From night owl to angry bird: Investigating the association between chronotype and aggression

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Abstract

Recent attempts to understand the sleep-aggression relationship highlight the importance of the role of cognition. A related but separate concept of sleep, chronotype (i.e., sleep timings) has also been suggested to contribute to levels of aggression. The current study explores the relationship between chronotype, sleep quality, hostility, aggression, and intimate partner violence (IPV). Two hundred and eight participants completed online questionnaires to explore the contribution of hostility and sleep quality as mediators of the chronotype-aggression relationship. Findings indicate that chronotype was associated with levels of aggression, with those with later chronotypes reporting higher levels of aggression. Two mediation models revealed that this relationship was mediated by hostile cognitions (i.e., hostile attribution biases), and partially mediated by sleep quality. The chronotype-IPV relationship was explored, but the association was not significant. Findings indicate that those with late chronotypes may be more susceptible to hostile cognitions which leads to aggressive outcomes. However, there may be additional factors contributing to this relationship when considering violence in relationships. Aggression-focused interventions may benefit from dissecting an individual's sleep patterns to reduce hostile cognitions and future research would benefit from objective measures of both chronotype and aggression.

Keywords: Aggression, Chronotype, Eveningness, Hostility, Sleep, Violence

Introduction

There have been recent attempts to understand the sleep-aggression relationship (Bozzay & Verona, 2023; Greenwood *et al.*, 2022; Van Veen *et al.*, 2021). Research has indicated that poor sleep quality and short sleep duration have been associated with increased verbal, physical, and indirect aggression (Barker *et al.*, 2016; Ireland & Culpin, 2006; Randler & Vollmer, 2013). Although the causal link is difficult to determine, there has been increased emphasis on exploring the potential cognitive pathways from poor sleep to increased outward and inward aggression (Greenwood *et al.*, 2022). Whilst there is some understanding of the importance of sleep quality and cognition in general aggression, less is understood about the importance of circadian rhythms in this relationship.

Circadian rhythm is the 24-hour internal body clock important for regulating the sleep-wake cycle (Reddy *et al.*, 2023). Whilst most individuals follow the 24-hour cycle, the natural inclination of the body to sleep at certain times varies from person to person. Chronotype is this natural inclination (Pacheco & Rehman, 2023). Chronotypes can be understood through Evolutionary Theory which states we sleep during the least productive hours of the day, namely for survival reasons, suggesting that our sleep-wake cycles are innate and biological (Samson *et al.*, 2017). Having a late chronotype, or eveningness is defined as feeling most alert in the evenings (Lang *et al.*, 2022), in comparison to an early chronotype, or morningness. Late

chronotype is associated with increased health risks (Partonen, 2015), mental health difficulties (Zou *et al.*, 2022), and aggression (Deibel *et al.*, 2020).

Research exploring this latter relationship is scarce. Primarily, research focuses on school children or adolescents (Randler & Vollmer, 2013; Randler *et al.*, 2014; Susman *et al.*, 2007; Tosuntas *et al.*, 2020). For example, recent research by Wang and colleagues (2023) found that late chronotype was associated with increased aggression including physical aggression, verbal aggression, anger, and hostility in 11–16-year-olds in China. Similarly, Susman *et al.* (2007) found that late chronotype was associated with relational aggression in girls aged 8-13 by measuring cortisol ratios. Most of the findings indicate that a relationship exists between chronotype and aggression in adolescents, but less is known about this association in adulthood. The only research to the authors' knowledge that considers the chronotype-aggression relationship in adults was conducted by Randler and Vollmer (2013). They found that whilst social jetlag (i.e., the discrepancy between biological body clock and social times, Caliandro *et al.*, 2021) was related to physical aggression, chronotype was only associated with one facet of aggression: hostility.

The importance of hostility to aggression is emphasised. According to the General Aggression Model (Anderson & Bushman, 2002), hostility is important in the activation of aggression-related scripts and schemas. Specifically, those who are aggressive are more likely to interpret ambiguous social events with hostility (Bushman & Anderson, 2002). The Social Information Processing (SIP) model (Dodge & Crick, 1990; Dodge *et al.*, 1990), helps to explain how errors in processing can result in aggression. Specifically, hostile attribution biases (i.e., interpreting others' behaviour as hostile although the cues are ambiguous; Klein Tuente et al., 2019), along with other social, cognitive, and behavioural factors, can help to explain aggressive behaviour (Caccaro *et al.*, 2009; Orobio de Castro *et al.*, 2002). Bushman and Anderson (2002) further highlight the presence of hostile expectancy biases (i.e., expecting another to show hostility) and hostile perception biases (i.e., perceiving social interactions as aggressive) to be important in understanding aggression. It could therefore be suggested that a late chronotype may be relevant to individuals' tendency to attribute, expect, and perceive the behaviour of others as hostile.

Such a proposition would fit with recent understandings of aggression in relation to sleep. Research indicates that late chronotype is associated with shorter sleep duration (Gianotti *et al.*, 2002; Juda *et al.*, 2013), poor sleep quality (Horne *et al.*, 2019; Juda *et al.*, 2013), and daytime dysfunction (Gianotti *et al.*, 2002). Recent research has drawn attention to the potential link between sleep and increased aggression (Barker *et al.*, 2016; Ireland & Culpin, 2006; Kamphuis *et al.*, 2012). The Cognitive Sleep Model for Aggression and Self Harm (CoSMASH; Greenwood *et al.*, 2022) draws on relevant cognitive insomnia models (Espie, 2007; Harvey, 2002) to explain the sleep-aggression relationship. The CoSMASH model is a preliminary conceptual model that may help to guide the understanding of the role of cognition in the sleep-aggression relationship (Greenwood *et al.*, 2022). Although the causal mechanisms remain unclear, the CoSMASH highlights that sleep problems increase the likelihood of experiencing cognitive rumination and worry, hopelessness, and negative sleep-related beliefs both before going to sleep and during the day. This in turn can increase negative

emotions which can lead to a negative sleep attribution bias (i.e., perceiving poor sleep quality over and above objective indicators) and further sleep problems (i.e., based on indicators of poor sleep such as daytime dysfunction and sleep duration). This may then lead to more accessible negative scripts and schemas, such as hostile attribution biases.

The notion that experiencing both objective and subjective sleep difficulties, including sleep attribution biases, could lead to further cognitive difficulties certainly fits with our understanding of aggression. As Krizan and Herlache (2016) highlight in their review of the pathways contributing to the sleep-aggression relationship, sleep difficulties may increase the accessibility of negative concepts in memory and/or may decrease the likelihood of reappraising a situation, both of which are important in the General Aggression Model (Anderson & Bushman, 2002). Sleep perception, or as termed here, sleep attribution biases, have been shown to disrupt cognitive processing when participants were falsely informed that they had slept well or poorly (Draganich & Erdal, 2014). Regardless of the indicators of sleep, those who were informed that they had not slept well showed a reduction in their cognitive abilities. Whilst this study did not explore aggression specifically, further research (Barker et al, 2016) found that prisoners perceiving their sleep to be poor had higher levels of reactive and proactive aggression. This highlights the relative importance of sleep perception to this relationship.

The CoSMASH was developed using a high-risk forensic population of psychiatric offenders (Greenwood *et al.*, 2022) and has yet to be applied to a community sample. Furthermore, the CoSMASH does not consider chronotype preference, which may influence the expression of aggression. Research suggests that sleep quality is associated with chronotype (Müller et al., 2015; Nowakowska-Domagała et al., 2022), with late chronotypes reporting poorer sleep quality than early chronotypes. This indicates sleep quality may be responsible for the potential chronotype-aggression relationship. However, we argue that whilst sleep quality is likely to contribute to the relationship, other factors, such as hostile attribution biases, should also be considered. Although there is no known research specifically exploring chronotype and hostile attribution bias, one study (Avery et al., 2018) explored chronotype and socioemotional cognition by asking participants about their perceptions of interpersonal situations. They found that late chronotype was associated with poorer socioemotional cognitive performance, suggesting that eveningness may be disrupting cognitive perception. As hostile attribution biases rely on an individual's perception of their social situation, it is therefore proposed that those with late chronotypes may have deficits in their ability to accurately process (and reprocess) a social situation. Alternatively, late chronotype could be impacting memory processes, reducing the likelihood of accessing more positive scripts and schemas which are important social cognitions (Huesmann, 1998). Evidence suggests that those with early chronotypes perform better on cognitive memory tasks (Heimola et al., 2021), although the research in this area is limited.

As previously described, research is beginning to explore the relationship between chronotype and aggression (Randler & Vollmer, 2013; Randler *et al.*, 2014; Susman *et al.*, 2007), but the focus has been on general aggression. There is one paper that examined cyberbullying (Tosuntas *et al.*, 2020), but there is no research to date exploring specific

aggression in an adult sample. More explicitly, the current research is interested in understanding the relationship between chronotype and Intimate Partner Violence (IPV).

IPV is defined as abuse occurring in a romantic relationship. It can include physical violence, sexual violence, psychological abuse, and stalking (Centers for Disease Control & Prevention, 2022). According to the Office for National Statistics, 6.9% of women and 3% of men in the United Kingdom were found to be victims of intimate partner violence (ONS, 2022). However, is it suggested that this is an underrepresentation of actual levels of violence between partners, with both men and women equally likely to be victims (Patra *et al.*, 2018). By its very nature, IPV is an act of aggression and previous research has examined different types of aggression in IPV. For example, Clements and colleagues (2018) explored trait aggression in perpetrators and non-perpetrators of IPV and found that perpetrators had higher levels of physical and verbal aggression, hostility, and anger than non-perpetrators. However, their findings also revealed that non-perpetrators were more likely to use overtly aggressive tactics (i.e., subjecting others who had provoked them to a loud noise), suggesting that the relationship may not be as clear as expected. It is suggested, however, that trait aggression is the most relevant form of aggression to IPV (Ruddle *et al.*, 2018). This may be due to the association with other relevant attributes (e.g., emotional regulation difficulties and anger rumination; Mathis & Mueller, 2015; Pederson *et al.*, 2011).

Hostility also appears to be relevant in understanding IPV perpetration. In a study by Thomas and Weston (2019), 241 college students were asked to respond to questions about their IPV perpetration and to answer questions about a range of relational and instrumental scenarios via the Social Information Processing-Attribution and Emotional Response Questionnaire (Coccaro *et al.*, 2009). Their findings indicated men with more hostile attribution biases to relational scenarios were more likely to use physical aggression and threatening behaviour towards their romantic partner. In contrast, female perpetrators with more hostile attribution biases for both relational and instrumental scenarios were more likely to report sexual abuse perpetration. Their findings suggest that gender may play a role in the interpretation of others' behaviour.

With regards to chronotype and IPV perpetration, there is no known research. However, there is some evidence of sleep-related difficulties and IPV perpetration (Keller *et al.*, 2014; Kirwan *et al.*, 2019; Rauer & El-Sheikh, 2012). For example, Rauer and El-Sheikh (2012) found that sleep difficulties predicted IPV perpetration one year after the initial reporting of sleep difficulties in men and women. However, their findings revealed that it was only limited to the perpetration of psychological IPV and not physical IPV. Interestingly, Rauer and El-Sheikj (2012) did not find a reciprocal relationship between sleep quality and IPV, as has previously been suggested with sleep and aggressive behaviours (e.g. Krizan & Herlache, 2016), indicating that poor sleep quality may be the causal factor in this relationship.

Kirwan and colleagues (2019) also explored the relationship between poor sleep quality and relationship violence in their analysis of 334 participants in the US. Their findings revealed that the relationship between sleep problems and relationship violence was partially mediated by emotional regulation. Whilst previous research has indicated a clear relationship between sleep difficulties and emotional regulation (O'Leary *et al.*, 2017) and emotional regulation and

IPV (Maloney *et al.*, 2023), Kirwan *et al.*'s (2019) findings indicate that there could be an additional factor above and beyond the regulation of emotional states that influences this relationship via a cognitive route. More exploration of chronotype on aggression generally, and IPV specifically is needed. It could be suggested that having a late chronotype can result in poor sleep quality which in turn results in a decreased ability to regulate one's emotions. This may make hostile cognitions more accessible (Greenwood *et al.*, 2022) and result in more aggression and IPV perpetration.

The Current Study

Whilst previous research has examined the sleep-aggression relationship, less is known about how chronotype may account for aggression. Furthermore, the CoSMASH model (Greenwood *et al.*, 2022) attempts to provide some understanding of the sleep-aggression relationship, but it has only been considered with a high-risk psychiatric sample. The current study, therefore, aims to explore the sleep-aggression relationship, focusing specifically on chronotype, in a community sample. It is predicted that a later chronotype will be associated with increased aggression. In line with the CoSMASH model (Greenwood *et al*., 2022), it is also anticipated that this relationship will be mediated by both hostile attribution biases and sleep quality. Additionally, the study will also aim to explore the role of chronotype on perpetrated aggression in relationships. It is predicted that a later chronotype will be associated with more self-reported IPV perpetration and this relationship will be mediated by hostile attribution biases, sleep quality, and aggression.

Method

Participants

Participants were members of the UK general population recruited via volunteer sampling method with the use of a social media advertisement. Participants were eligible if they were in a current or recent (within the last month) intimate relationship and were over the age of 18. There were 223 responses, however five participants were removed from the analysis as they only completed the demographic questions. The majority of the sample were female (n = 184), with 30 males and 3 non-gender conforming participants, and one participant who did not disclose their gender. Participants reported being in a current relationship (i.e., not living with a partner; n = 135), cohabiting (n = 31), married (n = 40), or recently single (n = 12). The length of participants' relationships varied from 0-6 months (n = 11), 6-12 months (n = 17), 1-2 years (n = 33), 2-3 years (n = 39), 3-4 years (n = 25), or 4+ years (n = 92). One participant did not answer this question. Ages ranged from 18 to 70 (M = 28.08; SD = 0.47). Participants received no compensation for their time.

Materials

Data were collected using self-report questionnaires via the online survey software Qualtrics.

Demographics Questionnaire

Demographic information was collected including age, gender, relationship status, and relationship length.

Pittsburgh Sleep Quality Index (PSQI; Buysse et al., 1989)

Consisting of 19 items, the PSQI comprises text-response and 4-point Likert scale questions to assess overall sleep quality in the previous month. The scale measures seven subcomponents of sleep: sleep quality, sleep duration, sleep efficiency, sleep latency, sleep disturbance, daytime dysfunction due to sleepiness, and the need to use medication. The seven components combined provide an overall global score of a maximum of 21 points, indicating poorer sleep. Only global scores were used in the current study. Example questions include *'During the past month, how would you rate your sleep quality overall'*, to assess sleep quality, and *'During the past month, how many hours of actual sleep did you get at night?'* to assess sleep efficiency. The PSQI demonstrated acceptable internal consistency in the current study (α = .72).

Morningness-Eveningness Questionnaire (MEQ; Horne & Ostberg, 1976)

The MEQ is a 19-item self-report questionnaire used to assess participants' sleep chronotype. Participants respond to each item on 4-point and 5-point Likert scales with higher scores categorising participants into "morning people" (i.e., those with an early chronotype) and lower scores indicating more "evening people" (i.e., those with a late chronotype). Example questions included *'How alert do you feel during the first half hour after you wake up in the morning?'* and *'If you got into bed at 11 PM (23 h), how tired would you be?'.* The MEQ demonstrated good internal consistency in the current study (α = .83).

Aggression Questionnaire (AQ; Buss & Perry, 1992)

The AQ, a 29-item questionnaire, was used to measure trait aggression. Respondents are asked to indicate on a 5-point Likert scale how characteristic each item is. Four subscales (physical aggression, verbal aggression, anger, and hostility) are combined to give an overall aggression score, with higher scores indicating higher levels of trait aggression. Example items include *"I get into more fights than the average person"* (physical aggression), *"When people annoy me, I tell them what I think of them"* (verbal aggression), *"I flare up quickly, but get over it quickly"* (anger), and *"I am suspicious of overly friendly strangers"* (hostility). Total scores were utilised in the current study and demonstrated good reliability (α = .85).

Social Information Processing-Attribution and Emotional Response Questionnaire (SIP-AEQ; Coccaro et al., 2009)

The SIP-AEQ assessed participant hostility using eight vignettes. Each vignette is designed to measure either direct aggression, such as being physically hurt by someone, or relational aggression, such as facing rejection from someone. The vignettes are followed by a set of questions scored on a 4-point Likert scale ranging from 0-4, with a maximum total score of 24 for each vignette. The set of questions are designed to measure direct hostile intent, indirect hostile intent, instrumental non-hostile intent, neutral/benign intent, and negative emotional response. This is done by asking participants to rate items after reading the vignettes, such as *'This person wanted to damage my car'*, and '*My friend wanted to expose my secret'*. Only the hostile responses (direct and indirect hostile intent) were utilised in the current study, with higher scores indicating higher levels of hostility. The scales demonstrated acceptable reliability (α = .72).

Revised Conflict Tactic Scale (CTS2; Straus et al., 1996).

Comprising 78 items, the CTS2 measured the prevalence and nature of partner-partner violence within an intimate relationship. The CTS2 is divided into two equal parts, 39 items measuring the participant's behaviour towards their partner, and 39 items measuring the partner's behaviour towards the participant with higher scores indicating higher levels of IPV. Participants indicated how often each item occurred in the past year and each item maps onto one of five subscales: physical assault, psychological aggression, sexual coercion, negotiation, and injury. Examples items include "*I pushed or shoved my partner"* (physical assault), "*I insulted or swore at my partner"* (physical aggression), *"I explained my side of a disagreement to my partner* (negotiation), "*I had a sprain, bruise or small cut because of a fight with my partner"* (injury), and *"I made my partner have sex without a condom"* (sexual coercion). The current study utilised the perpetration scores only (i.e. participants' behaviour towards their partner). The scale demonstrated excellent reliability in the current study ($\alpha = .96$).

Procedure

Ethical approval was obtained from the University of Central Lancashire Ethics Committee. Participants completed the questionnaires on the online survey software, Qualtrics. They were presented with an information sheet and provided informed consent, followed by the demographics questionnaire, the PSQI, the MEQ, the AQ, the SIP-AEQ, and the CTS2. The survey concluded with the debrief sheet containing information to ensure all informed consent and support helplines.

Statistical Analysis

Data were analysed using IBM SPSS version 28.0.1.1. The analysis began with the descriptive statistics (means, standard deviations, and frequencies where relevant) of the study variables for the total sample. Participants were categorised by their chronotype (morningness/eveningness) by performing a median split (m=48) to report their descriptive statistics. Parametric assumptions were tested, revealing that all study variables, other than the MEQ, were not normally distributed, therefore non-parametric Mann Whitney U-tests were performed on the study variables to compare those categorised as early chronotypes with those categorised as late chronotypes. Correlations were performed across the study variables followed. According to G*Power (Faul et al., 2007) a sample of 74 was needed to achieve power requirements, therefore our final sample of 218 was sufficient. Mediation models were tested using SPSS and the PROCESS macro (Hayes, 2018). Linear regressions were first conducted to test the relationship between variables. Step 1 examined the association between predictor and criterion variables. Step 2 included a regression of the predictor onto the mediating variable and step 3 included a regression of the mediating variable onto the criterion variable. The final step involved a final multiple linear regression to establish the direct relationship between the predictor and the criterion, whilst controlling for the mediating factors. To explore the relationship between chronotype and trait aggression scores (and each of the subscales), hostile attribution bias and total PSQI score (sleep) were entered as mediators into separate models. It was anticipated that three further separate models exploring the relationship between chronotype and IPV would be conducted, however, there was no significant association between chronotype and IPV (Step 1). In all models age, relationship

status, and relationship length were controlled for. Bootstrapping methods were used to resample the data at 95% confidence intervals (Preacher & Hayes, 2008).

Results

The majority of the total sample were female (84.4%), in a relationship but not living together (61.9%) and had been in a relationship for over four years (42.2%; see Table 1 for descriptive statistics). Those who were categorised as having a late chronotype were younger (M= 25.80, SD = 6.23) and on average, had poorer sleep (U = 498, p = .039), higher levels of aggression (U = 492, p = .048), higher levels of hostility (U = 407, p = .001), but there were no statistically significant differences in IPV perpetration (U = 528, p = .798).

Correlations between study variables are shown in Table 2. It is noted that because the subscales of the AQ and the CTS2 are summed to the totals, multicollinearity was detected. Therefore, the results should be interpreted with caution. Due to the non-normal distribution of data, the mediation analysis implemented non-parametric tests.

Table 1: Descriptive Statistics for Study Variables

Variable	Total sample (N = 218)	Morningness chronotype (n= 97)	Eveningness chronotype (n= 109)	Observed range	Potential range
Age [Mean years (SD)]	28.08 (9.47)	30.56 (11.59)	25.80 (6.23)	-	-
Gender [N (%)				-	-
Male	30 (13.8)	17 (16.2)	13 (11.5)	-	-
Female	184 (84.4)	88 (83.8)	96 (85)	-	-
Non-binary	3 (1.4)	0	3 (2.7)	-	-
Other	1 (0.5)	0	1 (0.9)	-	-
Relationship status [N (%)]				-	-
Recently single	12 (5.5)	8 (7.6)	4 (3.5)	-	-
In a relationship	135 (61.9)	55 (52.4)	80 (70.8)	-	-
Cohabiting	14.2 (31)	16 (15.2)	15 (13.3)	-	-
Married	40 (18.3)	26 (24.8)	14 (12.4)	-	-
*Relationship length [N (%)]**				-	-
0-6 months	11 (5)	6 (5.7)	5 (4.4)	-	-
6-12 months	17 (7.8)	8 (7.6)	9 (8.0)	-	-
1-2 years	33 (15.1)	17 (16.2)	16 (14.2)	-	-
2-3 years	39 (17.9)	16 (15.2)	23 (20.4)	-	-
3 – 4 years	25 (11.5)	14 (13.3)	11 (9.7)	-	-
4+ years	92 (42.2)	43 (41)	49 (43.4)	-	-
PSQI [Mean (SD)]	6.88 (3.51)	6.40 (3.42)	7.33 (3.56)	5 - 13	0 - 21
AQ [Mean (SD)]	71.1 (16.82)	70.28 (15.22)	73.59 (15.30)	36 – 91	29 - 145
Physical		22.87 (4.71)	23.18 (4.27)	14 – 26	9 - 45
Verbal		11.32 (3.81)	12.31 (4.30)	5 – 16	5 - 25
Anger		20.25 (3.98)	20.50 (4.12)	11 – 28	7 – 35
Hostility		15.84 (5.92)	17.59 (6.78)	6 – 27	8 – 40
SIP-AEQ Hostility [Mean (SD)]	40.03 (9.49)	40.44 (4.81)	42.57 (5.84)	29 – 73	0 - 96
CTS2 Perpetration [Mean (SD)]	46.78 (37.06)	47.17 (44.05)	46.43 (29.70)	0 - 296	0-975
Physical	5.05 (13.60)	5.99 (15.68)	4.21 (11.45)	0 - 96	0 – 300
Psychological	10.52 (11.21)	10.71 (11.75)	10.35 (10.76)	0 - 64	0 – 200

*One participant chose not to answer the relationship length question. *PSQI Pittsburgh Sleep Quality Index; MEQ Morningness Eveningness Questionnaire; AQ Aggression Questionnaire; SIP-AEQ Social Information Processing – Attribution & Emotional Response Questionnaire; CTS2 Conflict Tactics Scale Revised*

Table 2: Correlations among study variables

Variable	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1. Age	-													
2. Gender	-.117	-												
3. Relationship Status	.557**	-.013	-											
4. Relationship Length	.358**	.040	.479**	-										
5. PSQI Total	.053	-.075	-.032	.050	-									
6. MEQ Total	.237**	-.066	.131	.007	-.210**	-								
7. AQ Total	-.074	-.119	-.140*	-.081	.259***	-.181**	-							
8. Physical AQ	.061	-.184**	-.093	-.069	.122	-.130	.804**	-						
9. Verbal AQ	.006	-.152*	-.058	.008	.253**	.177*	.857**	.659**	-					
10. Anger AQ	-.205	.048	-.138*	-.108	.187**	-.088	.572**	.206**	.319**	-				
11. Hostility AQ	-.093	-.089	-.082	-.082	.254**	-.174*	.918**	.671**	.748**	.386**	-			
12. SIP-AEQ Hostility	-.220**	-.103	-.152*	-.063	.213**	-.299**	.479**	.748**	.395**	.305**	.484**	-		
13. CTS2 Perpetration	.049	-.118	-.0.33	-.083	.072	-.018	.282**	.281**	.252**	.011	.309*	.190**	-	
14. Psychological CTS2	.122	-.106	.075	.042	.086	.001	.352**	.343**	.336**	.038	.362**	.185**	.846**	-
15. Physical CTS2	.067	-.169*	0.26	-.145*	.024	.021	.233**	.262**	.215**	-.040	.259**	.147*	.914**	.711*

*PSQI Pittsburgh Sleep Quality Index; MEQ Morningness Eveningness Questionnaire; AQ Aggression Questionnaire; SIP-AEQ Social Information Processing – Attribution & Emotional Response Questionnaire; CTS2 Conflict Tactics Scale Revised; *p < .05; ** p < .01, *** p<.001*

Mediation analysis

To explore the potential for hostility being a mediator of the association between MEQ scores and AQ scores, mediation analyses were performed using PROCESS for SPSS to explore two models. The first explored whether hostile attribution biases mediated the association between chronotype and trait aggression and controlled for potential covariates (age, relationship status, and relationship length). In step 1, the regression of chronotype on trait aggression scores was significant ($b = -.331$, $t(4, 203) = 2.77$, $p = .028$). The second and third steps showed that the regression of chronotype on hostile attribution bias was significant ($b = -.122$, $t(4, 203,) = 21.66$, $p < .001$) and the regression of hostile attribution bias on trait aggression was also significant ($b = .949$, $t(5, 202) = 7.35$, $p < .001$). The final step revealed that when in the presence of the hostile attribution bias variable, there was no direct effect of chronotype on trait aggression ($b = -.216$, $t = -1.80$, $p = .072$), suggesting full mediation (see Figure 1a). The mediating role of hostile attribution biases on the specific subscales of the AQ was also explored to help identify the salient component of the AQ. Findings indicate that hostile attribution bias mediates the relationship between three out of the four AQ subscales (physical aggression, verbal aggression, and hostility, see Figure 1b).

A further mediation model was tested to determine whether the relationship between chronotype and trait aggression was mediated by sleep quality according to scores on the PSQI. The same process for the first mediation model was conducted. For step 1, the regression was significant ($b = -.346$, $t(4, 209) = -2.89$, $p = .004$). The second showed that the regression of chronotype of sleep quality was significant ($b = -.090$, $t(4, 209) = -3.34$, $p = .001$) and the third step showed that the regression of sleep quality on trait aggression was significant ($b = -.968$, $t(5, 208,) = 3.24$, $p = .001$). However, the direct effects of chronotype on trait aggression remained significant ($b = -.259$, $t = -2.16$, $p = .032$) and therefore indicated a partial mediation effect for sleep quality (see Figure 2a). Further exploring each AQ component, PSQI scores partially mediated the relationship between chronotype and verbal aggression and hostility, but not physical aggression or anger (see Figure 2b).

Three further mediation analyses were conducted to explore the relationship between chronotype and IPV with three potential mediators (total PSQI scores, hostile attribution bias, and total aggression scores). In step 1 of the analysis (exploring the association between chronotype as the predictor and IPV perpetration as the criterion), there were no total effects ($b = -.180$, $t (4, 199) = .590$, $p = .556$) suggesting no effect could be mediated. To further explore specific categories of violence perpetration, physical assault and psychological aggression subscales were entered as criterion variables to a mediation analysis but both failed to reach significance in step 1 (physical assault: $b = -.019$, $t (4, 199) = .-172$, $p = .864$; psychological aggression: $b = -.097$, $t (4, 199) = -.410$, $p = .682$).

1 a)

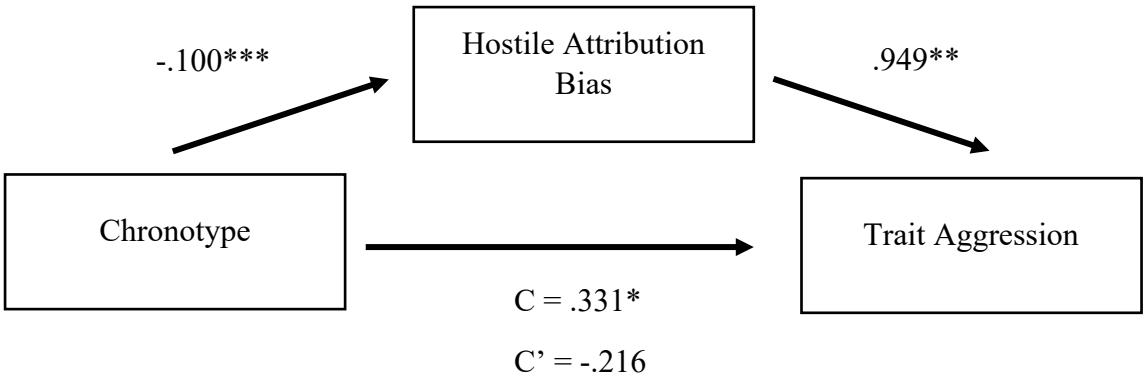

*Figure 1a: Mediation analysis of the association between Chronotype and Trait Aggression by Hostile Attribution Bias. Note N = 218, Analysis controlled by age, relationship status, and relationship length. *** p<.001, **p<.01, * p<.05*

1 b)

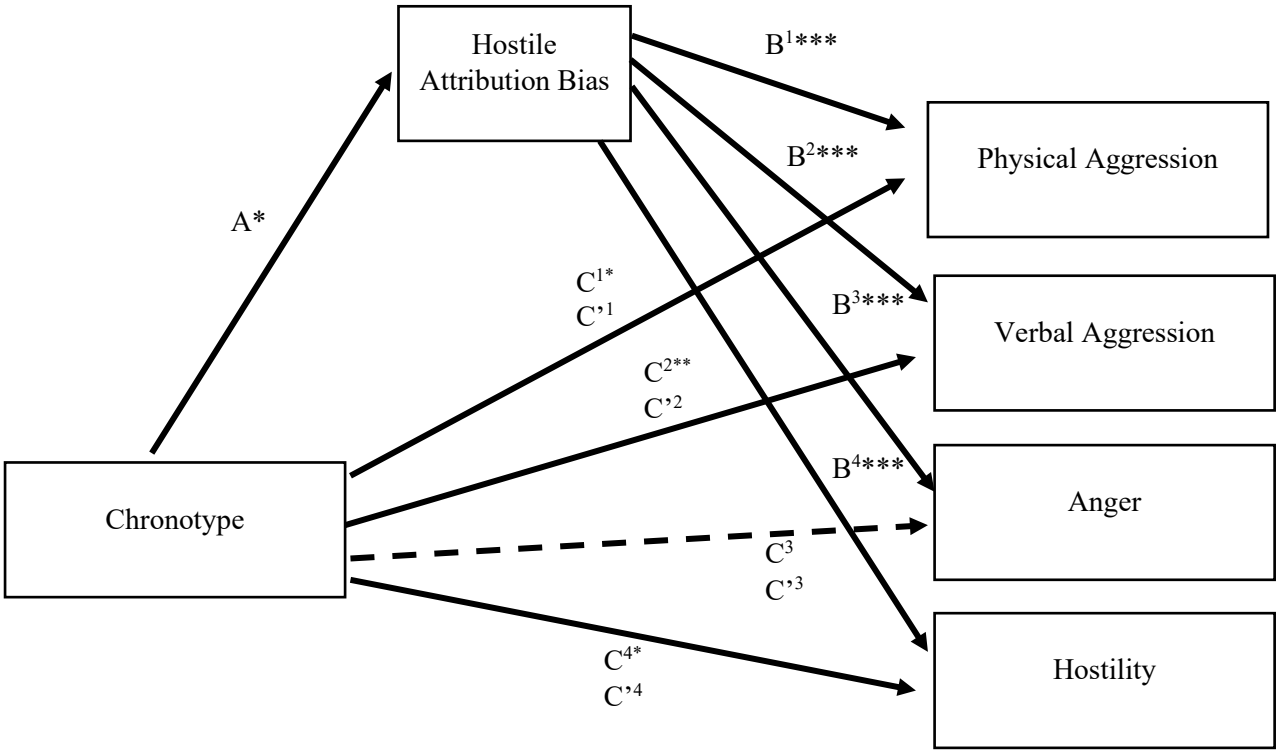

*Figure 1b: Mediation analysis of the association between Chronotype and each subscale of the Aggression Questionnaire with Social Information Processing - Attribution & Emotional Response Questionnaire hostility component as the mediator *** p<.001, **p<.01, * P<.05.*

A = b = -.100, t(4, 203) = -3.348, p = .001;

B1 = b = .339, t(5, 202) = 4.173, p <.001; B2 = b = .372, t (5, 202) = 5.075, p <.001; B3 = b = .291, t (5, 202) = 3.908, p <.001; B4 = b = .734, t (5, 202) = 6.628, p <.001

C1= b = -.086, t (4, 203) = -2.406, p=.017; C2= b = -.093, t (4, 203), = -2.812, p=.005; C3= b = -.030, t (4, 203) = -.701, p =.484; C4= b = -.129, t(4, 203) = -2.496, p = .013

C'1= b =-.052, t (4, 203) = -1.481, p = .140 ; C'2= b = -.056, t (4, 203) = -1.738, p = .084; C'3 = b = -.006, t (4, 203) = .188, p = .851; C'4 = b = -.056, t (4, 203) = -1.158, p = .248

2a)

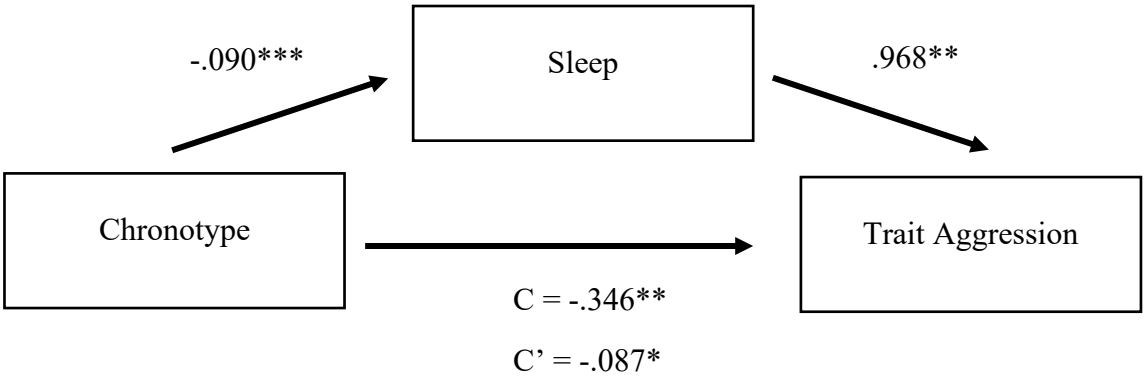

*Figure 2a Mediation analysis of the association between Chronotype and Trait Aggression by Sleep. Analysis controlled by age, relationship status, and relationship length. *** p<.001, **p<.01, * p<.05.*

2b)

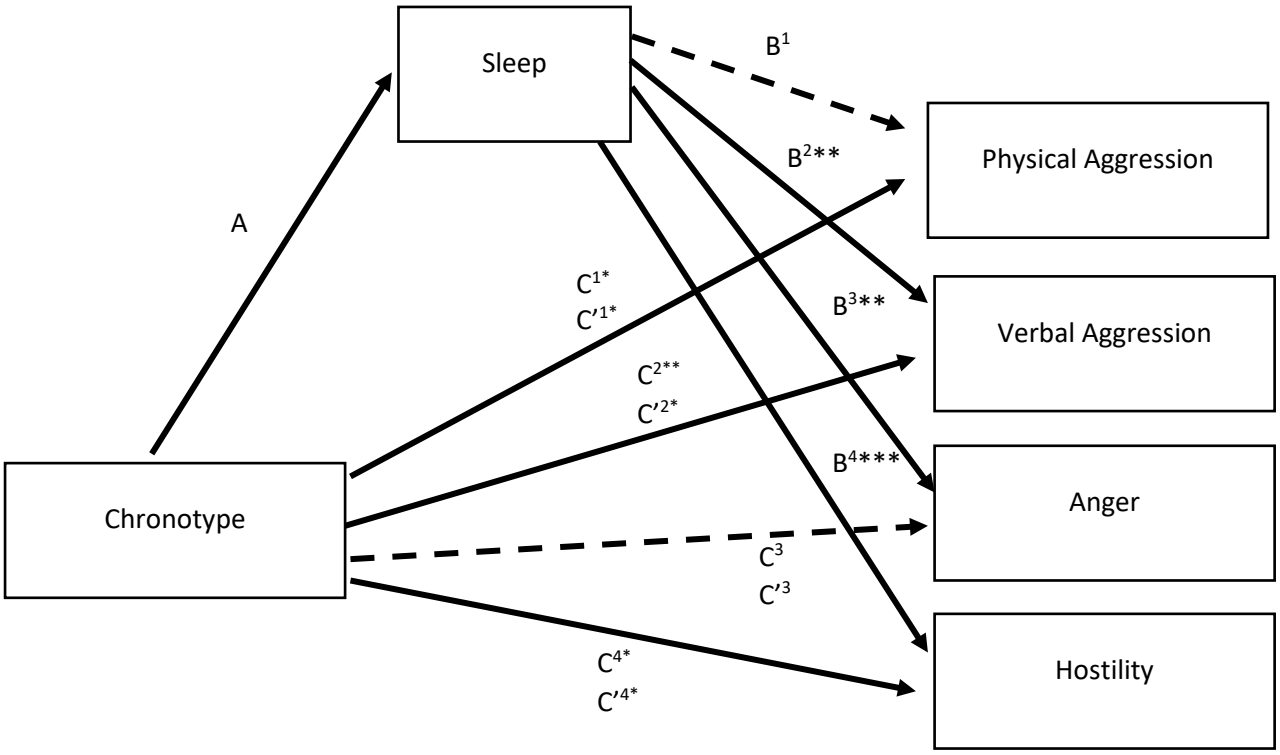

*Figure 2b: Mediation analysis of the association between Chronotype and each subscale of the Aggression Questionnaire with PSQI scores as the mediator *** p<.001, **p<.01, * P<.05.*

A = b = -.090, t (4, 209) = -3.337, p =.001

B1 = b = .098, t (5, 208) = 1.114, p = .267; B2 = b = .231, t (5, 208) = 2.899, p = .004; B3 = b = .234, t (5, 208) = 2.908, p = .004; B4 = b = .405, t (5, 208) = 3.233, p = .001

C1 = b = -.085, t (4, 209) = -2.463, p = .015; C2 = b = -.087, t (4, 209) = -2.747, p =.006; C3 =b = -.038, t (4, 209) = -1.192, p = .235; C4 = b = -.136, t (4, 209) = -2.716, p =.007

C'1 = b = -.076, t (4, 209) = -2.151, p = .033; C'2 = b = .066, t (4, 209) = -2.072, p = .040; C'3 = b = -.017, t (4, 209) = -.528, p = .598; C'4 = b =-.100, t (4, 209) = -1.979, p -.049

Discussion

In line with the first prediction, our findings indicate a significant association between chronotype and aggression. This finding is consistent with previous literature exploring chronotype and aggression in adolescents (Susman *et al*., 2007; Tosuntas *et al*., 2020; Wang *et al*., 2023). Furthermore, the current study also found that three of the AQ subscales were associated with chronotype (physical, verbal, and hostility), findings which both corroborate and contradict the only research exploring this relationship in adults (Randler & Vollmer, 2015). Their findings indicated that only the cognitive component of aggression (i.e. hostility) was related to chronotype. Hostility certainly appears to be an important factor here, but our current findings suggest that chronotype may be relevant to aggression beyond aggressive thoughts, but also extends to aggressive actions (i.e., verbal and physical aggression). One potential explanation for the association between chronotype and aggression is the concept of circadian misalignment (Diebel *et al*., 2020). Circadian misalignment is inappropriately timed sleep-wakefulness (Chaput *et al*., 2023), for example, working during the night. Circadian misalignment differs from poor sleep quality, in that the individual is not dissatisfied with the sleep per se, but rather they are dissatisfied with the timing of their sleep. It is proposed that aggression may be influenced by alterations in the expression of genes (e.g., Sirtuin1, Clock, and Avpr1a) and neurological pathways which can result in circadian misalignment and impact aggression-associated pathways (Deibel *et al*., 2020). For example, late chronotypes may activate the ventral striatum, which is associated with associative learning and is more active in forensic samples with psychopathy, known for aggressive tendencies (Korponay *et al*., 2017). Individuals who have late chronotypes may therefore be biologically inclined to be more aggressive.

Interestingly, our findings did not find an association between chronotype and anger, the emotional component of the Aggression Questionnaire (Buss & Perry, 1992). This finding was unexpected due to the interrelated concepts of hostility and anger, which together activate aggressive behaviour (Klein Tuente *et al*., 2019). Chronotype specifically may therefore be relevant in interrupting the cognitive processes, perhaps by increasing the accessibility of negative cognitions, but does not interfere with the emotional processing associated with it. However, it is important to note that anger is not the only emotion that is relevant to aggression (Elison *et al*., 2014), and therefore future research should explore additional contributions of emotions in addition to anger (e.g., shame, fear).

Our findings also support our second prediction: hostile attribution biases mediate the relationship between chronotype and aggression. Considering the previous literature exploring hostility in late chronotypes (Randler & Vollmer, 2013), it is unsurprising that there is an association between chronotype and hostile attribution biases. It is interesting to find that hostile attribution biases account for the link between chronotype and aggression, which may also be explained by circadian misalignment. Those who are dissatisfied with their sleep timings may have negative affect (e.g., anxiety) due to their current dissatisfaction (Cox & Olatunji, 2019). Such a notion would be consistent with the evidence from our findings that there is a negative association between sleep quality and chronotype (i.e., those with late chronotypes reported poorer sleep quality). This may increase the likelihood of accessing more

aggressive-related and hostile scripts, which then leads to an increase in aggression (Krizan & Herlache, 2016). Interestingly, when Greenwood *et al*. (2022) explored hostile attribution biases in their forensic sample, those who slept well following sleep intervention were better able to access prosocial scripts. It may therefore be that the sleep interventions help to indirectly overcome some of the effects of late chronotype. I t is therefore plausible that chronotype may account for accessing hostile attribution biases which lead to aggression and positively intervening with sleep may help to increase access to prosocial scripts.

An unexpected finding in the current study was that sleep quality only partially mediated the relationship between chronotype and aggression. Previous research indicates that those with a late chronotype are more likely to have reduced sleep quality (Horne *et al*., 2019; Juda *et al*., 2013), and this is in line with our findings. However, when accounting for sleep in the chronotype-aggression relationship, there was a reduced, but still a direct effect. As noted, the circadian misalignment effect could be accounting for the remaining direct effect, but future research would need to explore this. Furthermore, there may still be additional, unexplored variables (such as affective pathways) that could be accounting for this relationship.

This is the first research to explore the association between chronotype and IPV. No association was found, indicating that chronotype is not relevant to increasing the likelihood of perpetrating IPV. Given the association between chronotype and aggression (Susman *et al*., 2007; Tosuntas *et al*., 2020; Wang *et al*., 2023) and sleep quality and IPV (Keller *et al*., 2014; Kirwan *et al*., 2019; Rauer & El-Sheikh, 2012), these findings are unexpected. One potential explanation may be that chronotype can account for aggressive thoughts and perceptions, hence why there was an association between chronotype and trait aggression (and its subscales) but may not translate to overt aggression. In other words, chronotype may be influencing an individual's perception of their demeanour, but when perpetrated acts of aggression are considered, there are additional processes that prevent aggression from occurring. However, the current study did not explore potential factors beyond age, relationship status, and relationship length to account for the contribution. It is therefore proposed that future research explores additional factors such as emotional regulation, impulsivity, and self-control that could help explain the current findings.

Despite the clear strengths of this research including an original perspective of chronotype on both aggression and IPV in an adult community sample, the study is not without limitations. The current sample was based on a disproportionate number of female participants. Whilst there is some debate over the differences in aggression levels across genders (Hyde, 1984), gender may have confounded the results of the chronotype-IPV association, as females may be less likely to perpetrate violence against their partners. A sample that includes a larger number of male and non-binary or non-gendered individuals would help to affirm the current findings. Additionally, participants were asked to report the violence in their current relationship, but partner perspectives were not considered, and social desirability bias may have also contributed to the low levels of IPV found in the current study. Asking both partners to corroborate the information would help to eliminate any social desirability biases. A further limitation is the biased assumption of a dyadic relationship and therefore the study cannot account for those in polyamorous relationships. In terms of the limitations of the statistical

analysis, it is noted that whilst mediation analysis can be beneficial in understanding the indirect effects of specific variables, the use of this analysis with a cross-sectional dataset is limited. Longitudinal data would help to determine the causal influence of the sleep/chronotype on aggression. There are both research and clinical implications from the current findings. Exploring potential pathways from poor sleep to increased aggression should not ignore the contribution of chronotype. Chronotype may be able to account for the relationship, but more research needs to be conducted. To explore whether chronotype can account for overt aggression (i.e., aggressive acts), experimental research should be conducted in addition to objective measures of sleep to account for discrepancies with self-report measures of chronotype. Furthermore, future research should focus on exploring the impact of processes that may help to protect individuals from the effects of the sleep-aggression relationship, such as self-regulatory processes. Understanding the contribution of chronotype to aggression also helps clinicians. For example, monitoring sleep timings may be important for inpatient settings to help predict risk factors. Aggression-focused interventions may also benefit from including some psychoeducational work about the importance of sleep timings in addition to the importance of sleep quality. However, it is highlighted that the current findings are preliminary and within a community context, but future research may benefit from exploring these factors.

In conclusion, the current study adds to previous findings indicating that there is an association between chronotype and aggression. Hostile attribution biases appear to mediate this relationship, whilst sleep quality was only a partial mediator. There was no relationship between chronotype and IPV; this may suggest that chronotype is more important in understanding implicit aggression rather than explicit aggression towards partners. It is important to highlight that these findings are preliminary and include a disproportionate sample of female participants. Further research should focus on experimental findings to examine overt acts of aggression to further understand this relationship.

Impact Statement

The current research offers key implications for research and clinical practice.

- Interventions aiming to reduce aggressive tendencies in individuals should pay some attention to individuals' sleep and their chronotype. Helping to work towards more consistent sleep timing with earlier bedtimes and earlier waking times may help contribute towards more prosocial scripts and schemas.
- Those working in inpatient settings should try to promote the importance of earlier bedtimes but should be mindful of positive sleep hygiene practices.
- Future research should explore the chronotype-aggression relationship further by considering the impact on overt acts of aggression via experimental research.
- Future research should also consider the contribution of emotional regulation in the chronotype-aggression relationship as affective processes are linked with hostile attributions.
- Finally, future research should explore the longitudinal nature of the current finding to account for the limitations in the cross-sectional nature of the current study.

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