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No Impaired Integration in Psychopathy: Evidence From an Illusory Conjunction Paradigm

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Progress in psychopathy research has been hampered by ongoing contention about its fundamental cause. The Impaired Integration theory of psychopathy provides an attention-based account of information integration abnormalities. We set out to evaluate the suggested mechanism via an innovative application of the well-established illusory conjunction paradigm. Two hundred participants were recruited by utilizing a psychopathic-trait-maximization technique, sampling individuals from an ex-prisoner and a population sample. We found no support for information integration deficits in psychopathic individuals ($BF_{10} = 0.156$), and the absence of a relationship between psychopathic traits and illusory conjunctions remained when accounting for confounding variables. These findings question the mechanism proposed by the Impaired Integration theory and pave the way for future research to advance our understanding of psychopathic trait etiology by assessing specific and falsifiable mechanisms thought to bring about the observed cognitive and behavioral deficits.

Keywords: psychopathy, integration, response modulation, attention, illusory conjunction

Supplemental materials: https://doi.org/10.1037/per0000619.supp

Psychopathic individuals exhibit callous and unemotional tendencies with an inclination toward antisocial behavior, reflected in prison statistics, which suggest that 16% of all convicts meet diagnostic criteria for psychopathy. At a population prevalence of less than 1%, psychopaths make up a disproportionate share of the estimated $2.34 trillion in annual costs associated with crime in the United States (Kiehl & Hoffman, 2011). This raises the question of what could cause one to behave in such detrimental ways. Yet, a central mechanism remains elusive and competing accounts have been proposed to explain the range of observed psychopathic deficits. One line of research focuses on attention-dependent processing deficits that may reflect a transdiagnostic impairment in psychopathology more generally (Byrom & Murphy, 2018). For instance, the Impaired Integration theory (Hamilton et al., 2015) suggests that psychopathic individuals exhibit impairments in the processing of multidimensional perceptual information. Nonetheless, direct behavioral evidence is meager (e.g., Lindner et al., 2018) and the present research set out to assess whether psychopathic individuals exhibit an information integration deficit.

Psychopathy entails a collection of cooccurring personality traits including callous—unemotionality, lack of empathy, disinhibition, and antisocial tendencies. This constellation has retained forensic

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The data are available at https://osf.io/fydg3/

The experiment materials are available at https://osf.io/bm2yd/

The preregistered design is available at https://osf.io/6mhe9

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relevance for its utility in predicting severe and pervasive patterns of antisocial behavior, criminality, and resistance to rehabilitative intervention (D'Silva et al., 2004; Hare & Neumann, 2008; Maibom, 2014). In forensic settings, psychopathy is usually assessed with the Psychopathy Checklist-Revised (PCL-R; Hare, 2003), completed by a trained clinician based on a semi-structured interview along with official records. Although early approaches to self-report psychopathy measures were subject to criticism for validity concerns (Hare, 1985), the new generation of self-report measures has gained momentum in the assessment of psychopathic traits (Levenson et al., 1995; Lilienfeld & Andrews, 1996), demonstrating good convergent and discriminant validity in clinical (Neal & Sellbom, 2012) and community samples (Mahmut et al., 2011). Moreover, a mounting body of evidence suggests that psychopathy is a dimensional trait (Benning et al., 2005; Edens et al., 2006). Assessing the psychopathic spectrum serves to strengthen the validity of etiological models beyond forensic contexts, as well as the more general impact of psychopathic traits on normative emotional and cognitive processing.

The search for a potential core deficit for psychopathy dates back to Cleckley (1941) who popularized the notion of "some subtle but profound defect" (p. 403). Predominant accounts of this defect can be grouped into theories postulating affective, and attentional mechanisms. Lykken's (1957, 1995) low-fear hypothesis is a prominent affective account that suggests impaired fear processing. Psychopathic individuals are claimed to experience fear more weakly. An inclination to engage in deviant behaviors then, may result from a lack of fear of the negative outcomes associated with their behavior. Alternative attention-based models of psychopathy propose that affective deficits may rather be a consequence than the cause of psychopathy (Baskin-Sommers & Brazil, 2022; Baskin-Sommers et al., 2011). The Response Modulation Hypothesis (Baskin-Sommers et al., 2011; Gorenstein & Newman, 1980; Newman et al., 2010) suggests that psychopathic individuals struggle to modulate a dominant response set in favor of processing contextual cues, such as affective responses. However, prevailing psychopathy models have been criticized for creating an artificial separation between affect and cognition (Hamilton et al., 2015). This stance is supported by findings that demonstrate the interconnectedness of affect and cognition (Arnett et al., 1997; Baskin-Sommers et al., 2011; Newman et al., 2010; Wolf et al., 2012). For instance, Newman et al. (2010) showed that the effect of emotion was determined by the attentional focus in a fear-potentiated startle task. Psychopathic individuals' attention was focused on either, affect-related or unrelated information. Their results indicated that psychopathy was characterized by a reduced startle potentiation for threat when attention was directed at affect-irrelevant cues. However, this deficit characteristic of psychopathic individuals disappeared when individuals were encouraged to attend to affective information. These findings are hard to reconcile with emotion-based psychopathy accounts and call for alternative explanations for the observed modulating effect of attention (Larson et al., 2013; Scheeff et al., 2021; Tillem et al., 2021).

Attention-based theories of psychopathy postulate broad processing deficiencies which provide a compelling rationale for the abnormal performance of psychopathic individuals on non-affective tasks. A recent iteration of the attention-based etiological accounts is the Impaired Integration theory (Hamilton et al., 2015), which aims to bridge findings of affect and cognition. The model suggests impairments in connectivity between discrete networks (i.e., default mode and salience network) resulting in an attentional bottleneck (Baskin-Sommers & Brazil, 2022; Baskin-Sommers et al., 2011, 2013) which confines the amount of information that can be simultaneously attended (Sadeh & Verona, 2008, 2012; Vitale et al., 2007). This renders individuals with elevated psychopathic traits less able to simultaneously process multidimensional information, leading them to neglect peripheral or contextual information that falls outside of the attentional spotlight (Baskin-Sommers et al., 2011; Cohen & Ivry, 1989; Hamilton et al., 2015; Hamilton & Newman, 2018; Hoppenbrouwers et al., 2015, 2016; Treisman & Gelade, 1980). Yet, the existing literature on the impaired integration mechanism is based on indirect evidence from neurobiological (Johanson et al., 2020; Pujol et al., 2019) and behavioral studies (Anderson et al., 2018; see also Aisbitt & Murphy, 2016) which suggest that mechanisms of attention may hinder the flexible distribution of cognitive resources. Hamilton and Newman (2018) investigated the impact of processing load by employing a visual search task encompassing four stimuli and a predefined target. These stimulus arrangements were presented either sequentially or simultaneously, with the latter increasing the concurrent processing demand. The results indicated that psychopathy was associated with inferior accuracy and longer response latencies on trials requiring the simultaneous processing of visual information. The relative nature of the processing impairments of psychopathic individuals has enabled the Impaired Integration theory to account for findings of the presence and absence of prototypical affective response deficits (Baskin-Sommers et al., 2013; López et al., 2013; Munro et al., 2007).

Consequences of this attention-deficit are pronounced and may account for characteristic interpersonal deficits of psychopathy. For instance, psychopaths' insensitivity to the affective responses of others in their behavior may result from inattention to peripheral cues (Hoppenbrouwers et al., 2016; Newman et al., 2010; Sadeh & Verona, 2008; Scheeff et al., 2021). This is thought to contribute to the predisposition psychopathy conveys for antisocial behavior. Although the Impaired Integration model makes striking predictions regarding the behavior of psychopathic individuals, the suggested mechanism is yet to be evaluated and existing findings have struggled to differentiate between the subtle differences of existing attention-based accounts. With the present research, we set out to test whether psychopathy is associated with difficulties binding multidimensional cues, the central prediction of the Impaired Integration theory.

The binding of multidimensional stimuli is understood through the lens of the Feature Integration Theory, which has been cited over 15,000 times since its original formulation in 1980 (Treisman & Gelade, 1980). The theory postulates that perception can be broken down into two discrete processes, one automatic and one computationally demanding. The former stage encompasses automatic and parallel registration of visual features (e.g., color/shape) in the visual field. It is only under focused attention, that these components are sequentially integrated into a coherent percept. The Feature Integration Theory has been used to explain a well-described perceptual phenomenon, illusory conjunctions (Ashby et al., 1996; Henderson & McClelland, 2020), referring to incorrect feature groupings of two presented stimuli (Treisman & Schmidt, 1982). For instance, the perception of a red circle, following the brief presentation of a green circle alongside a red square. Illusory conjunctions occur under strict experimental conditions (Henderson & McClelland, 2020). Since attention is needed to correctly combine stimulus features, it follows that illusory conjunctions are most prevalentwhen attention is limited. Taken together, illusory conjunctions

are feature-binding errors that follow from limited processing resources during the rapid presentation of visual stimuli.

Meanwhile, "the Impaired Integration theory proposes that psychopathy is characterized by difficulty rapidly binding components of multidimensional sensory stimuli" (Hamilton et al., 2015, pp. 777–778). It becomes clear that illusory conjunctions fundamentally align with the information processing deficit postulated by the Impaired Integration theory. As such, the frequency of illusory conjunctions provides insight into the attentional resources available for stimulus binding, and should reflect psychopathy-related difficulties in multidimensional stimulus binding. Preliminary evidence indicates that individuals exhibit substantial differences in their ability to integrate perceptual information (Ashby et al., 1996; Qin et al., 2016; Watanabe et al., 2005).

Taken together, while indirect evidence consistent with some predictions of the Impaired Integration theory has been presented, the core tenant—impaired integration—is yet to be examined. We measured the successful binding under cognitive load with a well-established illusory conjunction paradigm. Moreover, we utilized a psychopathic trait maximization technique, sampling one part of the sample from an ex-prisoner, and the other part from a community population. This sampling technique aims to circumvent restriction in the range of psychopathy scores and allows for more robust conclusions across the levels of psychopathic traits. The hypothesized information integration deficit of psychopathy "is suspected to tax perceptual processing resources, thereby mimicking conditions of high perceptual load. As a result, attention would not extend to the processing of distractor stimuli" (Hamilton et al., 2015, p. 778). In line with this formulation, we predicted that individuals with elevated psychopathic traits exhibit heightened rates of illusory conjunction errors. The continued forensic relevance of psychopathy in predicting severe antisocial behavior, criminality, and resistance to rehabilitation, demands enhancing our understanding of the mechanism underlying observed deficits.

Method

The study was conducted in accordance with the standard set by the Declaration of Helsinki and approved by the local ethical committee of the University of Amsterdam (2022-CP-14464). We report how we determined our sample size, all data exclusions, all manipulations, and all measures in the study. Our method was informed by an informal and formal pilot with nine and 16 participants, respectively. Both pilots are presented in the online supplemental materials. The hypotheses, analyses, and exclusion criteria were preregistered (https://osf.io/6mhe9).

Participants

Two hundred participants were recruited via the crowdsourcing platform Prolific (https://www.prolific.com). An a priori power-analysis in G*power (Faul et al., 2007) indicated a sample of 199 participants to be suitable for detecting even a small effect ($f^2 = .04$) at .80 statistical power for a linear multiple regression with five predictors (output available on OSF). Eligibility for participation was limited to male, English-speaking individuals with healthy color perception, and access to a desktop or laptop computer. We employed a psychopathic trait maximization technique by sampling a subgroup of our participants based on a "yes" response to the default imprisonment pre-screener in Prolific ("Have you ever been in prison for committing a crime?"). Given the heightened prevalence of psychopathic traits in prisoner populations, our sampling procedure circumvents range restriction of our psychopathy measurement. Within a week of sampling on Prolific, we included 45 ex-prisoners, after which the remaining 155 participants were sampled based on a "No" response to the screening question. The decision to limit participation to male individuals was based on the following: males makeup over 90% of prison inmates (Federal Bureau of Prisons, 2022) and will likely be overrepresented in our ex-prisoner subsample (Kiehl & Hoffman, 2011). Second, the Impaired Integration theory bases its predictions predominantly on research conducted with males (Smith & Lilienfeld, 2015), and findings from other populations have been mixed (Newman & Schmitt, 1998; Vitale et al., 2007; Vitale & Newman, 2001). And last, some scholars have suggested that psychopathic traits are expressed differently in males and females (de Vogel & Lancel, 2016; Efferson & Glenn, 2018; Miller & Lynam, 2015; Wynn et al., 2012). Therefore, we took the conservative approach of investigating the hypothesized core deficit in the most researched group.

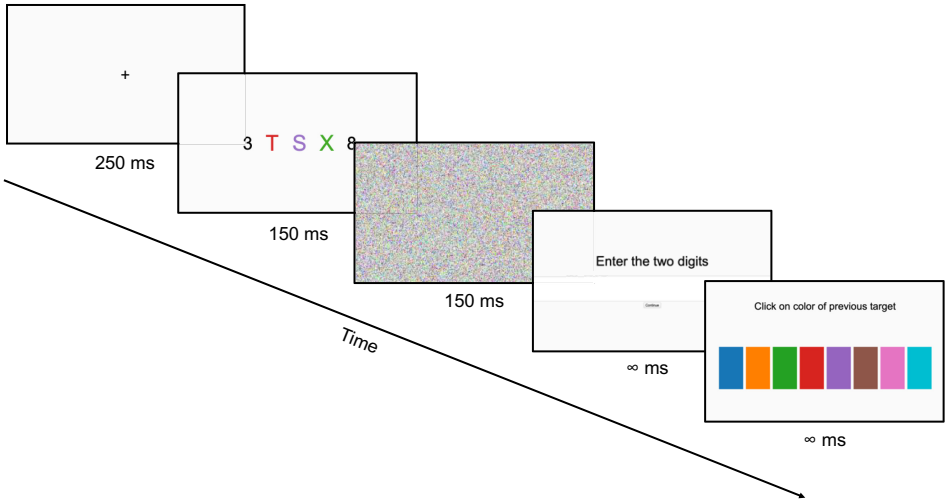
To maintain the fidelity of online responses, attention checks were added throughout the experiment. In the illusory conjunction task, this took the form of a regular trial with prolonged exposure duration (3,000 ms) and was presented after the 50th and 75th trial. The increased presentation duration ensured that all attentive participants could successfully indicate both, digits and target color, of the attention check trial. An additional attention check was presented upon completing the illusory conjunction task. Participants who failed more than one of the illusory conjunction trial attention checks were excluded. Following the completion of the task, participants were asked to indicate the two target letters of the preceding task. This was added to ensure that participants were searching for the correct target letters throughout the illusory conjunction task. Failing this attention check led to exclusion, regardless of performance on the other attention checks. In the three major questionnaires, the attention checks took the form of two statements directing participants to select a particular response (e.g., "This is a compliance check. Select 'Neutral' for this statement"). Based on these criteria, 49 participants were removed, and additional participants were recruited to reach the desired sample size. The final sample contained 200 males, ranging from 18 to 67 years of age ($M = 31.65$, $SD = 11.27$) and originating from 27 different countries. South Africa, Poland, and Mexico made up the largest proportions with 15%, 15%, and 10%, respectively.

Procedure

All participants were recruited via the crowdsourcing platform Prolific (https://www.prolific.com) and received instructions to disable all color-altering filters and position themselves approximately 60 cm from the screen. Upon providing informed consent, participants proceeded to the illusory conjunction task, involving the rapid presentation of colored digit-letter strings (150 ms). Following the completion of all 100 trials, participants proceed with the forwards and backwards digit span task (Braaten, 2018; online supplemental materials). Thereafter, participants completed the questionnaire battery, encompassing the Self-Report Psychopathy Scale fourth edition short form (SRP-IV-SF; Paulhus et al., 2017), the behavioral inhibition and behavioral activation system scale (BIS/BAS, Carver & White, 1994), the Adult Attention-Deficit/Hyperactivity Disorder (ADHD) Self-Report Scale (ASRS; DuPaul et al., 1998), and the Generalized Anxiety Disorder Scale (GAD-7; Spitzer et al., 2006). Finally, participants were reimbursed with 3.5 GBP for their 30-min time investment.

Figure 1

Example Illusory Conjunction Task Trial



Note. The size of displayed stimuli is enhanced for discernibility purposes. The example below illustrates how conjunction and feature errors were presented. A conjunction error occurs when the color of a distractor is incorrectly combined with the target letter (i.e., the participant indicates red (T) or purple (S) as the target's color instead of green (X)). A feature error occurs when a non-presented color is reported as the target's color (e.g., the participant indicates brown as the target's color). See the online article for the color version of this figure.

Materials

All experimental stimuli and questionnaires were presented with Inquisit (Inquisit 6, 2016). Information integration was quantified with an illusory conjunction task developed by Treisman and Schmidt (1982). An exemplar trial is depicted in Figure 1. Each trial commenced with the brief presentation of a central fixation cross on a light-grey background (#fafaf9), followed by the presentation of a digit-letter string, consisting of three distinctly colored letters flanked by two black digits (ranging from 1 to 9). The digits subtended a visual angle of 0.6° horizontally and 1° vertically at 60 cm. Letter colors were randomly selected without replacement. The eight possible colors were selected for maximum discriminability, while minimizing saturation and luminance differences (#1f77b4, #ff7f0e, #2ca02c, #d62728, #9467bd, #8c564b, #e377c2, #17becf). The letter strings consisted of one target (X, N) and two distractor letters (H, S, T, O). The target location was counterbalanced within each of the four 25 trial blocks, and letters were sampled without replacement. The letters were presented at a visual angle of 0.8° horizontally and 1.2° vertically. Altogether, the digit-letter string is subtended at 8° visual angle.

Psychopathy was assessed with the SRP-IV-SF (Paulhus et al., 2017) which comprises 29 self-report items (e.g., "I rarely follow the rules") that are answered on a 5-point Likert scale (ranging from "disagree strongly" to "agree strongly"). The SRP's four facets mirror the suggested four-factor structure of the PCL-R (Hare, 2003) and the instrument has demonstrated strong convergent validity with the PCL-R, and its psychometric properties have been well established in community (Gordts et al., 2017; Mahmut et al., 2011; Watt & Brooks, 2012; Williams et al., 2007) and incarcerated samples (Sandvik et al., 2012).

Additional measures to control for confounds and assess the validity of the tasks include the backwards and visual digit span task (Braaten, 2018), the BIS/BAS scale (Carver & White, 1994), the ASRS (DuPaul et al., 1998), and the GAD-7 (Spitzer et al., 2006), all of which are described in detail in online supplemental materials.

Data Analysis

Our confirmatory analysis assessed the primary hypothesis that psychopathic traits explain substantial variation in illusory conjunction rates. First, a chance correction was applied to the observed conjunction error rate. This correction is displayed in Equation 1, and mathematically equivalent to that of Henderson and McClelland (2020). This estimation is conservative and likely underestimates the true illusory conjunction effect (Henderson & McClelland, 2020).

$$T_{ConjunctionErrors} = E_{ConjunctionErrors} - \frac{targets}{features} * \frac{E_{FeatureErrors} * features}{features - distractors - targets} \quad (1)$$

where T = true and E = estimated. For a detailed derivation of the above formula see Henderson and McClelland (2020). The variables "targets," "features," and "distractors" remain constant across the experiment and take the values one, eight, and two, respectively.

The "true" conjunction error rates were assessed with a Bayesian multiple linear regression. The predictor psychopathy total score was added to assess the primary hypothesis that psychopathic traits and illusory conjunctions are associated. Subsequently, the predictors age, working memory capacity, attention deficit hyperactivity disorder, and anxiety were added to the null model to investigate whether these variables are related to the suspected relationship between psychopathy and illusory conjunctions. More specifically, in the case of the regression models including one or more control variables, the null hypothesis states that psychopathy does not predict illusory conjunction rates beyond the included

control variable(s), whereas the alternative hypothesis states that psychopathy does add substantial explanatory power. Throughout all analyses, we utilized a Jeffreys Zellner–Siow prior of .354 and a beta-binomial (1, 1) distribution as the model prior. All analyses were performed in JASP (Version 0.16.2; JASP Team, 2022) and the BayesFactor (Morey et al., 2021) and Bayesian Adaptive Sampling (Clyde et al., 2022) packages in the R computing environment. We inspected the model-averaged Bayes Factors, comparing the model including total psychopathy scores to the null model. The model-averaged Bayes Factors are reported to quantify how much more probable the observed data are under the model that includes the predictor psychopathy total scores. Additional control variables and interactions were assessed in the exploratory analyses.

Results

The descriptive statistics and correlations are presented in Table 1 and Figure 2 respectively. A detailed description and assessment of the variables and assumptions relevant to our linear Bayesian regression analyses is publicly available (https://osf.io/6vkx8/). The dependent variable *illusory conjunction rate* and the covariate *psychopathy total score* are of primary interest to the analyses. Our data indicate substantial between-individual variation in both, illusory conjunction rates ($M_{estimated} = .26$; $SD_{estimated} = .12$) and psychopathy scores ($M = 60.13$; $SD = 14.01$). Expressed as a proportion of all errors, illusory conjunctions made up 55% which exceeded the rate of feature errors and placed it well above the chance/guess rate of 12%. We performed a chance correction on the raw error rates to account for inflation due to guessing (see Equation 1). Thereafter, the illusory conjunction rate ($M_{true} = .22$; $SD_{true} = .11$) remained substantial, with participants averaging one illusory conjunction every five trials. This suggests that we were able to successfully induce illusory conjunctions during the rapid presentation of multidimensional stimuli, an important precondition for our later analyses. All subsequent analyses utilized the chance-corrected scores exclusively.

To investigate the hypothesis that psychopathic traits explain substantial variation in illusory conjunction rate, and whether said explanatory value holds when accounting for potential confounds, we utilize a Bayesian linear regression approach. Conventional frequentist regression analyses involve two stages of statistical inquiry. First, a single best model is defined. Thereafter, the regression coefficients of the best fitting model are used for prediction and inference concerning the importance of included predictors. This approach ignores our uncertainty during the first step, where several competing models may have provided adequate fit for a set of observations. The Bayesian linear regression approach utilized in this paper moves beyond this limitation by averaging across models. In other words, model weights are determined by their relative performance and produce a more accurate and robust prediction (e.g., van den Bergh et al., 2021).

We performed several Bayesian linear regressions (https://osf.io/6mhe9) to investigate the hypothesis that psychopathic traits explain substantial variation in the illusory conjunction rate, and whether said explanatory value holds when accounting for potential confounds. We utilized a default JZS prior of 0.354, which assigns a fat-tail normal distribution to the regression coefficients. For interpretation purposes, we utilized Jeffreys' scale for interpretation of any Bayes Factors (Jeffreys, 1998). For model priors, we used a uniform beta-binomial distribution with both, alpha and beta set to one. The results are summarized in Table 2, and we present the Bayesian linear regressions in order of increasing complexity below.

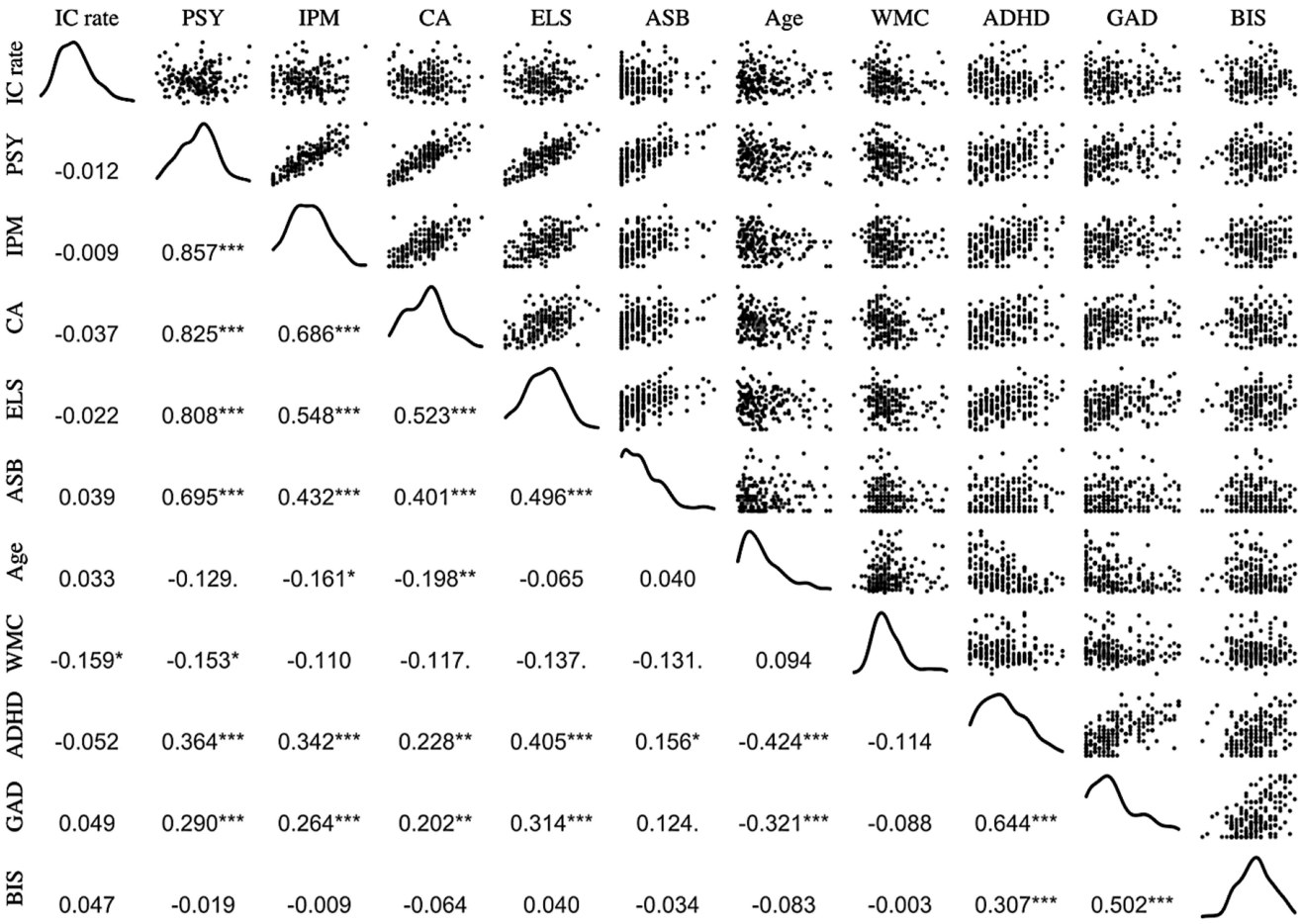
The Bayesian linear regression examining the hypothesis that psychopathic traits explain substantial variation in illusory conjunction rates found strong evidence in favor of the null hypothesis ($r = .00$; $SD = .00$; 95% CI [.00, .00]), with a corresponding Bayes Factor of 0.156 ($R^2 = .00$). The corresponding sensitivity analyses compared the posterior distributions based on the range of possible priors. This analysis revealed that regardless of the utilized prior, the data provide moderate to strong support for the null hypothesis. Subsequent Bayesian linear regressions revealed further evidence against the null hypothesis that psychopathic traits explain substantial variation in illusory conjunction rates when accounting for the control variables age ($BF_{10} = 0.234$; $R^2 = .001$), working memory capacity ($BF_{10} = 0.294$; $R^2 = .028$), attention-deficit hyperactivity disorder ($BF_{10} = 0.313$; $R^2 = .031$), or general anxiety ($BF_{10} = 0.348$; $R^2 = .042$).

Table 1
Descriptive Statistics for the Illusory Conjunction Task, SRP-IV-SF, and Control Variables

Variable	*M*	*SD*	Range	Cronbach's alpha	*p*	Skewness	Kurtosis
IC	0.22	0.11	0–.58	/	100	0.66	0.37
				Psychopathy			
Total	60.13	14.01	29–98	.869	29	0.11	−0.18
Interpersonal	16.48	5.02	7–32	.759	7	0.17	−0.39
Callous	15.28	4.29	7–28	.656	7	0.18	−0.37
Lifestyle	16.58	4.54	7–30	.720	7	0.00	−0.28
Antisocial	11.8	3.61	8–25	.548	8	1.19	1.41
				Other			
Age	31.65	11.27	18–67	/	/	1.19	0.83
WMC	8.02	2.17	3.5–15.5	.926	/	1.27	1.83
ASRS	6.11	4.02	0–17	.814	18	0.46	−0.47
GAD-7	6.78	5.59	0–21	.809	7	0.82	−0.18
BIS Subscale	19.96	3.58	9–28	.507	6	−0.12	−0.13

Note. Reported illusory conjunction (IC) rates are chance corrected. The number of items per scale is denoted by *p*. Split-half reliability was computed separately for the illusory conjunction task. Using 5,000 random splits, the Spearman-brown corrected reliability estimate was .87 (95% CI [.84, .89]).

Figure 2
Correlation Matrix



Note. The Pearson's correlations between the variables are depicted in the lower triangle, with * denoting findings at $p < .05$ level (2-tailed), ** denoting findings at $p < .01$ level (2-tailed), and *** denoting findings at $p < .001$ level (2-tailed). The density distributions are displayed on the diagonal. The scatterplots between two variables are displayed in the upper triangle. IC rate = illusory conjunction rate; PSY = psychopathy total score; IPM = interpersonal facet score; CA = callous affect facet score; ELS = erratic lifestyle facet score; ASB = antisocial behavior facet score; WMC = working memory capacity; ADHD = attention-deficit hyperactivity disorder; GAD = generalized anxiety disorder; BIS = behavioral inhibition system.

To explore these findings, we performed several supplementary analyses. For an exhaustive presentation of these analyses, we refer to the OSF (https://osf.io/snfrp/).

First, we performed a quartile split on the psychopathy total scores and compared the first and fourth quartiles with a Bayesian *t*-test. The results support the null hypothesis $BF_{10} = 0.214$), suggesting

Table 2
Bayesian Linear Regressions

Model	P(M)	P(M|data)	BF_M	M	R_2
Null model	.500	.865	6.425	.219	.000
Psychopathy	.500	.135	0.156	.000	.000
Null model (incl. age)	.500	.810	4.274	.219	.001
Psychopathy	.500	.190	0.234	.000	.001
Null model (incl. age, WMC)	.500	.773	3.397	.219	.028
Psychopathy	.500	.227	0.294	.000	.028
Null model (incl. age, WMC, ADHD)	.500	.865	3.194	.219	.031
Psychopathy	.500	.135	0.313	.000	.031
Null model (incl. age, WMC, ADHD, GAD)	.500	.742	2.873	.219	.042
Psychopathy	.500	.258	0.348	.000	.042

Note. The above models are ordered in increasing complexity, with another control variable added to the null model at each iteration.

that there is no difference in illusory conjunction rates between the two quartiles ($M_1 = .222$, $M_4 = .212$, $SD_1 = .110$, $SD_4 = .118$). A follow-up prior sensitivity analysis revealed this finding to be stable across a range of prior specifications.

Second, we performed separate Bayesian linear regressions for the facets of the SRP-IV-SF. Our data for the interpersonal ($BF_{10} = 0.155$), affective ($BF_{10} = 0.155$), lifestyle ($BF_{10} = 0.160$), and antisocial facets ($BF_{10} = 0.177$) were more likely under the null hypothesis that the respective facet scores do not explain substantial variance in the observed illusory conjunction rates.

Third, we performed a paired sampled Bayesian *t*-test to assess whether participants exhibited differential performance on the two target letters. Our findings indicated that performance on target letter N ($M = .132$, $SD = .061$) and X ($M = .135$, $SD = .066$) trials did not differ ($BF_{10} = 0.116$).

Fourth, we entered individual trial-level data for illusory conjunctions into a latent factor analysis (Brazil et al., 2017; Driessen et al., 2021). The unbiased factor loadings were correlated with the psychopathy total scores. This approach provides a more data-driven method of cleaning the data, instead of using subjective approaches that rely on a standard deviation cut-off to remove outliers. The Bayesian linear regression for psychopathy scores and the latent variable yield strong evidence in favor of the null hypothesis ($BF_{10} = 0.165$).

Discussion

The Impaired Integration theory is an attention-based account of psychopathy that has been proposed to account for both emotion and attention deficits in psychopathy. This framework makes predictions at the behavioral, cognitive, and neurobiological levels. The present research examined the central premise of the Impaired Integration theory, that "psychopathy is characterized by difficulty rapidly binding components of multidimensional sensory stimuli" (Hamilton et al., 2015, pp. 777–778).

Our findings did not lend support to the propositions of the Impaired Integration theory, that "psychopathy is characterized by difficulty rapidly binding components of multidimensional sensory stimuli" (Hamilton et al., 2015, pp. 777–778). On the contrary, our findings revealed that psychopathic traits are not indicative of impairments in information integration accuracy, as reflected in the rate of illusory conjunctions. Moreover, the observed pattern remained stable across the interpersonal, affective, lifestyle, and antisocial psychopathy facets, suggesting that our results cannot be explained by differential associations of the specific psychopathy facets. In contrast, the Impaired Integration theory suggests that "psychopathy is characterized by difficulty rapidly binding components of multidimensional sensory stimuli" (Hamilton et al., 2015, pp. 777, 778).

Overall, these results provided behavioral evidence that psychopathy may not involve an information integration deficit, in contrast to indirect evidence from neurobiological studies that tend to align with predictions of the Impaired Integration theory (Johanson et al., 2020).

Psychopathy has been associated with a range of neurobiological abnormalities (Johanson et al., 2020), and findings regarding the default mode and salience network have supported predictions of the Impaired Integration theory. Abnormalities in those two broad networks have been observed across a range of studies (Deming & Koenigs, 2020). While there are some indications that general resting-state data may be predictive of brain activity during task performance (Tavor et al., 2016), it remains questionable whether changes during task engagement may alter the dynamics of implicated brain networks. More recent network approaches have advanced our understanding of the neurobiological abnormalities in psychopathic individuals (Dotterer, 2018; Stam & Reijneveld, 2007). In one of the first applications of graph theoretical analyses in psychopathy, Philippi et al. (2015) found network structures of psychopathic individuals to be less coordinated with fewer connections between distant hubs. Auxiliary evidence for reduced connectivity between neural networks of psychopathic individuals comes from Lindner et al. (2018), who found psychopathic traits to be associated with abnormal topology in the salience and default mode network.

However, there are several reasons to be cautious when interpreting these findings. First, abnormalities in the salience and default mode networks emerge from the broad literature documenting wide-ranging neurobiological abnormalities of psychopathic individuals. Hence, abnormalities are not exclusive to the regions implicated in the suspected impaired integration deficit (Blair, 2013; Blair & Mitchell, 2009; Johanson et al., 2020) and may or may not reflect an impaired integration mechanism. Second, these network findings remain correlational and are limited in determining the direction of relations between network nodes. As such, conclusions about functionality are speculative and future research assessing the direction of observed connections is needed to test more specific predictions of the theory. Third, imaging studies relying on changes in neural activity have not reliably replicated structural abnormalities, and the heterogeneity across neurobiological findings makes interpretation in regard to specific theories premature (Koenigs et al., 2011). Finally, it is common to explore various analysis pipelines in search of the "best results" (Lindquist, 2020; Paret et al., 2022). In the absence of appropriate preregistration and reporting standards, this can cause systematic inflation of type 1 errors and incorrect inferences (Flournoy et al., 2020; Verschuere et al., 2021). Taken together, the scientific literature pointing to an impairment in information integration as the root cause of psychopathy is limited at best, and not supported by our present findings.

Beyond the Impaired Integration theory, our findings speak to attention-based psychopathy accounts in general. This follows from the fact that these accounts tend to make similar predictions. The attentional bottleneck account, for instance, suggests that psychopathic individuals have an exaggerated bottleneck which constraints the amount of information that can be simultaneously processed (Aisbitt & Murphy, 2016; Baskin-Sommers & Brazil, 2022; Baskin-Sommers et al., 2011). While an exaggerated bottleneck does not speak to the integration of information specifically, it does suggest that psychopathic individuals exhibit greater difficulties with complex processing tasks. In the case of our illusory conjunction task, psychopathic individuals devote their attention to the primary task, the correct identification of the digits. Given that this leaves fewer attentional resources for letter and color processing, the bottleneck account would predict heightened illusory conjunction error rates in psychopathic individuals. As such, our findings are not only incompatible with the Impaired Integration account, but also oppose the predictions of other attention-based theories of psychopathic trait etiology.

These findings relate to a fundamental critique of psychopathy theories. Both attentional and emotional theories assume psychopathy to be a monolithic entity (e.g., Lilienfeld, 2013). However, a growing body of research points to the diverse clinical presentation of psychopathy, reflected in modern conceptualizations which define psychopathy as a constellation of co-occurring personality traits (D'Silva et al., 2004; Hare & Neumann, 2008; Lilienfeld & Andrews, 1996; Lynam & Widiger, 2007; Miller et al., 2001; Widiger & Lynam, 1998). Therefore, parsimonious accounts may not adequately reflect the heterogeneity of psychopathy, and a single deficit is unlikely to explain the clinical presentation of psychopathy.

Nevertheless, we need to acknowledge that our conclusions are rooted in the assumption that illusory conjunctions reflect attention-dependent feature binding errors (Treisman & Gelade, 1980). This assumption has not remained uncontested, and Donk (1999) went as far as to suggest that the perceptual system makes no binding errors, with illusory conjunctions constituting confusions of target and nontarget, rather than the insufficient allocation of attention during the binding of perceptual stimuli. This viewpoint does not only challenge the central proposition of the Feature Integration Theory (Treisman & Gelade, 1980) but the interpretation of our present findings. If illusory conjunctions are not the consequence of perceptual system malfunctions, we would have been mistaken to utilize them as a proxy measure of information integration capacity. Other configural processing tasks may provide routes to understanding information processing deficits (e.g., Byrom & Murphy, 2016, 2018, 2019). However, Quinlan (2003) reviewed the evidence pertaining to the debate and concluded that the evidence in favor of true illusory conjunctions is overwhelming. Although the debate was never formally resolved, compelling evidence in favor of true illusory conjunctions has been presented since then (Botella et al., 2001; Emrich & Ferber, 2012; Henderson & McClelland, 2020; Prinzmetal, 2012; Prinzmetal et al., 2002; Vul et al., 2019). Therefore, we consider the theoretical possibility of illusory conjunctions not reflecting perceptual binding errors to be unlikely.

The present findings are subject to several limitations. First, data largely came from a crowdsourced community sample. While existing evidence has made a compelling argument to consider psychopathy to be dimensional (Dematteo et al., 2005; Guay et al., 2007) and exist as an accumulation of personality traits (Benning et al., 2005; Edens et al., 2006), a limited range in psychopathy scores may prevent conclusions about the high extreme. Nonetheless, psychopathy scores in our sample ranged from 29 to 98, and a comparison of illusory conjunction rates between the highest and lowest psychopathy scoring quartile revealed evidence in favor of no difference ($d = 0.035$, $BF_{10} = 0.214$; https://osf.io/snfrp/).

Furthermore, our results are limited by the characteristics of the novel methodology that aimed to quantify integration deficits. Given that our task included one level of difficulty, we were unable to demonstrate within-individual differences in illusory conjunction rates, contingent on the processing demands of the task. Therefore, we cannot escape the possibility that information integration in the present paradigm is a global capacity that varies between but lacks variation within individuals. The extant literature on feature integration has demonstrated little interest in individual differences per se (Carr et al., 1998; Watanabe et al., 2005) but there are promising indications that feature integration is dependent on task difficulty (Henderson & McClelland, 2020; Prinzmetal, 2012; Vul et al., 2019).

At last, whereas we do consider the possibility of confounding variables suppressing an effect of psychopathic traits on information integration unlikely, it is not impossible. This being the first examination of feature binding as a function of psychopathic traits, we incorporated a limited set of control variables that may confound the suspected relationship. These variables were age, working memory capacity as a proxy of the corresponding IQ facet, attention-deficit hyperactivity disorder, and general anxiety as a proxy of overall mental health. Future studies may consider additional confounds such as more comprehensive assessments of psychological distress to further our understanding of information integration of psychopathic individuals.

Conclusion

In summary, the present research constitutes the first examination of the central proposition of the Impaired Integration theory, a psychopathy-related impairment in the binding of perceptual information. This suspected deficit was quantified by illusory conjunctions, defined as attention-dependent errors in the binding of stimulus features. Our results indicated that psychopathic traits were unrelated to individual differences in the ability to integrate perceptual information. These findings challenge the proposition that psychopathy is rooted in an information integration deficit and mark an important examination of the hypothesized core mechanism of the Impaired Integration theory. This research paves the way for future studies to advance our understanding of psychopathic trait etiology by assessing and specifying falsifiable mechanisms thought to bring about the observed cognitive and behavioral deficits.

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