

The association between eveningness and autistic traits: mediating effects of depression and insomnia

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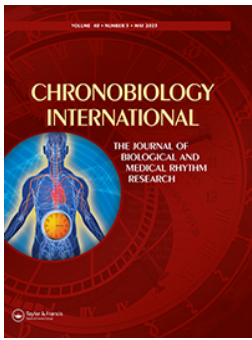
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The association between eveningness and autistic traits: Mediating effects of depression and insomnia

Ellie Harris and Richard Carciofo 

School of Psychology and Clinical Language Sciences, University of Reading, Reading, UK

ABSTRACT

There is a lack of research on the relationships between autistic traits and morningness-eveningness. The current research explored associations between autistic traits (preferences for routine, difficulties with imagination, difficulties with social skills, fixations with numbers and patterns, and difficulties with attention switching) and morningness-eveningness, including the component of Morning Affect (alertness/energy upon awakening). The potential mediation effects of depression and insomnia were also tested. 163 adults (university students and general population) completed an online survey including questionnaire measures of autistic traits, morningness-eveningness, depression, and insomnia. Positive correlations were found between most autistic trait subcomponents, depression, and insomnia. The autistic trait of difficulties in attention switching was correlated with more eveningness and with less Morning Affect, but significant correlations were not observed with any other autistic trait. Depression mediated the relationship between eveningness and difficulties in attention switching. Although insomnia alone was not a significant mediator, when combined with depression in a serial mediator model, a significant mediation effect was shown. The current results suggest that greater eveningness may be related with the autistic trait of difficulties in attention switching possibly through the mechanism of increased insomnia and elevated risk for depression. These findings may potentially inform interventions.

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Autism; autistic traits; chronotype; morningness-eveningness; depression; insomnia

Introduction

Circadian rhythms in biological functioning, including body temperature and dim-light melatonin onset (DLMO), are associated with chronotype (morningness-eveningness), i.e., individual differences in the timing of activity, sleep, and rising, with a spectrum ranging from morning-type to evening-type, with most people categorised as intermediate type (Adan et al. 2012). Typically developing children experience a shift from more morningness to more eveningness as they reach adolescence, with increasing morningness from early to late adulthood (Randler 2016; Roenneberg et al. 2004).

Chronotype is associated with mental health (Taylor and Hasler, 2018). For example, eveningness has been associated with depression (Au and Reece 2017), anxiety (Cox and Olatunji 2019), substance use (Suh et al. 2017), and sleep problems (Bakotic et al. 2017). Together, this research suggests that morningness-eveningness could be a nonspecific transdiagnostic contributor to the susceptibility of many mental illnesses. Sleep quality has been proposed as a mechanism linking morningness-eveningness and mental health (Taylor and Hasler 2018). Insomnia is a strong predictor of subsequent

depression (Johnson et al. 2006), and insomnia symptoms and poor sleep quality mediate associations between eveningness and depressive symptoms (Simor et al. 2015). In addition, the construct of Morning Affect (less alertness/energy upon waking, corresponding to more sleep inertia; Carciofo 2023) has received increasing attention in recent years as a component of circadian functioning, as it has been found to show differential associations; for instance, lower Morning Affect is more strongly correlated with depressive symptoms, and with longer sleep onset latency, than is eveningness (Demirhan et al. 2019; Jankowski 2016).

Autism is a neurodevelopmental condition that is generally characterised by repetitive or stereotyped behaviours and with an early-onset social-communication difficulty that can cause changes in communication and social behaviours. Autism is seen as a spectrum that ranges from severe to mild, and autistic individuals may require lifelong support in some aspect of their lives (Lord et al. 2018). Traits of autism can differ in appearance and severity between each individual, and the traits identified in research can differ depending on the questionnaire used. Some examples of autistic traits are preferences for routine,

CONTACT Richard Carciofo  r.g.carciofo@reading.ac.uk  School of Psychology and Clinical Language Sciences, University of Reading, Reading RG6 6AH, UK

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difficulties with imagination, difficulties with social skills, fixations with numbers and patterns, and difficulties with attention switching (Hoekstra et al. 2011).

Autism is associated with circadian rhythm abnormalities, as shown by the high prevalence of sleep disruptions in autistic individuals (Deliens et al. 2015; Goldman et al. 2009). Autistic behaviour patterns have been associated with sleep problems across the lifespan, including longer sleep onset latency and insomnia, and these are inter-related with anxiety and depression (Schreck and Richdale 2020). Autistic children and adolescents are at a higher rate of suffering from insomnia than typically developing children (ranging from 40%–80%), and this is correlated with more challenging behaviours, and increased family stress levels (Cortesi et al. 2010; Williams et al. 2004). Adults with autism also demonstrate more sleep impairment in both subjective and objective measures (Morgan et al. 2020).

Furthermore, autism is associated with significantly higher rates of psychiatric illnesses (Leyfer et al. 2006). Eaves and Ho (2008) found that 77% of their sample of autistic young adults had comorbid diagnoses, such as depression and bipolar disorder. However, in considering potential mechanisms involved in the high prevalence of psychiatric illness in autistic individuals, the associations between chronotype and mental health in the autistic population has been under researched, although there is evidence that sleep may be a mediator. Türkoğlu et al. (2020) found that higher autistic behaviour scores were associated with eveningness, and sleep disturbances were a mediating factor between eveningness and autistic symptom severity. Also, adults with diagnoses of ADHD or autism were more likely to have an evening chronotype, and to have poorer sleep (Migliarese et al. 2020). Furthermore, Ahn et al. (2021) investigated inter-relationships between chronotype, depression, and alexithymia. Alexithymia is characterised by having difficulty describing feelings, difficulty distinguishing bodily sensations and feelings, and a tendency to focus on external experiences rather than internal experiences (Sifneos 1973). Ahn et al. (2021) found that eveningness was associated with alexithymia and that this relationship was mediated by depression symptoms. These findings are particularly important as it has been shown that there are high rates of alexithymia in autistic individuals (Kinnaird et al. 2019), so it opens the possibility that depression could also mediate the relationship between morningness-eveningness and autistic traits.

Thus, previous research has shown an association between eveningness and autism, with sleep quality and depression being potential mediators of this relationship. However, previous research has focused on children and/or involved participants diagnosed as autistic. Past

research has also failed to explore which autistic traits may be involved in these associations. So, the current research aimed to expand upon previous findings on the relationship between autism and eveningness by: 1) using a dimensional approach by recruiting adults from the general population – an under researched group in this subject matter – to explore whether certain autistic traits are more strongly associated with morningness-eveningness; 2) including a preliminary test of whether Morning Affect is associated with autistic traits; 3) testing whether depression and insomnia are mediators of the relationship between morningness-eveningness and autistic traits. As already established in previous research (Au and Reece 2017; Demirhan et al. 2019; Jankowski 2016; Johnson et al. 2006; Schreck and Richdale 2020; Simor et al. 2015), associations between autistic traits and depression, eveningness and depression, low Morning Affect and depression, autistic traits and insomnia, low Morning Affect and insomnia, eveningness and insomnia, and depression and insomnia were expected. In addition, given the findings of Türkoğlu et al. (2020) and Migliarese et al. (2020), it was expected that autistic traits would be associated with eveningness. Also, given the mutual associations between low Morning Affect and depression, and autism and depression, it was predicted that Morning Affect would be negatively correlated with autistic traits. The relative associations between morningness-eveningness, Morning Affect, depression, insomnia, and specific autistic traits (preferences for routine, difficulties with imagination, difficulties with social skills, fixations with numbers and patterns, and difficulties with attention switching) were explored.

Method

Participants

English speakers aged 18/older were eligible to participate. Recruitment took place on the SONA participant recruitment system at the University of Reading, with course credits awarded for participation. Additional participants were recruited through Prolific (<https://www.prolific.co/>), with £1.50 remuneration for participation, and via advertisements on social media (without remuneration). There were 181 respondents to the survey, however only 163 completed all questions, 119 from SONA, 22 from Prolific and 22 from social media. 83% of the sample identified as female ($N = 136$), 15% as male ($N = 25$), with one identified as non-binary, and one other/preferred not to say; 85% of the sample were aged between 18–28, the eldest aged between 59–68. Ethical approval for the study was provided by the

Ethics committee of the School of Psychology and Clinical Language Sciences, University of Reading (approval number: 2022-068-RC).

Materials

The Autism-Spectrum Quotient (AQ-28; Hoekstra et al. 2011) has 28 questions assessing autistic traits, utilising a 4-point Likert scale (definitely agree/slightly agree/slightly disagree/definitely disagree); higher scores indicate more autistic traits. There are five subfactors: preferences for routine, difficulties with imagination, difficulties with social skills, fixations with numbers and patterns, and difficulties with attention switching.

The Composite Scale of Morningness (CSM; Smith et al. 1989) has 13 items assessing morningness-eveningness, including the sub-component of Morning Affect (items 3, 4, 5 and 12) with Likert-type scales; higher scores indicate more/higher morningness/Morning Affect.

The Centre for Epidemiological Studies – Depression Scale Short (CES-D short; Andresen et al. 1994) has 10 items, each rated on a 4-point Likert scale with higher scores indicating more depressiveness. The CES-D short has been shown to have high internal consistency and test-retest reliability within different populations (Andresen et al. 1994).

The Insomnia Severity Index (ISI; Morin 1993) has seven items measuring perceptions of insomnia (subjective symptoms, consequences, and degree of distress caused). Each item is rated on a 5-point Likert scale with scores ranging from 0–28; higher scores suggest more severe insomnia. Response options for one item were mistakenly set to a 6-point Likert scale instead of a 5-point scale on the survey building website, so the maximum possible score was 29.

Demographic items were: “how old are you?,” with options of 18–28, 29–38, 39–48, 49–58, 59–68, 69–78, 79 + and “how do you identify?,” with options of “male,” “female,” “non-binary,” “other/prefer not to say.” Additional questions were: “Have you ever been diagnosed with depression? Have you ever been diagnosed with a neurodevelopmental disorder? Have you ever been diagnosed with insomnia?,” and “Is English your first language?,” each with options of “yes,” “no,” “prefer not to say.”

Design

The cross-sectional online survey was hosted on the REDCap (Research Electronic Data Capture) survey platform. On accessing the survey link, participants were presented with the information sheet and consent form. After

clicking an option to give informed consent, participants were presented with the questionnaires in this order: the demographic questions, CES-D short, ISI, AQ-28, and finally the CSM, followed by an electronic de-briefing.

Planned analysis

Descriptive statistics were calculated for each scale/subscale, including the mean, standard deviation, range, skewness, kurtosis, and internal consistency (Cronbach’s alpha). Gender differences in variables were assessed with t-tests. Correlations between variables were computed with Pearson’s product-moment correlation, for which coefficients of .10, .30, and .50 may respectively indicate small, medium, and large effect sizes; to establish medium effect sizes with 80% power at $p = 0.05$, a sample size of $N = 85$ is suggested (Cohen 1992); for small/medium ($r = .2$) correlations $N = 194$ (<https://sample-size.net/correlation-sample-size/>). The SPSS Process Macro (Hayes 2022) was used for mediation analysis. Morningness-eveningness scores were the predictor variable and autistic traits the dependant variable, with either CES-D or ISI as the mediator.

Results

Descriptive statistics

Only 17.79% of participants reported previous diagnosis of depression, 4.90% insomnia, and 3.07% neurodevelopmental disorders; 82.82% of participants were native English speakers. Descriptive statistics for scales/subscales are shown in Table 1. Distributions all approximated normality (skewness < 1 , and kurtosis mostly < 1), with wide ranges for scores, and acceptable/good internal consistency, with values of Cronbach’s alpha all > 0.7 , apart from the AQ-28 subfactors of preferences for routine and difficulties attention switching (both 4-item subscales).

Age was significantly correlated ($ps < .05$) with morningness-eveningness ($r = 0.24$), Morning Affect ($r = 0.17$), AQ-28 ($r = 0.19$), and the AQ-28 subfactor of difficulties with social skills ($r = 0.29$). Significant gender (male or female) differences were shown for morningness-eveningness scores [$t(43.72) = 2.12$, $p = 0.04$] and the AQ-28 subfactor of fixations on numbers and patterns [$t(159) = 2.08$, $p = 0.04$].

Correlations

There were significant positive correlations between CES-D scores and ISI scores, CES-D scores and total AQ-28 scores, and ISI scores and total AQ-28 scores (Table 2). There were significant negative correlations between CES-

Table 1. Descriptive statistics for each scale and subscale.

	Mean	Standard Deviation	Skewness	Kurtosis	Actual Range	Possible Range	Cronbach's Alpha
Morningness-Eveningness	30.48	7.22	0.82	-0.44	14–48	13–55	0.86
Morning Affect	9.10	2.62	0.04	-0.40	4–16	4–16	0.78
CES-D	12.25	5.79	0.47	-0.20	1–29	0–30	0.84
ISI	11.06	5.67	-0.01	-0.61	0–24	0–29	0.82
AQ-28 Total	65.24	10.10	0.27	1.51	35–104	28–112	0.85
AQ-28 Imagination	16.87	3.59	0.24	1.05	8–31	8–32	0.72
AQ-28 Social Skills	19.63	4.65	0.33	0.17	9–32	8–32	0.85
AQ-28 Numbers/Patterns	10.99	3.33	0.00	-0.23	5–19	5–20	0.83
AQ-28 Routine	10.43	2.25	-0.08	0.11	4–16	4–16	0.62
AQ-28 Attention Switching	10.28	2.07	0.52	0.23	6–16	4–16	0.61

N = 163. CES-D = Centre for Epidemiological Studies – Depression Short Scale; ISI = Insomnia Severity Index; AQ-28 = Autism Quotient.

Table 2. Correlations between study variables.

	CES-D	ISI	Morningness-Eveningness	Morning Affect
Total AQ-28	0.33***	0.24**	0.03	-0.06
AQ-28 Social Skills	0.30***	0.24**	0.04	-0.04
AQ-28 Routine	0.33***	0.16*	-0.04	-0.14
AQ-28 Imagination	0.20**	0.10	0.02	-0.02
AQ-28 Attention Switching	0.29***	0.16*	-0.16*	-0.26**
AQ-28 Numbers and Patterns	0.04	0.12	0.08	0.09
CES-D	-	0.63***	-0.35***	-0.35***
ISI		-	-0.39***	-0.39***
Morningness-Eveningness			-	0.71***

N = 163. CES-D = Centre for Epidemiological Studies – Depression Scale Short. ISI = Insomnia Severity Index. AQ-28 = Autism Quotient.

* $p \leq 0.05$, ** $p \leq 0.01$, *** $p \leq 0.001$.

D and morningness-eveningness scores, CES-D scores and Morning Affect scores, ISI scores and morningness-eveningness scores, and ISI scores and Morning Affect scores. AQ-28 fixations with numbers and patterns subfactor had no significant correlations with any of the variables. There were significant correlations for AQ-28 Social Skills and AQ-28 preferences for routine with CES-D and ISI scores, but these AQ-28 subfactors did not significantly correlate with morningness-eveningness or Morning Affect scores. The AQ-28 difficulties with imagination subfactor only had one significant correlation, with CES-D (positive). The AQ-28 subfactor of difficulties in attention switching had significant positive correlations with CES-D and ISI and significant negative correlations with morningness-eveningness and Morning Affect. So, increases in difficulties in attention switching were associated with more depression and insomnia, and less morningness and lower Morning Affect. Lower Morning Affect also had a small correlation with the AQ-28 routine subfactor, but this did not reach statistical significance.

Mediation analysis

As the AQ-28 subfactor of difficulties in attention switching was the only subfactor that significantly correlated with morningness-eveningness, this variable was used in the mediation analysis. With morningness-eveningness as the predictor, depression as the mediator, and AQ-28 difficulties in attention switching as the

criterion, a significant indirect/mediation effect was found (Figure 1). The direct effect of morningness-eveningness on difficulties in attention switching was not significant. The indirect effect remained significant after controlling for the demographic items: age, gender (male/female), and (utilising only the yes or no responses), disorder status for depression/neurodevelopmental disorder/insomnia, and native English-speaker.

With morningness-eveningness as the predictor, insomnia as the mediator, and AQ-28 difficulties in attention switching as the criterion, the indirect effect was not significant ($B = -0.01$, 95% CI = -0.04 , 0.01).

Given that there is an established relationship between insomnia and depression, as also found in the current study (Table 2), a further, exploratory model tested whether insomnia and depression may be sequential mediators in the relationship between eveningness and the autistic trait of difficulties in attention switching. Firstly, in a single mediator model, insomnia had a significant indirect effect on attention switching through depression (indirect effect $B = .071$, 95% CI = $.024$, $.12$; direct effect $B = -.0116$, $p = 0.74$). When both insomnia and depression were included as sequential mediators between morningness-eveningness and attention switching (Figure 2), the indirect effect was significant ($B = -0.02$, 95% CI = -0.04 , -0.01). The direct effect of morningness-eveningness on difficulties in attention switching was not significant. The indirect

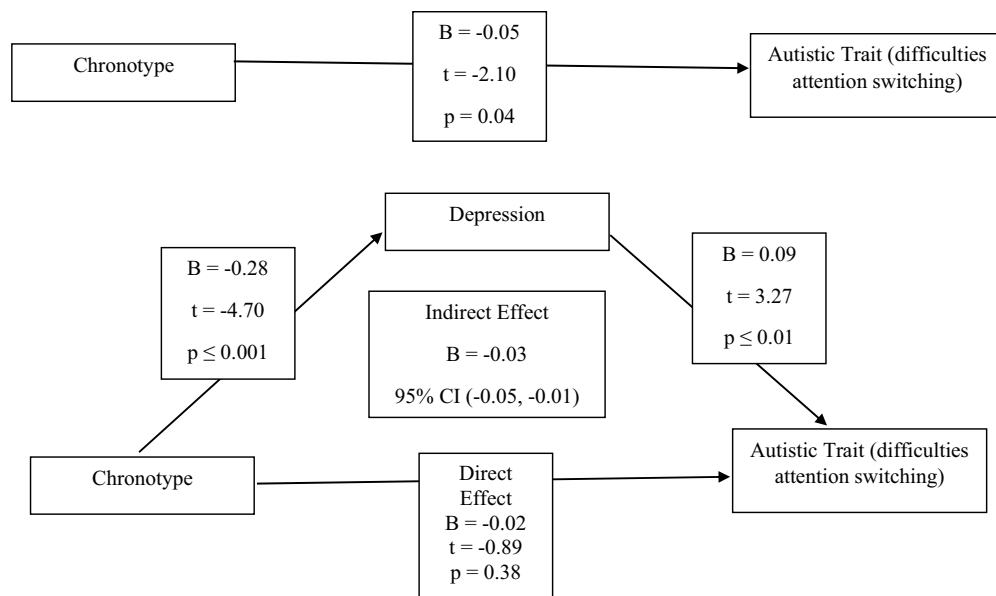


Figure 1. Mediation effects of depression.

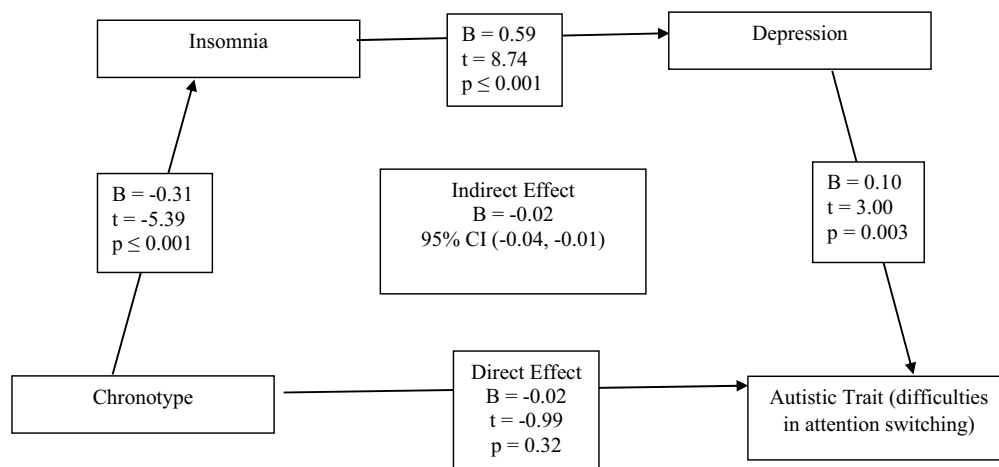


Figure 2. Mediation effects of insomnia and depression.

effect remained significant after controlling for the demographic items.

Discussion

The current aims were firstly, to expand upon previous research by using a dimensional approach and recruiting adults of the general population (an under-researched group in this subject area) to discover whether there is an association between morningness-eveningness and autistic traits, and Morning Affect and autistic traits, and also to explore relative associations with specific autistic traits (preferences for routine, difficulties with imagination, difficulties with social skills, fixations with numbers and patterns, and difficulties with attention switching). Secondly, to investigate

whether depression and insomnia are mediators in the relationship between morningness-eveningness and autistic traits.

The questionnaire scales and subscales showed acceptable/good internal consistency, and previously established associations were replicated: increases in total autistic trait scores were associated with increases in symptoms of depression, and increasing insomnia symptoms, consistent with the findings of Morgan et al. (2020) and Eaves and Ho (2008). Also, there were negative correlations between depression and Morning Affect, and depression and morningness-eveningness, i.e., as depression symptoms increased, eveningness increased, and Morning Affect decreased, consistent with the findings of Hidalgo et al. (2009), Simor et al. (2015), and Jankowski (2016). Negative

correlations were also found between insomnia and morningness-eveningness, and insomnia and Morning Affect (more insomnia associated with more eveningness, and less Morning Affect), as found by Simor et al. (2015) and Demirhan et al. (2019).

The results also showed that, contrary to predictions, the correlations between overall autistic traits and both morningness-eveningness and Morning Affect, were weak and not statistically significant, perhaps because the participants were recruited from the general population, whereas much of the previous research on autism has involved participants from the clinical population (e.g., Migliarese et al. 2020; Türkoğlu et al. 2020). Previous research with clinical participants found small effect sizes, and these may be weaker in the general population. In addition, while Ahn et al. (2021) found a correlation between morningness-eveningness and alexithymia, associations may differ for autistic traits, despite there being a strong association between alexithymia and autism (Kinnaird et al. 2019).

Further analysis of associations with the five subfactors of autistic traits identified in the AQ-28 showed significant positive correlations between depression and all the autistic subfactors apart from fixations on numbers and patterns. The positive correlation between depression and difficulties in attention switching is consistent with some previously reported findings: Ishizuka et al. (2022) found that high scores in difficulties in attention switching predicted the persistence of depression scores after three months, and scores in difficulties with attention switching in autistic adults were higher in those who have attempted suicide compared to those who have not (Paquette-Smith et al. 2014). Insomnia scores positively correlated with the traits of poor social skills, preference for routine, and difficulties in attention switching. Only the autistic trait of difficulties in attention switching correlated negatively with morningness-eveningness and Morning Affect (as attention switching difficulties increased, eveningness increased and Morning Affect decreased). The other autistic traits showed only weak correlations (absolute r s all $< .1$) with morningness-eveningness or Morning Affect, except for a small, but non-significant correlation ($r = -.14$) between Morning Affect and the AQ-28 routine subfactor.

These negative correlations found between difficulties in attention switching and morningness-eveningness and Morning Affect are interesting new findings. Furthermore, as hypothesised, the indirect effect from morningness-eveningness to attention switching through depression was found to be significant. These results are consistent with, and extend, those

of Ahn et al. (2021) who found that depression mediates the relationship between eveningness and alexithymia. These findings may suggest that treating depressive symptoms in evening-types may potentially diminish the impact of difficulties in attention switching.

However, the hypothesised indirect effect from morningness-eveningness to attention switching through insomnia was found to be not significant. This finding was surprising given that Türkoğlu et al. (2020) and Migliarese et al. (2020) found poor sleep to be mediators in the morningness-eveningness and autism relationship. The sampling of clinical populations with diagnoses of autism in these studies may explain why these results differ; also, further research on these relationships could include a wider range of sleep factors in addition to insomnia.

A further, exploratory, mediation analysis was undertaken with insomnia and depression as sequential mediators in the relationship between morningness-eveningness and difficulties in attention switching, and a significant indirect/mediation effect was found for this model. These results are consistent with evidence that insomnia may be a risk factor for the development of depression (Fang et al. 2019; Johnson et al. 2006), and with evidence that insomnia mediates between eveningness and negative emotionality (Simor et al. 2015).

Limitations and further research

The current research utilised self-report measures, which may impact the validity and reliability of the data; in addition, 17.18% of the sample reported not being native speakers of English, which potentially produced some misunderstanding/misinterpreting of scale items. However, the scales used have all been previously validated, showed good internal consistency in the current research, and replicated correlations found in previous research, indicating that language issues did not compromise validity. Nevertheless, objective measures of sleep or morningness-eveningness (e.g., actigraphy or DLMO), could strengthen future research. In addition, the current study involved a cross-sectional design, so conclusions about causality cannot be made, and the proposed mediation models will require further testing in longitudinal research. Furthermore, the sample was limited in size and diversity, so future research could include larger, more varied samples to provide more data on associations between morningness-eveningness and autistic traits in the general population, allowing to test for correlations and mediation effects with more statistical power. Future longitudinal research could utilise both adult and child

participants in clinical and general populations, to more fully understand the inter-relationships between specific autistic traits, mental health issues, sleep quality, and morningness-eveningness. Potential biological factors in these relationships may also be investigated; for instance, higher levels of testosterone have been associated with higher scores on the AQ attention switching subfactor in males (Takagishi et al. 2010), and with more eveningness in males (Jankowski et al. 2019).

Further research may also more fully investigate the potential role of Morning Affect in the relationships between eveningness, insomnia, depression, and difficulties in attention switching. In addition, the small correlation between Morning Affect and the AQ-28 routine subfactor, which did not reach statistical significance in the current study, may be further investigated in research with larger samples. The Morningness-Eveningness-Stability-Scale improved (Randler et al. 2016), which includes subscales for Morning Affect, Eveningness, and Distinctness (amplitude of diurnal variation in functioning), which has been validated in several countries/languages (e.g., Rahafar et al. 2017), could be a useful research tool for such further research. Other variables that may be involved include personality traits. It has been found that difficulty in attention switching is highly correlated with low extraversion, low agreeableness, and high neuroticism scores (Austin 2005). All three of these correlates have also been associated with eveningness, with evening-types more likely to be higher in neuroticism and lower in extraversion and agreeableness (Randler et al. 2017). Also, a recent study by Oomen et al. (2021) found that during Covid-19 lockdown depression and anxiety scores increased in autistic adults, with one of the stated reasons for this being the difficulty in creating a new routine. This suggests an association between the importance of routines and mental health for autistic individuals; the importance of maintaining a regular sleep-wake pattern may also be investigated.

By identifying individuals with higher levels of certain autistic traits, support for mental health issues could be made available and easier to access for them; preventive treatment measures could also be taken to lessen the likelihood of those individuals developing mental health issues.

Conclusions

The current study contributed to understanding the relationships between morningness-eveningness and autistic traits by studying a general, non-clinical sample and investigating associations with specific

autistic traits. Although morningness-eveningness and Morning Affect did not show significant correlations with total autistic trait scores, or with most of the specific autistic traits, both more eveningness, and less Morning Affect, were significantly correlated with the autistic trait of difficulties in attention switching. This research indicates that those with an eveningness chronotype, and less energy/alertness upon awakening exhibit more difficulties in attention switching. Furthermore, depression, and insomnia and depression in sequence, were found to mediate the relationship between eveningness and difficulties in attention switching, suggesting the potential value of future research on the mechanisms of association between these variables, which may further understanding and suggest potential interventions.

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ORCID

Richard Carciofo  <http://orcid.org/0000-0003-2069-7047>

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