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Eye tracking shows no substantive relationships between individual differences related to aggression and visual attention to unambiguously violent stimuli

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ABSTRACT

Social-cognitive theories of aggression stipulate that aggressive people have an attentional bias for aggressive and ambiguously aggressive cues. This biased social information processing is thought to occur from very basic attentional processes (encoding) through to higher order interpretative processes (representation). The present research was a detailed investigation into the relationships between aggression-related personality dimensions in young adults and attention toward images depicting general violence, intimate partner violence, and non-violent images. Participants completed measures of trait aggression, intimate partner violence perpetration and victimization, alcohol use, psychopathy, empathy, and insecure adult attachment. In a dual-picture free-viewing eye tracker paradigm, participants viewed three trial types for 2000 ms: general violence versus neutral cues; intimate partner violence versus neutral cues; and intimate partner violence versus general violence. Experiment 1 ($N = 127$) showed a few of the predicted relationships between the traits and attention, but Experiment 2 ($N = 127$) failed to replicate these findings and there was no overlap in significant results between studies. These data provide very little support for attentional biases in a healthy population toward unambiguously violent stimuli as a function of aggression-related traits.

1. Introduction

In an effort to understand cognitive processes underlying individual differences in aggressiveness, visual attention has become a target of study. Social information processing theory suggests that individual differences in reactive aggression are partially attributable to conscious and unconscious attentional processes (Crick & Dodge, 1994). One implication of this theory is that visual attentional processing may differentiate more aggressive people from less aggressive people. Social information processing theory posits several cognitive and behavioral stages that unfold sequentially. The first stage is the *encoding process*, which involves perception and attention toward social cues. During the second stage, the *representation process,* interpretation of the social cues takes place.

The use of different eye tracking measures that assess more automatic (*encoding*) versus more reflective (*representation*) processes may shed some light on how attention operates during each of these stages. For instance, automatic biases may be apparent in the image that captures attention (i.e., first fixation), how long before one fixates on an image (i.e., time to first fixation), and how long they look at this first attention-grabbing image (i.e., first fixation duration). Interpretation is a relatively more conscious process. In the present research, we examined the relationship between aggression-related traits and eye movements indicative of encoding and interpretation of unambiguously violent images.

In studies of attentional bias toward anger and aggressive stimuli that did not use eye tracking, the evidence for attentional biases in aggressive individuals or those prone to anger is inconsistent (e.g., Honk et al., 2001; Cohen et al., 1998; Eckhardt & Cohen, 1997; Smith & Waterman, 2003, 2004). However, these studies did not use

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unambiguously violent images. Instead, they used angry faces or aggressive words with modified cognitive tasks such as the Stroop or dot-probe.

The integrated cognitive model of trait anger and reactive aggression (Wilkowski & Robinson, 2010) offers a complementary approach to attentional processes among people high in aggressive traits. According to this model, people high in trait aggressiveness show selective attention toward aggressive stimuli, albeit with an emphasis on ambiguously hostile stimuli. The integrated cognitive model suggests that aggressive people have trouble disengaging attention from ambiguously hostile stimuli. However, because our stimuli are unambiguously hostile, we may see null correlations between aggressive traits and eye tracking measures indicative of the representation stage of the social information processing model (e.g., dwell time).

Eye tracking technology offers the possibility of examining encoding and interpretation among people with aggressive traits. Most of this research has focused on interpretation, particularly in relation to the hostile attribution bias, which is a stable tendency to interpret ambiguous behavior as intentionally hostile (Tuente et al., 2019). Several eye tracking studies investigated eye gaze related to hostile attribution biases in adults and children (Horsley et al., 2010; Laue et al., 2018; Lin et al., 2016; Troop-Gordon et al., 2018; Troop-Gordon et al., 2019; Wilkowski et al., 2007; Zajenkowska & Rajchert, 2020). In these studies, participants typically viewed social scenes that could be interpreted as non-aggressive, ambiguously aggressive, or aggressive. (e.g., Wilkowski et al., 2007). Results tended to show positive relationships between aggressive traits and attention toward ambiguously aggressive stimuli. The explanation for this counterintuitive phenomenon is known as the "schema inconsistent hypothesis" in which aggressive people focus more on ambiguous and non-aggressive social cues than aggressive cues. They do so in order to ostensibly make sense of the scenes that are inconsistent with their hostile worldview (AlMoghrabi et al., 2019; Wilkowski et al., 2007). Thus, aggressive people tend to spend time puzzling over ambiguously aggressive social situations than less aggressive people. However, it is noteworthy that although this is the general pattern of findings, some studies found that less aggressive individuals also gazed longer at ambiguous or non-hostile cues (Wilkowski et al., 2007, Zajenkowska & Rajchert, 2020). These latter studies suggest that the schema inconsistent hypothesis might not be limited solely to aggressive people. Examining different measures of attention toward unambiguously aggressive stimuli may shed light on this counterintuitive phenomenon.

This prior research has examined how interpreting hostile intent may require later-stage, top-down cognitive processing. Indeed, according to social information processing theory, causal attributions occur during the second "representation" stage of the model. Thus, the encoding stage can be considered a bottom-up, stimulus-driven phenomenon, whereas interpretation is a top-down process. In support of this notion, one study found that children with low levels of effortful control, who were quick to detect angry faces, were more aggressive than the other children (Nozadi et al., 2018). This finding suggests that a lack of top-down control can facilitate early visual processing of anger-related stimuli. Later-stage attentional processes related to interpretation can be inferred from the total amount of time participants look at violent stimuli (i.e., dwell time).

In another study of aggressive traits, people with borderline personality disorder and healthy controls viewed anger, fearful, happy, and neutral faces for 150 ms and 5000 ms (Bertsch et al., 2017). Participants with borderline personality disorder, who were also high on trait aggression, showed faster saccades toward angry and fearful faces, suggesting biased encoding toward threat-related stimuli (Bertsch et al., 2017). For images presented for 5000 ms, aggressive participants with borderline personality disorder demonstrated shorter fixation durations on angry faces. Together, these results suggest the possibility that encoding aggressive stimuli by aggression-prone individuals is likely a bottom-up process that occurs early. By contrast, as specified by the social information processing model, making hostile attributions happens during the subsequent representation stage in the social information processing model (Crick & Dodge, 1994). If so, we should observe positive correlations between measures of early visual attention such as time to first fixation, first fixations, and first fixation duration on violent images and aggressive traits. By contrast, we may observe null correlations with a measure of top-down processing (i.e., dwell time) on violent images as the images in the present studies are unambiguously violent. Because our unambiguously violent images do not require lengthy interpretation and are schema-consistent with aggressive individuals, they may not elicit lengthy dwell times. We did not have any hypotheses regarding neutral images.

In addition to trait aggression, other dimensions related to aggressive behavior may be relevant to eye gaze toward violent stimuli. For instance, alcohol use has a robust positive effect on aggression (Duke et al., 2018); empathy has a small negative relationship with aggression (Ritchie et al., 2022); psychopathic traits are associated with aggression; insecure adult attachment styles are associated with risk for intimate partner violence (IPV) (Velotti et al., 2022). Furthermore, the relationship between personality and eye movements is bidirectional. For instance, psychopathy and antagonism can be detected from eye tracking data in response to affective stimuli using machine learning (Berkovsky et al., 2019).

The present research was a detailed investigation into the relationships between aggression-related personality dimensions in young adults and attention toward unambiguous images depicting general violence, intimate partner violence, and non-violence. Specifically, we measured trait aggression, alcohol use, psychopathy, empathy, intimate partner violence, and adult attachment dimensions. We then correlated these personality dimensions with eye gaze during exposure to these images (Crick & Dodge, 1994). To our knowledge, this is the most comprehensive investigation into attention and aggression-relevant traits using eye tracking methods. With one exception, our research has the largest sample sizes to date and are approximately twice as large as the median sample size of the studies reviewed here. Our study was also novel in the use of unambiguously violent images and images of intimate partner violence. Prior work has focused on ambiguous stimuli at the representation stage or attention to emotional faces and the eyes (e.g., Gehrer et al., 2019).

We measured eye movements associated with attentional encoding such as time to first fixation, the proportion of first fixations on violent stimuli, and first fixation duration. Our design using unambiguous stimuli allowed us to investigate encoding processes without relying on the interpretation of complex, ambiguous social situations. Thus, our aim was to test the hypothesis that aggressive people would show greater rates of attention toward violent images - indicative of encoding - than less aggressive people. We expected no relationship between aggressive traits and representation (i.e., dwell time). We expected that the encoding measures would be positively correlated with trait aggression, alcohol use, psychopathy, insecure attachment, and negatively correlated with trait empathy. We also calculated an index of total dwell time as a top-down measure of attention and interpretation.

1.1. Data availability

Data, R code, and supplementary materials are available here: https://osf.io/zx9cy/. An a priori power analysis with the *pwr* package in R (Champely, 2020) suggested that this sample size was sufficient for detecting a small-to-moderate correlation of $r = .25$, with a minimum power of .82. Thus, our stopping rule was to cease data collection at 128 participants.

2. Study 1

Study 1 investigated the extent to which trait aggression, alcohol use, IPV perpetration and victimization, and empathy would correlate with

encoding (i.e., time to first fixation, proportion of first fixations on violent images and first fixation duration) and representation measures of visual attention (i.e., dwell time).

2.1. Method

2.1.1. Participants

Participants were 128 undergraduate psychology students from the University of New South Wales (UNSW). Inclusion criteria were: (1) normal or corrected vision; (2) no epilepsy or family history; and (4) aged 18 or above. Out of the 128 participants, one was excluded from subsequent analyses due to issues with the eye tracking calibration. The final sample consisted of 127 participants (95 women, 32 men; M_{age} = 19.10; SD_{age} = 2.30; Range = 18–26). Participants reported their ethnicities as Asian (52.8 %), Caucasian (32.3 %), Middle Eastern (1.6 %), and multiple or other ethnicities (13.4 %).

2.1.2. Design

In a within-subjects design, photos depicting general violence, intimate partner violence (IPV) and neutral scenes were presented. The dependent variables were proportion of first-fixations on violent stimuli, time to first fixation, first fixation duration, and total dwell time. These dependent variables were chosen because they are commonly used to assess attentional biases and are reliably measured with eye-trackers (Popa et al., 2015; Skinner et al., 2018).

2.1.3. Apparatus

All participants completed the study on a Windows-based computer using the Tobii Pro Spectrum eye-tracker (https://www.tobiipro.com). MATLAB (The MathWorks, Natick, MA) controlled stimulus presentation using Psychophysics Toolbox extensions (Brainard & Vision, 1997). Participants were seated 60 cm away and head stabilized with a chin rest when viewing the stimuli on a 23.8-in. monitor screen. Stimuli (images) were subtended 13 by 13° of visual angle and presented against a black background. Eye movements from both eyes were recorded at 600 Hz throughout the entire length of each trial.

2.1.4. Materials

Stimuli consisted of 32 violent images, 32 images depicting IPV and 32 neutral images. The majority of the images were taken from the International Affective Picture System (Lang & Bradley, 2007). Three were obtained from internet image searches using key words such as household items, violent, and intimate partner violence. All images were controlled for size, cropped to 500 × 500 pixels. Fig. 1 shows three examples of images that would be classified as neutral, violent, and IPV.

2.1.4.1. Eye tracking task. The task involved participants viewing three types of trials presented side-by-side in a dual-image free viewing paradigm: violent versus neutral images; IPV versus neutral images; and IPV versus violent images. Within trial types, 16 of each image types (i.e., violent, IPV, neutral) were presented. This combination created a total of 48 trials. Each trial began with a central fixation cross in the middle of the screen. Once 1000 ms of eye gaze was recorded on the fixation cross, the stimuli were presented for 2000 ms. Each image was presented once. The trial types, image types and location of presentation were all randomized. The eye-tracker began recording eye movements with the initial presentation of the images, and halted recording with the disappearance of images. An example of the trial is presented in Fig. 2. We specified two areas of interest for eye gaze measurements: one for the entirety of each image location. On each trial, we recorded the total amount of time spent viewing each image (i.e., total dwell time), the stimulus image upon which eye-gaze was first fixated upon (i.e., proportion of first fixations on violent or IPV images), how long it took to fixate on an image (i.e., time to first fixation), and the duration of the first fixation (i.e., first fixation duration). Our focus was on violent images. Note that fixations were defined as periods when the gaze location was stable for at least 100 ms (see Data Processing).

2.1.4.2. Trait aggression. The Brief Aggression Questionnaire (Webster et al., 2014) is a 12-item self-report scale for trait aggression (e.g., "If I have to resort to violence to protect my rights, I will" (1 = *extremely uncharacteristic of me* to 5 = *extremely characteristic of me*). The Brief Aggression Questionnaire has good test-retest reliability (r = .81) over 12-weeks. It has good convergent validity with other self-report and behavioral measures of anger and aggression including the full-length Aggression Questionnaire (Buss & Perry, 1992; Webster et al., 2014, 2015).

2.1.4.3. Intimate partner violence. The Revised Conflict Tactics Scale – 2 (Straus et al., 1996) is a 78-item self-report measure of violence within intimate relationships and the use of negotiation in a dating, cohabiting, or marital relationships. The Revised Conflict Tactics Scale-2 is widely used in studies assessing IPV (Chapman & Gillespie, 2019). The questionnaire consists of 4 violence subscales that participants complete once for perpetration and once for victimization: physical assault, sexual coercion, injury, and psychological aggression. Participants indicate how often each behavior has occurred (0 = *this has never happened before* to 7 = *once in the past year*). We assigned a value of 1 to the additional response "*not in the past year, but it did happen before*". Items were summed into separate perpetration and victimization scores. The Revised Conflict Tactics Scale – 2 is reliable and valid across different

Fig. 1. Example of images from Study 1.
Note. Neutral, violent, and intimate partner violence (left to right).

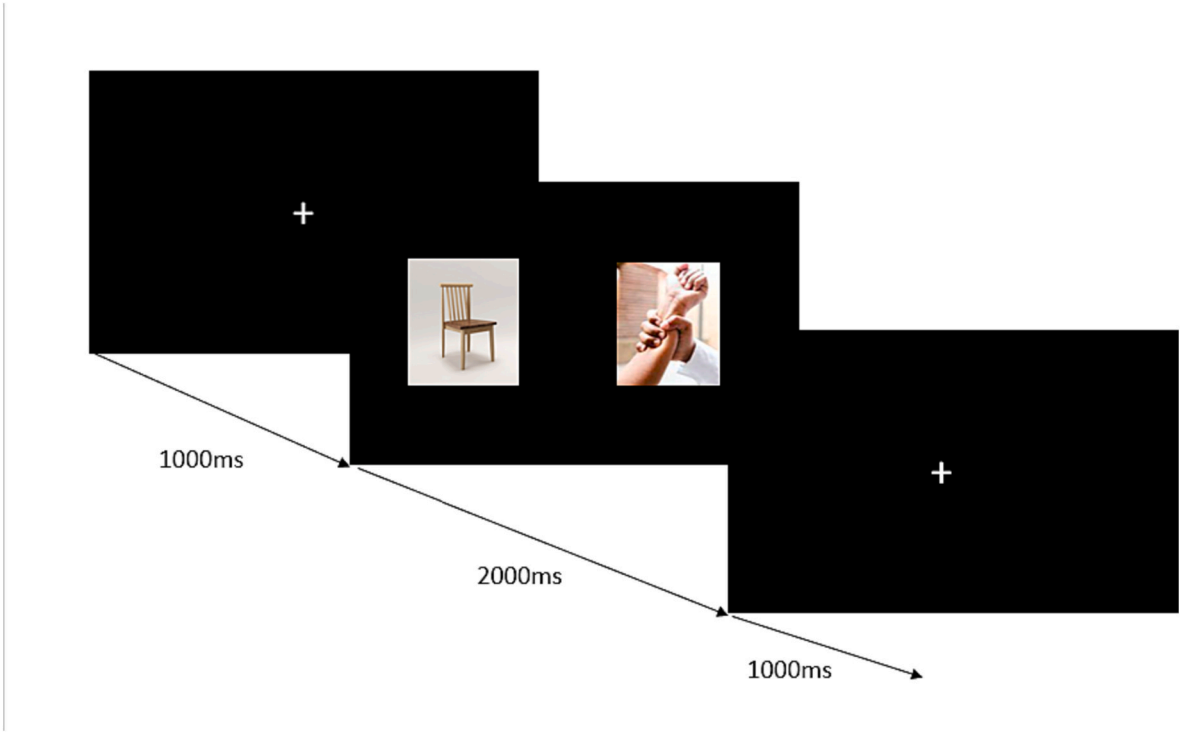

Fig. 2. Illustration of trial structure.

populations and cultures (Costa & Barros, 2016; Straus, 2004).

2.1.4.4. Psychopathy. The Levenson Self-Report Psychopathy Scale (Levenson et al., 1995) is a 26-item scale developed to assess psychopathic traits in non-institutionalized samples and for psychological research. It has two subscales: Primary psychopathy (e.g., "Looking out for myself is my top priority") and secondary psychopathy (e.g., "Love is overrated") (1 = *disagree strongly* to 4 = *agree strongly*). The Levenson Self-Report Psychopathy Scale possesses good internal consistency and test-retest reliability over 8-weeks (r = .83; Lynam et al., 1999). Additionally, the scale demonstrated adequate convergent validity with Hare's (1985) Self-Report Psychopathy Scale.

2.1.4.5. Empathy. The Empathic Concern subscale of the Interpersonal Reactivity Index (Davis, 1983) is a 7-item scale assessing feelings of sympathy and concern for unfortunate others (e.g., "I often have tender, concerned feelings for people less fortunate than me"). Participants were asked to indicate the degree to which each statement accurately described them (1 = *Does not describe me well* to 5 = *Described me very well*). The Interpersonal Reactivity Index has acceptable construct validity and internal consistency reliability (e.g., Péloquin & Lafontaine, 2010).

2.1.4.6. Alcohol use. The Alcohol Use Disorders Identification Test is a well-validated 10-item screening tool (Saunders et al., 1993). This test assesses alcohol consumption, drinking behaviors, and alcohol related problems (e.g., "How often do you have a drink containing alcohol?"). Responses were scored from 0 to 4 on the first 8 questions, and the last two are scored on a 3-point scale from 0, 2 and 4. A score of 8 and above indicates harmful or hazardous alcohol use. The Alcohol Use Disorders Identification had good test-retest reliability over 6-weeks (Spearman's rank-order r = .81) (Daeppen et al., 2000). The measure has good convergent validity with other alcohol screening measures (i.e., Michigan Alcohol Screening Test and MacAndrew Alcoholism Scale) (Bohn et al., 1995).

2.1.5. Procedure

Participants were tested individually. Upon arrival, they were informed that the study aimed to examine how individuals process and respond to different emotional facial expressions and images. Participants first provided demographics (i.e., gender, age, ethnicity) and then completed the self-report individual difference questionnaires via Qualtrics. Next, the eye tracking portion began with participants instructed to view the screen freely while keeping their head motionless on the chin rest (refer to Appendix B for verbatim instructions). A 5-point calibration was carried out before the experimental trials. This task took participants approximately 1 min 36 s.

2.1.6. Data processing

Valid gaze-location data were recorded in M = 98.2 % (SD = 1.7 %) of samples from the eye-tracker. Dwell time per trial was first calculated as the total amount of time that eye gaze was recorded at either of the image locations (no valid gaze data was recorded on 0.2 % of all trials). To identify fixations, we used Salvucci and Goldberg's (2000) velocity threshold identification algorithm. Following linear interpolation across gaps in the raw gaze data of <75 ms, the data were smoothed with a five-point moving average filter. Fixations were defined as periods when the gaze location was stable with a velocity criterion of <40° visual angle per second, for at least 100 ms. The mean x and y coordinates across the entire fixation period were calculated. If the mean fixation coordinates fell within one of the image AOIs, the fixation was coded at being on that image. On 4.2 % of total trials, no fixations (i.e., of at least 100 ms) were recorded on either image. There were three primary measures of interest that were calculated for the analysis. Table 1 shows the operationalization of eye tracking variables.

2.1.7. Statistical analyses

Using R (R Core Team, 2023) version 4.2.3, we computed Pearson's correlations between the individual difference measures and the three eye tracking variables. Because the number of correlations was large, we adjusted p-values to control for familywise error rate (α = .05) with Benjamini and Hochberg's (1995) false discovery rate. We used this

Table 1
Descriptions and definitions of eye tracking measurements.

Eye tracking variable	Operationalization	Relationship to attention
Time to first fixation	Duration of time before the first fixation	Measure of early processing (encoding process)
Proportion of first fixations	Proportion of trials in which participants fixated (>100 ms) first on a violent or IPV image	Bottom-up measure of stimuli detection (encoding process)
First fixation duration	Duration of time spent looking at the violent or IPV image that was fixated upon first	Bottom-up measure of attentional capture (encoding process)
Dwell time	Total amount of time spent looking at violent or IPV images	Top-down measure of attentional engagement (interpretive process)

procedure with each individual difference variable for each trial type. Descriptive statistics and Cronbach's αs were calculated with the *psych* package (Revelle, 2023).

2.2. Results and discussion

Table 2 provides the mean and standard deviation for the dependent variables. Means, standard deviations, Cronbach's αs, and correlations among the independent variables are presented in Table 3. Internal reliability estimates were acceptable, although not uniformly high (αs = .69 to .85). Lower reliability may have reduced statistical power to some extent. Histograms for the independent and dependent variables are presented in the Supplementary Materials Figs. 1 and 2. Variables were normally distributed except intimate partner violence and first fixation duration. Internal reliability coefficients were acceptable. The correlations between the variables were as expected based on past research, providing evidence of construct validity.

The primary results are presented in Table 4. None of the correlations between the individual difference measures and the time to first fixation or proportion of first fixations on violent images (in violent versus neutral trials) were significant. However, dwell time on violent images was significantly correlated with trait aggression, both IPV perpetration and victimization, alcohol use, and secondary psychopathy. For the IPV images (in IPV versus neutral trials), IPV victimization and secondary psychopathy positively correlated with dwell time on IPV images. There were no significant correlations with eye tracking for any of the individual difference measures on the IPV versus violent trials. Primary psychopathy and empathy were not correlated with any dependent variable. Together, these results suggest that some aggressive people may show attentional engagement toward violent images, but this engagement did not include encoding processes.

It is difficult to determine why some aggressive traits were associated with dwell time. However, these findings are consistent with the integrative cognitive model, which suggests that aggressive individuals may have trouble disengaging from the violent stimuli (Wilkowski & Robinson, 2010). It may be that these individuals found the violent images more interesting than individuals lower in these traits. As such, we included a self-report measure of interest in Study 2. Also, of note was that primary psychopathy and empathy showed no relationships with the attentional measures. Perhaps this finding is because these two traits are indirectly related to aggression. Psychopathy and empathy are broad constructs implicated in many social behaviors other than aggression.

3. Study 2

Study 2 attempted to replicate Study 1 with minor changes. Study 2 included a separate set of images that were scrambled versions of the stimuli (Fig. 3). The scrambled images were included to rule out the possibility that visual characteristics unrelated to the semantic content accounted for our findings (e.g., brightness, color). Moreover, because some of the neutral images did not contain people in Study 1, the neutral images in Study 2 all contained people. We also included a measure of adult attachment style as meta-analyses have shown that insecure attachment is positively associated with IPV (Spencer et al., 2021). We also omitted the empathy measure as it was unrelated to the eye-tracking variables. One possibility for the failure to find many significant relationships in Study 1 may be that our paradigm does not accurately index attention toward the different image types. Therefore, we included questions to determine the extent to which participants were aware of which images captured their attention the most. We then correlated those responses with the eye tracking variables to gauge the extent to which participants consciously noticed which images caught their attention. In addition, given the correlations between some of the aggressive traits and dwell time in Study 1, we sought to determine whether these correlations would be due to greater self-reported attentional engagement.

Table 2
Means and standard deviation for eye tracking variables.

	Study 1		Study 2		Study 2 scrambled	
	M	*SD*	*M*	*SD*	*M*	*SD*
Violent versus neutral trials						
Time to first fixation on violent (ms)	233.08	47.74	24.50	85.89	334.69	158.34
First fixation on violent (proportion)	.50	.09	.48	.09	.49	.13
First fixation duration on violent (ms)	194.52	8.67	18.03	52.50	317.14	178.21
Dwell time on violent (sec)	0.94	0.19	0.97	0.23	0.73	0.18
IPV versus neutral trials						
Time to first fixation on IPV (ms)	233.58	46.98	247.55	73.93	334.69	151.45
First fixation on IPV (proportion)	.49	.10	.48	.10	.46	.12
First fixation duration on IPV (ms)	182.39	59.92	179.93	69.81	327.75	198.84
Dwell time on IPV (sec)	0.91	0.14	0.88	0.23	0.68	0.18
IPV versus violent trials						
Time to first fixation on IPV (ms)	245.27	67.90	243.53	76.52	328.87	126.36
Time to first fixation on violent (ms)	239.58	67.46	246.90	72.30	317.75	109.06
First fixation on IPV (proportion)	.51	.11	.50	.09	.47	.12
First fixation on violent (proportion)	.50	.10	.51	.10	.54	.14
First fixation duration on IPV (ms)	191.11	86.97	178.35	7.33	313.63	192.3
First fixation duration on violent (ms)	201.66	66.31	184.67	61.67	323.89	159.52
Dwell time on IPV (sec)	.80	.13	.51	.19	.72	.19
Dwell time on violent (sec)	0.91	0.14	0.97	0.23	0.78	0.19

Note. *M* = Mean, *SD* = Standard Deviation, *IPV* = Intimate Partner Violence.

Table 3
Descriptive statistics and partial correlations among the individual difference measures in Study 1.

	Trait aggression α = .76	IPV perpetration α = .83	IPV victimization α = .84	Alcohol use α = .74	Primary psychopathy α = .85	Secondary psychopathy α = .72	Empathy α = .69
Trait aggression	2.52 (.62)						
IPV perpetration	**.49* (.34, .61)**	4.15 (6.82)					
IPV victimization	**.38* (.22, .52)**	**.89* (.84, .92)**	4.31 (7.33)				
Alcohol use	**.30* (.14, .45)**	**.40* (.24, .54)**	**.40* (.24, .54)**	5.96 (4.25)			
Primary psychopathy	**.53* (.39, .64)**	**.24* (.07, .40)**	.18 (.01, .35)	.10 (−.08, .27)	1.79 (.44)		
Secondary psychopathy	**.51* (.37, .63)**	**.41* (.26, .55)**	**.36* (.20, .51)**	.20 (.02, .36)	**.46 (.31, .59)**	2.08 (.46)	
Empathy	−.11 (−.28, .07)	−.003 (−.18, .17)	.05 (−.12, .22)	−.04 (−.21, .14)	**−.45 (−.58, −.30)**	−.15 (−.32, .02)	3.58 (0.58)
Female gender	−.13 (−.30, .05)	.10 (−.07, .27)	.09 (−.08, .26)	−.13 (−.30, .05)	−.09 (−.26, .08)	.15 (−.03, .31)	.19 (.02, .35)

Note: 95 % confidence intervals are presented in parentheses. Means and (standard deviations) are presented on the diagonal. P-values were adjusted for multiple comparisons with the Benjamini and Hochberg (1995) method. Significant correlations are in bold font. * $p < .05$.

Table 4
Correlations between individual difference measures and eye tracking outcomes as a function of the three trial types in Study 1.

	Trait aggression	IPV perpetration	IPV victimization	Alcohol use	Primary psychopathy	Secondary psychopathy	Empathy
Violent versus neutral trials							
Time to first fixation on violent	.04 (−.14, .21)	−.04 (−.21, 14)	−.05 (−.23, .12)	.13 (−.05, .29)	.01 (−.17, .18)	−.04 (−.21, .14)	.07 (−.11, .24)
First fixation at violent (proportion)	−.06 (−.23, .12)	.13 (−.05, .30)	.14 (−.04, .30)	−.01 (−.19, .17)	−.10 (−.27, .08)	−.07 (−.24, .11)	.01 (−.17, .18)
First fixation duration on violent	.10 (−.08, .27)	.03 (−.15, .20)	.02 (−.16, .19)	.11 (−.07, .28)	−.003 (−.18, .17)	−.01 (−.18, .17)	.14 (−.04, .31)
Dwell time on violent	**.23* (.06, .39)**	**.25* (.08, .41)**	**.27* (.10, .43)**	**.28* (.11, .43)**	.12 (−.06, .29)	**.27* (.10, .43)**	.07 (−.11, .24)
IPV versus neutral trials							
Time to first fixation on IPV	.003 (−.17, .18)	.01 (−.17, .18)	.01 (−.17, .18)	.14 (−.04, .31)	−.04 (−.21, .14)	−.07 (−.25, .10)	.05 (−.13, .22)
First fixation at IPV (proportion)	.04 (−.14, .21)	.12 (−.06, .28)	.12 (−.06, .29)	.07 (−.11, .24)	.15 (−.03, .32)	.14 (−.04, .31)	−.07 (−.25, .10)
First fixation duration on IPV	−.01 (−.18, .17)	−.02 (−.19, .16)	−.06 (−.23, .12)	.11 (−.07, .28)	−.02 (−.19, .16)	−.09 (−.26, .09)	−.02 (−.19, .16)
Dwell time on IPV	.07 (−.11, .24)	.22 (.05, .38)	**.25* (.08, .41)**	.23 (.05, .39)	.04 (−.14, .21)	**.26* (.09, .42)**	.08 (−.10, 16)
IPV versus violent trials							
Time to first fixation on IPV	.04 (−.14, .21)	−.01 (−.19, .16)	−.04 (−.21, .14)	−.09 (−.26, .09)	−.02 (−.19, .16)	−.03 (−.20, .15)	.05 (−.12, .23)
Time to first fixation on violent	.04 (−.14, .21)	.07 (−.11, .24)	.05 (−.13, .22)	.15 (−.02, .32)	−.02 (−.19, .16)	−.03 (−.20, .15)	.04 (−.14, .21)
First fixation on IPV (proportion)	−.02 (−.20, .16)	.11 (−.07, .28)	.18 (.004, .34)	.02 (−.15, .20)	−.12 (−.28, .06)	.04 (−.13, .21)	.08 (−.10, .26)
First fixation on violent (proportion)	.02 (−.15, .20)	−.11 (−.28, .07)	−.18 (−.34, −.001)	−.02 (−.20, .15)	.11 (−.06, .28)	−.04 (−.21, .14)	−.08 (−.25, .10)
First fixation duration on IPV	−.11 (−.28, .06)	−.05 (−.13, .22)	−.03 (−.21, .14)	−.18 (−.34, −.004)	−.02 (−.20, .16)	−.11 (−.28, .07)	.01, (−.16, .19)
First fixation duration on violent	.003 (−.17, .18)	−.07 (−.24, .11)	−.12 (−.29, .06)	−.07 (−.24, .10)	−.05 (−.23, .12)	−.17 (−.33, .01)	.02 (−.16, .19)
Dwell time on IPV	−.03 (−.21, .14)	−.02 (−.19, .16)	−.02 (−.19, .16)	.003 (−.17, .18)	−.11 (−.28, .07)	−.01 (−.18, .17)	.13 (−.04, .30)
Dwell time on violent	.03 (−.15, .20)	.05 (−.13, .22)	.05 (−.13, .22)	−.04 (−.22, .13)	.11 (−.06, .28)	.07 (−.11, .24)	−.16 (−.33, .02)

Note: 95 % confidence intervals are presented in parentheses. Within each individual difference measure and trial type, p-values were adjusted for multiple comparisons with the Benjamini and Hochberg (1995) method. *$p \leq .05$. Correlations are partial Pearson's controlling for gender. Significant correlations are in bold font.

3.1. Participants

Participants were 131 undergraduate psychology students. Exclusion criteria were identical to Study 1. Out of the 131 participants, two were excluded due to insufficient gaze data and two for reporting ages under 18. The final sample consisted of 127 participants (78 women, 48 men, 3 other; M_{age} = 19.78; SD_{age} = 3.29; *min* = 18; max = 39). Participants reported being from a wide range of ethnic groups, including Asian (51 %), Caucasian (29 %), Middle Eastern (2 %), and multiple or other ethnicities (17 %).

3.2. Materials

3.2.1. Attachment

The Experience in Close Relationships – Revised scale (Fraley et al., 2000) is a 36-item measure of adult attachment styles in romantic relationships. The questionnaire measures individuals on two subscales of attachment: Avoidance (e.g., "I prefer not to be too close to romantic partners") and Anxiety (e.g., "I worry about being abandoned") (1 = *disagree strongly*, 4 = *neutral/mixed*, 7 = *agree strongly*). Sibley et al. (2005) found the scale to be reliable over a 3-week test-retest interval (r = .85) in undergraduate students. The scale also showed adequate convergent validity with Bartholomew and Horowitz's (1991) widely used Relationship Questionnaire. In this current study, the subscales yielded good reliability.

3.2.2. Mental engagement

After completing the eye tracker portion of the study, participants were presented with four questions to assess cognitive engagement with the images. Two questions assessed conscious awareness of dwelling on the general violence images (i.e., "I found myself dwelling on the other images of general violence the most" and "The images of general

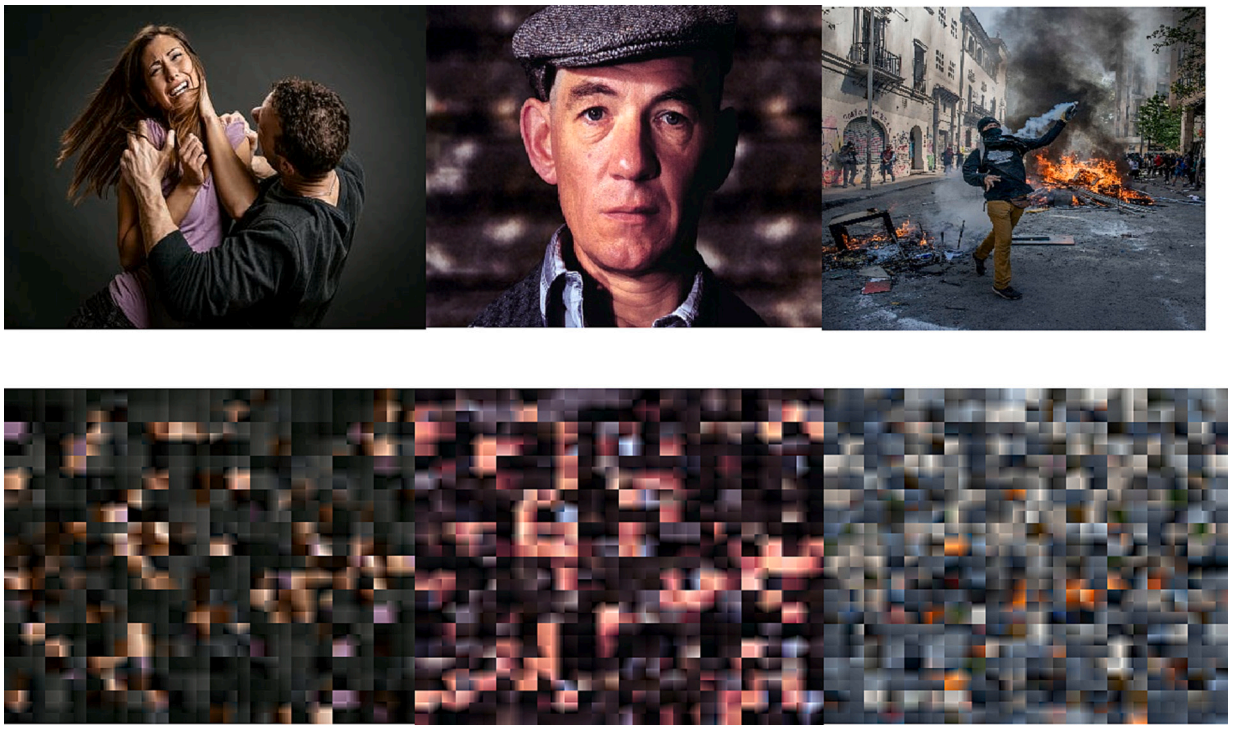

Fig. 3. Example of images from Study 2.
Note: The top panel shows IPV, neutral, and violent (left to right) images; The bottom panel shows scrambled versions of the same images.

violence caught my attention more than the images of violence toward women") (1 = disagree strongly, to 5 = agree strongly), $r[125] = .68$, $p < .0001$, $CI_{95} = .57, .76$. Two questions assessed dwelling on the IPV images (i.e., "I found myself dwelling on the images of violence against women the most" and "The images of men hurting women caught my attention the most"), $r[125] = .52$, $p < .0001$, $CI_{95} = .38, .64$. We separately averaged each of the two mental engagement types (i.e., general violence and IPV).

3.3. Results and discussion

Table 2 shows the means and standard deviations for the eye tracking variables for both the standard and scrambled images. Table 5 provides the means, standard deviations, Cronbach's αs, and correlations among the independent variables. Internal reliability estimates were acceptable, although not uniformly high (αs = .62 to .92). Lower reliability may have reduced statistical power to some extent. Histograms for the independent and dependent variables are presented in the Supplementary Materials Figs. 3 and 4. Variables were normally distributed except intimate partner violence and the AUDIT. The primary results are presented in Table 6. Significant correlations are displayed as well as those which were significant in Study 1. There was no overlap to the correlations between studies and only 6 significant correlations. The correlation matrix for the scrambled images is in Supplementary Materials Table 1.

The mental engagement measures provided evidence that the paradigm did index conscious attention toward the stimuli type. For the violent versus neutral trials, the measure assessing subjective attention toward general violence was positive correlated with dwell time on general violence images, $r(125) = .25$, $p_{BH} = .016$, $CI_{95} = .08, .40$; but the measure assessing attention toward IPV images was not correlated with dwell time on the general violence images, $r(125) = .002$.

Table 5
Descriptive statistics and partial correlations among the individual difference measures in Study 2.

	Trait aggression α = .74	IPV perpetration α = .79	IPV victimization α = .79	Alcohol use α = .77	Primary psychopathy α = .84	Secondary psychopathy α = .62	Avoidant attachment α = .92	Anxious attachment α = .88
Trait aggression	2.62 (.61)							
IPV perpetration	**.43* (.28, .56)**	5.85 (7.25)						
IPV victimization	.21- (.03, .37)	**.70* (.60, .78)**	8.15 (11.54)					
Alcohol use	.20 (.02, .36)	.13 (−.05, .30)	.17 (−.002, .34)	6.25 (4.60)				
Primary psychopathy	**.49* (.34, .61)**	**.29* (.12, .44)**	.14 (−.04, .31)	.10 (−.08, .27)	1.82 (.44)			
Secondary psychopathy	**.43* (.28, .57)**	**.26* (.09, .42)**	**.24* (.06, .39)**	**.21* (.04, .37)**	**.44* (.29, .57)**	2.08 (.42)		
Avoidant attachment	−.06 (−.23, .12)	−.03 (−.20, .15)	.13 (−.04, .30)	.02 (−.15, .20)	.06 (−.12, .23)	**.21* (.04, .37)**	3.10 (.99)	
Anxious attachment	**.35* (.19, .50)**	.14 (−.03, .31)	.02 (−.15, .20)	.20 (.03, .37)	**.27* (.10, .42)**	**.34* (.18, .49)**	−.04 (−.22, .13)	3.80 (1.06)

Note: 95 % confidence intervals are presented in parentheses. Means and (standard deviations) are presented on the diagonal. P-values were adjusted for multiple comparisons with the Benjamini and Hochberg (1995) method. *p ≤ .05. Correlations are Pearson's r. Significant correlations are in bold font.

Table 6
Correlations between individual difference measures and eye tracking outcomes as a function of the three trial types in Study 2.

	Trait aggression	IPV perpetration	IPV victimization	Alcohol use	Primary psychopathy	Secondary psychopathy	Avoidant attachment	Anxious attachment
Violent versus Neutral trials								
Time to first fixation on violent	−.07 (−.24, .11)	−.03 (−.20, .15)	.02 (−.16, .19)	−.09 (−.26, .08)	−.02 (−.20, .15)	−.03 (−.21, .14)	.03 (−.14, .21)	.05 (−.13, .22)
First fixation at violent (proportion)	.06 (−.11, .24)	−.02 (−.19, .16)	.15 (−.03, .31)	.09 (−.08, .26)	.06 (−.12, .23)	.14 (−.04, .31)	−.18 (−.34, −.002)	.002 (−.17, .18)
First fixation duration on violent	−.02 (−.20, .15)	.03 (−.15, .21)	.08 (−.10, .25)	.03 (−.15, .20)	.14 (−.04, .31)	.22* (.04, .38)	.02 (−.16, .19)	.05 (−.12, .23)
Dwell time on violent	.11 (−.07, .28)	−.003 (−.18, .17)	.03 (−.15 .20)	.13 (−.05, .30)	.06 (−.11, .24)	.04 (−.14, .22)	.08 (−.10, .25)	.06 (−.12, .23)
IPV versus Neutral trials								
Time to first fixation on IPV	.05 (−.12, .22)	.01 (−.17, .18)	.00 (−.17, 17)	−.15 (−.32, .03)	−.02 (.20, .15)	.12 (−.06, .29)	.03 (−.15, .20)	.08 (−.10, .25)
First fixation at IPV (proportion)	−.05 (−.23, .12)	−.05 (−.22, .13)	.04 (−.14, .21)	.05 (−.12, .23)	−.07 (−.24, .11)	.002 (−.17, .18)	.07 (−.10, .25)	.04 (−.14, .21)
First fixation duration on IPV	.03 (−.15, .20)	.11 (−.07, .28)	.15 (−.02, .32)	−.10 (−.27, .08)	.14 (−.04, .30)	.18 (.001, .34)	−.07 (−.11, .24)	.01 (−.16, .19)
Dwell time on IPV	−.02 (−.19, .16)	.02 (−.16, .19)	−.01 (−.18, .17)	.12 (−.06, .29)	.003 (−.17, .18)	.05 (−.13, .22)	.11 (−.07, .28)	.05 (−.12, .23)
IPV versus Violent trials								
Time to first fixation on IPV	−.02 (−.19, .15)	−.06 (−.23, .11)	−.01 (−.19, .16)	−.09 (−.26, .09)	−.03 (−.20, .15)	.02 (−.15, .19)	−.02 (−.20, .15)	−.06 (−.23, .11)
Time to first fixation on violent	.001(−.17, .18)	−.01 (.19, .16)	.10 (−.08, .27)	−.02 (−.19, .16)	.01 (−.17, .18)	.04 (−.14, .21)	.004 (−.17, .18)	.05 (−.13, .22)
First fixation on IPV (proportion)	−.04 (−.21, .14)	.19 (.02, .36)	.23* (.05, .39)	−.05 (−.22, .13)	−.04 (−.21, .14)	−.11 (−.28, .06)	−.07 (−.24, .11)	−.05 (−.22, .13)
First fixation on violent (proportion)	.04 (−.14, 21)	−19 (−.36, −.02)	−23* (−.39, −.05)	.05 (−.13, .22)	.04 (−.14, .21)	.11 (−06, .28)	.07 (−.11, .24)	.05 (−.13, .22)
First fixation duration on IPV	.04 (−.14, .22)	.03 (−.15, .20)	.12 (−.05, .29)	−.01 (−.18, .17)	.12 (−.06, .29)	.20* (.03, .36)	−.08 (−.25, .09)	.07 (−.10, .24)
First fixation duration on violent	.05 (−.13, .22)	.09 (−.08, .27)	.20* (.03, .36)	.02 (−.15, .20)	.21* (.03, .37)	20* (.02, .36)	.06 (−.12, .23)	.15 (−.03, .32)
Dwell time on IPV	−.09 (−.26, .09)	.01 (−.17, .18)	.03 (−.14, .21)	−.02 (−.19, .16)	−.04 (−.21, .14)	.12 (−.06, .29)	.21* (.04, .37)	.06 (−.12, .23)
Dwell time on violent	.12 (−.06, .29)	−.03 (−.20, .15)	−.17 (−.33, .01)	.04 (−.14, .21)	.06 (−.11, .24)	−.10 (−.27, .07)	−.10 (−.27, .08)	−.07 (−.24, .11)

Note: 95 % confidence intervals are presented in parentheses. Within each individual difference measure and trial type, p-values were adjusted for multiple comparisons with the Benjamini and Hochberg (1995) method. *p ≤ .05. Correlations are Pearson's r. Red font = significant in Study 1, but not Study 2; green font = significant in Study 2, but not Study 1.

Similarly, for IPV versus neutral trials, the mental engagement measure for attention to IPV images was positively corelated with dwell time on IPV images, $r(125) = .25$, $p_{BH} = .033$, $CI_{95} = .07, .40$, but the measure assessing attention toward general violence was not correlated with dwell time on the IPV images, $r(125) = -.01$.

For IPV versus general violence trials, two dissociations were observed. First, the measure of attention toward general violence images was positively correlated with dwell time on the general violence images, $r(125) = .37$, $p_{BH} < .001$, $CI_{95} = .21, .51$, but negatively correlated with dwell time on the IPV images, $r(125) = -.31$, $p_{BH} = .001$, $CI_{95} = -.46, -.14$. Second, the measure of mental engagement toward IPV images was positively correlated with dwell time on IPV images, $r(125) = .30$, $p_{BH} = .002$, $CI_{95} = .13, .45$, but inversely correlated with dwell time on general violence images, $r(125) = -.31$, $p_{BH} = .001$, $CI_{95} = -.46, -.14$. No significant relationships were observed for time to first fixation, proportion of first fixations or first fixation duration, suggesting that dwell time and the mental engagement measure assess conscious processing. The only significant correlation between the personality variables and the mental engagement items was between mental engagement on the general violence images and avoidant attachment, $r(125) = -.22$, $p_{BH} = .047$, $CI_{95} = -.38, -.05$. Thus, people high in aggressive traits did not appear to show greater interest in the images than people low in aggressive traits.

4. General discussion

The aim of this research was to identify the extent to which individual differences related to aggression correlate with attentional measures assessed with eye tracking toward violent visual stimuli. Although numerous studies show that aggressive people are attracted to ambiguously aggressive images, across these two studies, there was no substantive support for the notion that people with aggressive traits are drawn to unambiguously violent images. There were few significant correlations between the trait measures and eye tracking outcomes. Furthermore, there was no replication across studies.

The correlations between the mental engagement items and dwell time suggested that the paradigm we used was a valid way to measure interest in the two violent image types. Indeed, participants who spent more time dwelling on violent or IPV images were able to consciously report this behavior. The individual difference measures did not correlate with self-reported mental engagement. Thus, whether by self-report or eye tracking, there was no support for people with aggressive traits showing a bias toward violent stimuli. People were engaged with the images but that the level of engagement did not depend on individual differences relevant to aggression.

The use of different paradigms may explain the null effects observed here. Much of the research on aggression and eye tracking has involved the use of paradigms similar to Wilkowski et al. (2007), which included ambiguously aggressive images. We did not find the typical positive relationship between aggressive dimensions and gaze on non-aggressive stimuli. However, our stimuli were not ambiguous in nature. Thus, there may not have been enough "room" for aggressive people to show attentional biases given the unambiguous nature of our images. These prior studies were intended to assess eye movements associated with

hostile attribution biases; but our studies were intended to assess attention toward less cognitively complex images. Thus, aggressive people may show biases toward ambiguous social situations but not toward unambiguous portrayals of violence.

Our stimuli were violent but not directly threatening in nature. Had we used more threatening images (e.g., a man pointing a gun at the participant), we might have seen correlations between the trait measures and the eye tracking outcomes. Investigating this possibility is a promising avenue for future research.

Another reason for the potential failure to observe the predicted associations between individual differences related to aggression and the eye tracking outcomes may be restricted ranges within some of our individual differences. However, a post hoc inspection of the range of scores revealed that scores were not greatly restricted, except for the IPV questionnaires (see Supplementary Figs. 1 & 2). Nonetheless, repetition of these studies with a forensic sample may prove informative. Indeed, numerous studies examined the relationships between psychopathy and eye tracking outcomes in response to threatening facial stimuli. These findings, with forensic and non-forensic samples typically find that psychopathy is associated with reduced attention toward the eyes (e.g., Gehrer et al., 2019).

On a theoretical level, the largely null results may have been due from failure to induce a hostile situation such as an insult or other provocation. According to social cognitive models of personality, situational features (e.g., anger provocation) elicit encoding processes and subsequent behavior (Mischel & Shoda, 1995). Similarly, the General Aggression Model posits interactions between situations and aggressive personality traits in producing hostile cognition (Anderson & Bushman, 2002). Indeed, in studies that did not use eye tracking, one study found that participants high in trait aggression only showed bias for angry faces after an insult (Cohen et al., 1998). Similarly, another study found the same effect of provocation on anger words on a modified Stroop task (Eckhardt & Cohen, 1997). Thus, inducing anger may activate cognitive processes in those high in trait aggression that bias attentional processes toward aggressive stimuli.

In sum, the present research found that a broad range of aggression-related individual differences were not reliably associated with automatic or controlled eye gaze toward violent images.

CRediT authorship contribution statement

Denson, Watson, Bertsch, and Beames conceptualized and designed the studies. Yeong and Armstrong collected data and developed stimuli materials. Denson, Yeong, and Armstrong analyzed the data. Watson handled technical aspects of the eye tracking.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

The link to the OSF with all data and code is provided in the paper.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.paid.2023.112425.

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