tests for correlation and regression analyses. *Behavior research methods*, 41(4), 1149-1160.
- Fernandez, E., Day, A., & Boyle, G. J. (2015). Measures of anger and hostility in adults. In *Measures of personality and social psychological constructs* (pp. 74-100). Academic Press.
- Figner, B., & Murphy, R. O. (2011). Using skin conductance in judgment and decision making research. *A handbook of process tracing methods for decision research*, 163-184.

- Galovski, T. E., Malta, L. S., & Blanchard, E. B. (2006). *Road rage: Assessment and treatment of the angry, aggressive driver*. American Psychological Association.
- Greco, V., & Roger, D. (2001). Coping with uncertainty: The construction and validation of a new measure. *Personality and individual differences*, 31(4), 519-534.
- Gur, R. C., Sara, R., Hagendoorn, M., Marom, O., Hughett, P., Macy, L., ... & Gur, R. E. (2002). A method for obtaining 3-dimensional facial expressions and its standardization for use in neurocognitive studies. *Journal of neuroscience methods*, 115(2), 137-143.
- Harty, S. C., Miller, C. J., Newcorn, J. H., & Halperin, J. M. (2009). Adolescents with childhood ADHD and comorbid disruptive behavior disorders: aggression, anger, and hostility. *Child Psychiatry and Human Development*, 40(1), 85-97.
- Heesink, L., Rademaker, A., Vermetten, E., Geuze, E., & Kleber, R. (2015). Longitudinal measures of hostility in deployed military personnel. *Psychiatry research*, 229(1-2), 479-484.
- Heesink, L., Gladwin, T. E., Vink, M., van Honk, J., Kleber, R., & Geuze, E. (2018). Neural activity during the viewing of emotional pictures in veterans with pathological anger and aggression. *European psychiatry*, 47, 1-8.
- Herridge, M. L., Harrison, D. W., Mollet, G. A., & Shenal, B. V. (2004). Hostility and facial affect recognition: Effects of a cold pressor stressor on accuracy and cardiovascular reactivity. *Brain and Cognition*, 55(3), 564-571.
- Hirt, F. S., Moser, I., Werlen, E., Imhof, C., & Bergamin, P. (2018, October). A comparison of students' emotional self-reports with automated facial emotion recognition in a reading situation. In *Proceedings of the Sixth International Conference on Technological Ecosystems for Enhancing Multiculturality* (pp. 320-327). ACM.
- Holmes, M. (2004). Feeling beyond rules: Politicizing the sociology of emotion and anger in feminist politics. *European Journal of Social Theory*, 7(2), 209-227.
- Kerrihard, A. L., Khair, M. B., Blumberg, R., Feldman, C. H., & Wunderlich, S. M. (2017). The effects of acclimation to the United States and other demographic factors on responses to salt levels in foods: An examination utilizing face reader technology. *Appetite*, 116, 315-322.
- Kim, M. J., Loucks, R. A., Neta, M., Davis, F. C., Oler, J. A., Mazzulla, E. C., & Whalen, P. J. (2010). Behind the mask: the influence of mask-type on amygdala response to fearful faces. *Social cognitive and affective neuroscience*, 5(4), 363-368.
- Kline, P. (2014). *The new psychometrics: science, psychology and measurement*. Routledge.
- Kotani, Y., Ohgami, Y., Yoshida, N., Kiryu, S., & Inoue, Y. (2017). Anticipation process of the human brain measured by stimulus-preceding negativity (SPN). *The Journal of Physical Fitness and Sports Medicine*, 6(1), 7-14.
- Larkin, K. T., Martin, R. R., & McClain, S. E. (2002). Cynical hostility and the accuracy of decoding facial expressions of emotions. *Journal of Behavioral Medicine*, 25(3), 285-292.
- Lewinski, P. (2015). Automated facial coding software outperforms people in recognizing neutral faces as neutral from standardized datasets. *Frontiers in psychology*, 6, 1386.

- Lewinski, P., Tan, E. S., Fransen, M. L., Czarna, K., & Butler, C. (2016). Hindering facial mimicry in ad viewing: effects on consumers' emotions, attitudes and purchase intentions. In *Advances in Advertising Research* (Vol. VI) (pp. 281-288). Springer Gabler, Wiesbaden.
- Lee, Amy Hyoeun, and Raymond DiGiuseppe. "Anger and aggression treatments: a review of meta-analyses." *Current opinion in psychology* 19 (2018): 65-74.
- Lemerise, E. A., & Dodge, K. A. (2008). The development of anger and hostile interactions. *Handbook of emotions*, 3, 730-741.
- Luecken, L. J., & Gallo, L. C. (2008). *Handbook of physiological research methods in health psychology*. Sage.
- Lyman, P. (2004). The domestication of anger: The use and abuse of anger in politics. *European Journal of Social Theory*, 7(2), 133-147.
- Matthews, G., Warm, J. S., Reinerman, L. E., Langheim, L. K., & Saxby, D. J. (2010). Task engagement, attention, and executive control. In *Handbook of individual differences in cognition* (pp. 205-230). Springer, New York, NY.
- Painuly, N., Sharan, P., & Mattoo, S. K. (2005). Relationship of anger and anger attacks with depression. *European archives of psychiatry and clinical neuroscience*, 255(4), 215-222.
- Poli, S., Sarlo, M., Bortoletto, M., Buodo, G., & Palomba, D. (2007). Stimulus-preceding negativity and heart rate changes in anticipation of affective pictures. *International Journal of Psychophysiology*, 65(1), 32-39.
- Riem, M. M., & Karreman, A. (2019). Experimental manipulation of emotion regulation changes mothers' physiological and facial expressive responses to infant crying. *Infant Behavior and Development*, 55, 22-31.
- Tema, T. R., Poggenpoel, M., & Myburgh, C. P. H. (2011). Experiences of psychiatric nurses exposed to hostility from patients in a forensic ward. *Journal of Nursing Management*, 19(7), 915-924.
- Tottenham, N., Tanaka, J. W., Leon, A. C., McCarry, T., Nurse, M., Hare, T. A., ... & Nelson, C. (2009). The NimStim set of facial expressions: judgments from untrained research participants. *Psychiatry research*, 168(3), 242-249.
- Tressoldi, P. (2016). Anticipation of random future events. In *Anticipation Across Disciplines* (pp. 11-17). Springer, Cham.
- Tsikandilakis, M., & Chapman, P. (2018). Skin conductance responses to masked emotional faces are modulated by hit rate but not signal detection theory adjustments for subjective differences in the detection threshold. *Perception*, 47(4), 432-450.
- Tsikandilakis, M., Chapman, P., & Peirce, J. (2018). Target meta-awareness is a necessary condition for physiological responses to masked emotional faces: Evidence from combined skin conductance and heart rate assessment. *Consciousness and cognition*, 58, 75-89.

Tsikandilakis, M., Bali, P., & Chapman, P. (2019). Beauty Is in the Eye of the Beholder: The Appraisal of Facial Attractiveness and Its Relation to Conscious Awareness. *Perception*, 48(1), 72-92.

van der Ploeg, M. M., Brosschot, J. F., Versluis, A., & Verkuil, B. (2017). Peripheral physiological responses to subliminally presented negative affective stimuli: A systematic review. *Biological psychology*, 129, 131-153.

van der Schalk, Job, et al. "Moving faces, looking places: validation of the Amsterdam Dynamic Facial Expression Set (ADFES)." *Emotion* 11.4 (2011): 907.

Whalen, P. J. (2007). The uncertainty of it all. *Trends in cognitive sciences*, 11(12), 499-500.

Zhang, S., Hu, S., Chao, H. H., Luo, X., Farr, O. M., & Chiang-shan, R. L. (2012). Cerebral correlates of skin conductance responses in a cognitive task. *Neuroimage*, 62(3), 1489-1498.