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Review

Using Bayesian methods to update and expand the meta-analytic evidence of the five-factor model's relation to antisocial behavior

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HIGHLIGHTS

- Bayesian meta-analytic methods were used to examine the relation between the FFM domains and a variety of antisocial behavior (ASB) outcomes.
- Agreeableness was the strongest negative correlate of nearly all forms of ASB (except child molestation) followed by conscientiousness.
- Current results provide insights for etiological models of ASB and suggest potential directions for future intervention efforts.

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ABSTRACT

The Five Factor Model (FFM) of personality is the dominant hierarchical model of personality. Previous work has demonstrated the importance of the FFM domains and facets in understanding a variety of antisocial behaviors ranging from non-violent antisocial behavior to a variety of aggression outcomes. The aim of the present meta-analysis was to quantitatively summarize the empirical work that has examined these relations, as well as update and expand previous work in this area using Bayesian meta-analytic methods. A comprehensive search of available literature on the FFM and antisocial behavior was conducted and posterior distributions of effect sizes were computed for the FFM domains (across 12 antisocial outcomes). The meta-analytic results supported the primary importance of (low) Agreeableness and (low) Conscientiousness in predicting antisocial behavior across antisocial outcomes, with the exception of the outcome related to child molestation. The importance of Neuroticism was more dependent on the specific antisocial outcome under examination. The results are discussed in the context of the descriptive research on the FFM and antisocial behavior, and how Bayesian methods provide additional utility in estimation and prediction compared to more common frequentist methods. Furthermore, we recommend that future work on the FFM and antisocial behavior move towards process-level analyses to further examine how traits are implicated in different forms of antisocial behavior.

Given the high societal and individual costs attributable to the consequences of antisocial behavior, it has been the focus of much research in psychology. Research on antisocial behavior spans multiple disciplines but has received consistent attention from personality researchers over the last three decades, as a cluster of personality traits have been shown to be consistently related to antisocial and aggressive behavior (e.g., antagonistic and disinhibitory related traits; Jones, Miller, & Lynam, 2011). Furthermore, the relations observed between antisocial behavior and personality tend to be moderate in size, suggesting that certain personality traits are important risk factors for antisocial and aggressive behavior. The goal of the present project is to provide an empirical summary of the literature on the Five-Factor Model (FFM; McCrae & John, 1992) and antisocial behavior. Ultimately, the project aims to expand and improve previous meta-analytic work in this area while providing the most comprehensive summary of the FFM literature as it relates to a variety of antisocial behavior outcomes.

The empirical relations between personality traits and antisocial behavior have shown that traits related to antagonism (e.g., callousness, non-compliance) and disinhibition (e.g., nonplanfulness, irresponsibility) are implicated in a variety of antisocial behaviors (Miller & Lynam, 2001) while other interstitial traits, like trait anger and hostility, which contain elements of both neuroticism and antagonism, also show consistent positive relations with antisocial behavior (e.g., Miller, Zeichner, & Wilson, 2012). In clinical and forensic research, personality constructs that are known to contain significant content related to

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antagonism and disinhibition (e.g., psychopathy; Lynam & Miller, 2015; antisocial personality disorder; Samuel & Widiger, 2008) also show the strongest positive relations with antisocial behavior (Hare & Neumann, 2008). Although much of the work on personality and antisocial behavior is cross-sectional, longitudinal evidence has also shown that personality traits predict antisocial behavior both concurrently and later in life (e.g., Henry, Caspi, Moffitt, & Silva, 1996; Vize, Lynam, Lamkin, Miller, & Pardini, 2016).

Despite the consistent relations between personality and antisocial behavior, models of aggression and antisocial behavior that aim to elucidate the causal mechanisms of aggression have yet to fully explicate the role that specific personality traits may play in the development of aggression. Arguably, the most well-known model of aggression is the general aggression model (GAM; Bushman & Anderson, 2002). The GAM is primarily a social-cognitive model of aggression in which aggression scripts or schemas are activated by specific triggering events. In addition, the GAM posits that the likelihood of aggressive behavior occurring in any given situation is dependent on current internal states (e.g., affect and arousal) as well as appraisal and decision processes (DeWall, Anderson, & Bushman, 2011). The GAM also mentions the role of personality as a factor in aggressive behavior, but personality is framed within the GAM primarily as an accumulation of learning experiences with less focus on how personality acts as a more dynamic risk-factor for aggression (Ferguson & Dyck, 2012).

Other models of aggression (e.g., the catalyst model; Ferguson et al., 2008), argue that individuals with high levels of trait aggression are more likely to engage in aggressive behavior or violence during times of environmental strain. In criminology, theoretical work has focused on what tends to be called “criminality” and in most theories of crime and antisocial behavior, personality traits like low self-control are grouped under the broader concept of criminality (Wilcox, Sullivan, Jones, & van Gelder, 2014). Additionally, personality's role in crime and antisocial behavior tends to be examined through the lens of multidimensional constructs like psychopathy (e.g., Delisi, 2009). Although personality traits are given greater consideration in some models compared to others, personality research has much more to offer in regard to etiological theories on antisocial behavior.

First, personality-related traits appear early in life (De Pauw & Mervielde, 2010; Elliot & Thrash, 2010). Personality has also been shown to be relatively stable, and its stability tends to increase over the course of development (Caspi, Roberts, & Shiner, 2005; Roberts & DelVecchio, 2000) with environmental mechanisms primarily driving this increasing stability (Briley & Tucker-Drob, 2014). In turn, personality traits may help explain why antisocial behavior tends to show continuity over development for particular individuals (Moffitt, 1993). For example, Harden, Quinn, and Tucker-Drob (2012) found that changes in delinquent behavior over the course of development was primarily driven by changes in sensation-seeking, with baseline levels of sensation seeking as well as within-person change in sensation seeking being driven primarily by genetic factors. Second, personality traits refer to broad tendencies of acting, feeling, and thinking which allow for traits to serve as transdiagnostic factors—processes that cut across related but conceptually distinct behavior problems (Krueger, Markon, Patrick, Benning, & Kramer, 2007). Last, a substantial empirical literature on general personality exists, allowing the more specific research on personality and antisocial behavior to be connected to a larger research base. For example, much is known about trait distributions across gender and age (Costa, Terracciano, & McCrae, 2001; McCrae, Martin, & Costa, 2005). Multiple researchers are studying the dynamic characteristics of personality development and continuity over time (e.g., Caspi et al., 2005). Other researchers study the processes underlying specific traits such as Agreeableness (e.g., Meier, Robinson, & Wilkowski, 2006) and Conscientiousness (e.g., Roberts, Chernyshenko, Stark, & Goldberg, 2005). Still others are studying the biological underpinnings of the traits (DeYoung et al., 2010; Yamagata et al., 2006).

1. Structural models of personality

A few prominent models of personality have been developed, all of which aim to organize specific personality traits under broader superfactors. Models that have garnered the most research in relation to antisocial behavior include Eysenck's Psychoticism-Extraversion-Neuroticism model (PEN; Eysenck & Eysenck, 1970), Tellegen's three-factor model (1985), and the Five Factor Model of personality (FFM; McCrae & John, 1992). Within the PEN model, Psychoticism is composed of traits related to egocentricity, (low) interpersonal warmth, and impulsivity; Extraversion is composed of traits related to agency and sociability; Neuroticism is made up of traits related to emotional stability and adjustment. Tellegen's (1985) model also proposes three primary dimensions: Positive and Negative Emotionality and Constraint. Similar to the Big Five (BF; Goldberg, 1993), the FFM posits a hierarchical structure of personality that is described by the five broad domains of Neuroticism, Extraversion, Openness, Agreeableness, and Conscientiousness, with each of the five domains being underlain by six lower-order facets.

Though each of the three models was derived independently, there is a notable degree of similarity and overlap across the models. All explicitly include the two superordinate factors related to Neuroticism and Extraversion. In addition, each model assesses traits related to impulse control (Conscientiousness in the FFM; Constraint in Tellegen's 3-factor model; elements of Psychoticism in Eysenck's model; Costa & McCrae, 1995) as well as preferences for harmonious interpersonal relations (Agreeableness in the FFM; dimensions of Negative Emotionality in Tellegen's model—specifically alienation and aggression; elements of Psychoticism in the PEN model). In their meta-analysis of structural models of personality and antisocial behavior, Miller and Lynam (2001) found that the dimensions of each structural model that showed the most notable relations with antisocial behavior could be understood as measures of Agreeableness or Conscientiousness. Other work that has focused on structural models of personality and antisocial behavior has also supported such findings, showing that the broad domains of Neuroticism/emotionality and Impulsivity/disinhibition show the largest relations with antisocial behavior (Cale, 2006), though examining such broad personality dimensions likely limits one's ability to examine the more specific traits driving such relations (i.e., antagonism related traits that live within the Neuroticism/emotionality and Impulsivity/disinhibition domains).

Research has shown that the FFM domains contain more homogenous traits relative to the Eysenck and Tellegen's models, where some factors within the latter two models contain heterogeneous content (e.g., Psychoticism from the PEN model) that make interpretation of factor level empirical relations more difficult (Watson, Clark, & Harkness, 1994). Another strength of the FFM worth noting in the context of research on antisocial behavior is that one is able to avoid criterion-predictor overlap. FFM measures assess normal-range personality traits, which allow for a relatively “pure” assessment of how individual differences contribute to antisocial behavior that are uncontaminated by explicitly antisocial items (as is often the case when examining the link between psychopathy and externalizing outcomes). Furthermore, the FFM allows for research on personality and antisocial behavior to be integrated into the existing FFM literature which has accumulated over the past 20 years.

2. The FFM and antisocial behavior

Within FFM research, results have typically implicated the domains of Agreeableness and Conscientiousness as important correlates of antisocial and aggressive behavior (Jones et al., 2011; Vize, Collison, & Lynam, in press). Furthermore, the importance of (low) Agreeableness and (low) Conscientiousness has tended to be consistent when different types of antisocial outcomes are examined (e.g., reactive and proactive aggression: Miller & Lynam, 2006; relational aggression: Reardon,

Tackett, & Lynam, 2017). Other FFM domains have been found to be important for more specific outcomes. For example, Neuroticism has shown moderate to large positive relations with reactive forms of aggression (e.g., Miller et al., 2012) while Extraversion and Openness tend to show small, if any, relation to antisocial outcomes at the domain level.

To date, two separate meta-analyses have explicitly focused on the relation between the FFM and broadly defined antisocial behavior (Jones et al., 2011; Miller & Lynam, 2001), though neither meta-analysis examined more specific forms of antisocial and aggressive behaviors. In their 2011 meta-analysis, Jones, Miller, and Lynam showed that the domains of Agreeableness and Conscientiousness were the most robust correlates of antisocial behavior (*r*s of −0.31 and − 0.23, respectively) while neuroticism showed a small positive relation ($r = 0.09$). Extraversion and Openness were largely unrelated to antisocial behavior.

Although fewer data were available for facet analyses, Jones et al. (2011) found that effects at the domain level masked important heterogeneity at the facet level. Though the broader domains of Extraversion and Neuroticism showed relatively small relations with antisocial behavior (*r*s of −0.01 and 0.09, respectively), facets within the domains showed notably larger relations. Within Neuroticism, the Angry Hostility facet ($r = 0.20$) and Impulsivity facet ($r = 0.18$) showed larger positive relations than the broader domain. Within Extraversion, the Warmth facet ($r = -0.20$) showed a significant negative relation.

3. Improving previous meta-analytic work on the FFM and antisocial behavior

The meta-analysis published by Jones et al. has been widely cited and was the first to offer an empirical summary of the literature on the FFM and its relation to antisocial behavior at the domain and facet level. The present meta-analysis seeks to build upon the previous results by increasing the number of studies included, incorporating additional meta-analytic methods not used in the initial study (e.g., Bayesian methods, disattenuation of correlations, use of random effects models), and expanding the scope of the meta-analysis to include coverage of a wider range of antisocial behaviors, including sexually-related antisocial behavior.

Despite its impact, the Jones et al. (2011) meta-analysis was relatively small (*N*s ranging from 10,186 to 10,311), and their use of fixed-effects models limited their ability to make inferences beyond the sample of studies included in their analyses. An important benefit of an increased meta-analytic sample size is the ability to include more specific outcomes. Specifically, Jones et al. (2011) were only able to estimate effects for a broad antisocial outcome and a broad aggression outcome. With additional samples, the ability to estimate effects for more specific outcomes (e.g., non-violent antisocial behavior, physical aggression, proactive versus reactive aggression, sexual aggression) can provide a more nuanced understanding of the FFM's relations with more fine-grained antisocial outcomes. Different types of antisocial behavior have shown divergent personality correlates in previous research yet this heterogeneity may be lost when only examining broad-based antisocial behavior (e.g., Neuroticism's relation with reactive forms of aggression; Miller & Lynam, 2006).

The present meta-analysis also incorporates disattenuated correlations in order to partially correct for the influence of measurement error (operationalized here as low internal consistency) on the relations between the FFM and antisocial behavior. When measurement error is not taken into account, the observed relations between two constructs can lead to an underestimation of their true relation in the population (Schmidt, Le, & Ilies, 2003). Furthermore, systematic differences in reliability across FFM domains (e.g., if Conscientiousness scales tend to have higher reliability than Openness scales) may lead to biased estimates.

Second, the present meta-analysis is broader in scope than the previous meta-analyses in that it includes data on sexually related antisocial behavior such as sexual assault and child molestation in order to examine if the FFM domains show differential relations with these outcomes compared to non-sexually related antisocial outcomes. From the perspective of the FFM, sexually-related antisocial outcomes may show the same personality correlates as that of general antisocial behavior, namely (low) Agreeableness and (low) Conscientiousness.

The examination of the personality of sex offenders (both child molesters and non-child molesters) has been a consistent focus of forensic research (Davis & Archer, 2010). Yet, only recently have researchers started to assess sex offenders with FFM based instruments (e.g., Becerra-Garcia, Garcia-Leon, Muela-Martinez, & Egan, 2013). In turn, the present meta-analysis can bridge FFM research on general antisocial behavior and research on individual differences within sex offender populations, the latter of which has yet to incorporate a consistent framework in conceptualizing personality differences among offenders (Marshall, Smallbone, & Marshall, 2014).

Last, we use Bayesian meta-analytic methods to explore the relations between the FFM and a variety of antisocial outcomes. Proponents of Bayesian methods have long argued for its strengths relative to other data analytic techniques frequently used in the social sciences (e.g., Kruschke, 2010a), yet its use in personality and clinical research remains limited. There are numerous benefits of Bayesian methods, and Bayesian approaches have already been used to strengthen analyses that are frequently used by psychology researchers (e.g., Muthén & Asparouhov, 2012). Our hope is to continue this trend by applying Bayesian methods to traditional meta-analytic methods commonly used in personality and clinical research.

4. Advantages of Bayesian methods

A substantial amount of writing has been devoted to delineating the strengths of Bayesian methods compared to traditional frequentist methods (e.g., Hoijtink & Chow, 2017; Morey, Romeijn, & Rouder, 2016; Rouder, Morey, Verhagen, Province, & Wagenmakers, 2016; Wagenmakers, Morey, & Lee, 2016).[1] Though a review of all the strengths of Bayesian methods will not be included, a few strengths deserve mention. First, Bayesian methods allow for direct, probabilistic statements to be made, conditional on the available data and prior beliefs about the effect under investigation. Furthermore, the uncertainty about the effect of interest is included in the posterior distribution, which represents a researcher's beliefs about the effect of interest after the data have been examined. The uncertainty can be quantified by the highest posterior density (HPD) interval. For example, a 95% HPD interval covers 95% of the most probable parameter values within the posterior distribution. This can be compared with a 95% percent confidence interval (CI), the more commonly utilized statistic that is used to quantify uncertainty in a meta-analytic point estimate. However, researchers attribute qualities to confidence intervals that are in fact qualities of Bayesian credible intervals (e.g., “We can be 95% certain that the true value falls in the range of the interval”). Though we believe probabilistic predictions about what values are most likely what researchers are interested in, this information is not actually provided by a confidence interval (Morey, Hoekstra, Rouder, Lee, & Wagenmakers, 2016). As Morey et al. (2016) highlight, a CI,

> “…is a numerical interval constructed around the estimate of a parameter. Such an interval does not, however, directly indicate a property of the parameter; instead, it indicates a property of the procedure, as is typical for a frequentist technique…The key point is that the CIs do not provide for a statement about the parameter as it

[1] Although we do not provide an in-depth introduction to the basics of Bayesian statistics, accessible introductions to Bayesian methods can be found elsewhere (e.g., Kruschke, 2010b; McElreath, 2016)

relates to the particular sample at hand; instead, they provide for a statement about the performance of the procedure of drawing such intervals in repeated use." (p. 1159).

In other words, CIs allow one to make inferences about procedures as opposed to the data, the latter of which will likely be of more interest to researchers conducting meta-analyses.

Second, Bayesian methods for meta-analysis provide an analytical framework that allows for straightforward empirical updating. In many cases, meta-analytic studies are used to update the evidence about a particular effect or relation after a more substantial empirical literature has developed (Schmidt & Raju, 2007). Bayesian methods allow for results that directly inform how certain we are about a parameter given extant data, and in turn, Bayesian updating in the context of meta-analyses appears to be a notable strength of Bayesian methods. Previous meta-analyses can provide empirical information that allows for researchers to develop informed prior beliefs for more current data. Thus, the *full* amount of knowledge that has been made available is incorporated into the most current effect size estimate.

Though these highlighted strengths are not exhaustive, they provide sufficient evidence to encourage researchers in psychological science and personality research to begin to integrate Bayesian meta-analytic methods into their work. Furthermore, it is likely that a mixture of Bayesian methods and non-Bayesian methods will be most useful to meta-analysts in psychological science. For example, many useful statistics that do not have an immediate Bayesian counterpart still offer important information about meta-analytic data. Examples include the I^2 statistic that quantifies the amount of between study variability in effect sizes in a straight-forward manner (Higgins, Thompson, Deeks, & Altman, 2003), p-curve analyses (Simonsohn, Nelson, & Simmons, 2014), and trim-and-fill methods (Duval & Tweedie, 2000).

5. Method

5.1. Literature Search

In order to ensure a comprehensive search of the extant literature that has examined the relations between the FFM and antisocial behavior, the following FFM search terms were used in our search of the PsycINFO database: FFM, Big Five, HEXACO, NEO-PI-R, Neuroticism, Extraversion, Openness, Agreeableness, Conscientiousness, and personality. These search terms were crossed with the search terms of aggression, violence, antisocial, crime, delinquency, bullying, offending, sex offen*, sexual violence, rape, rapi*, pedo*, and child molest*. For the sexually-related antisocial search terms (sex offen* through child molest*), there was no time restriction used for the literature search. For the other antisocial search terms, we confined our search to studies published since 2011, given the previous meta-analysis of Jones et al. (2011). Excluding the sexually based antisocial behavior search terms, the same search terms used in the Jones et al. (2011) meta-analysis were used for the present meta-analysis.

Inclusion criteria for studies were that the study must be in English and report on some feature of antisocial behavior (e.g., aggression) and include a measure of personality that assessed the FFM domains and/or facets. Antisocial behavior outcomes that were based on measures of antisocial personality disorder (APD) or psychopathy were excluded because although they do include content related to aggression/antisocial behavior, they also contain significant trait-based content which would inflate effect size estimates (Miller & Lynam, 2001). We used the correlation coefficient as our effect size. In cases where authors likely had data where correlation coefficients could be easily attained but were not reported (e.g., if authors conducted multivariate analyses like regression), the authors were contacted for the relevant data. In order to compute partially disattenuated relations, we extracted the reliability coefficients for each domain scale.[2]

We also attempted to solicit unpublished data from authors active in this research area. After reviewing papers for inclusion in the meta-analysis, any authors who had published at least two separate papers on the relations between the FFM and antisocial behavior were contacted by e-mail and were asked to contribute any unpublished data they had available. Only one author contacted was able to provide unpublished data, though this author provided unpublished data from seven independent samples.

5.2. Literature search results

For our literature search on the FFM and antisocial behavior, 582 studies were initially returned using our search terms. Next, titles and abstracts were reviewed for any mention of personality and antisocial behavior, ensuring that our first pass through the 582 returned studies was relatively broad in selecting studies for further examination. Based on this review, 101 studies were identified for further examination. For our separate literature search on the FFM and sexually-motivated antisocial behavior, a total of 82 studies were returned using our search terms. After review of the titles and abstracts, a total of 34 studies were identified for further review. The texts of the 135 studies were more thoroughly reviewed to ensure that they met the inclusion criteria of the meta-analysis. The review identified studies with missing information and the authors were contacted by e-mail.[3]

An additional 62 studies were excluded for not meeting the necessary inclusion criteria, with the majority of studies being excluded for not including a measure of some form of antisocial behavior. After combining the 73 new studies with the studies originally included in the Jones et al. (2011) meta-analysis, a total of 125 studies and $k = 138$ independent samples were included in the present meta-analysis. Fig. 1 displays a flow chart mapping how studies were included in the present meta-analysis. The full list of included studies, along with the information each study contributed (i.e., type of outcome) can be seen in Supplementary Table 1.

A total of 11 antisocial behavior outcomes were initially identified for domain level analyses. The antisocial behavior categories were based on the expert opinions of the authors in addition to the requirement that the number of effect sizes for a particular category needed to be sufficient for meta-analytic analyses (the cutoff was set at $k \geq 3$). Ultimately, the latter requirement did not result in any categories being excluded from analyses. The final categories included an average antisocial behavior outcome, an average aggressive behavior outcome, general aggression, physical aggression, proactive aggression, reactive aggression, relational aggression, verbal aggression, bullying, non-violent antisocial behavior, and sexual aggression.[4] The average antisocial outcome was derived by averaging the multiple effect sizes reported in a given sample across different types of antisocial behaviors. For example, if a sample reported correlations for Neuroticism's relations with non-violent delinquency, physical aggression, and relational

[2] In cases where Cronbach's alpha was not reported ($k = 56$), we utilized the 'metafor' package to meta-analytically impute reliability coefficients for these samples. A more detailed explanation of this process can be found in the supplementary materials.

[3] A total of 77 authors were contacted regarding missing information and/or to inquire about the availability of data that were not reported in a published paper but otherwise might be available. Of the 77 authors contacted, 41 authors responded and provided either all or some of the requested data when available. Six authors responded that the requested data were not available.

[4] Combining child molestation with non-child molestation sexual aggression proved to be problematic given that domain effect sizes for these two outcomes diverged drastically from one another and introduced substantial heterogeneity into effect size estimates. Thus, we examined sexual aggression (i.e., sexual assault/rape) and child molestation outcomes separately resulting in a total of 12 outcomes as opposed to 11. Samples with effect sizes based on child molestation outcomes ($k = 5$) were also excluded from contributing effect sizes to the average antisocial and aggressive behavior outcomes.

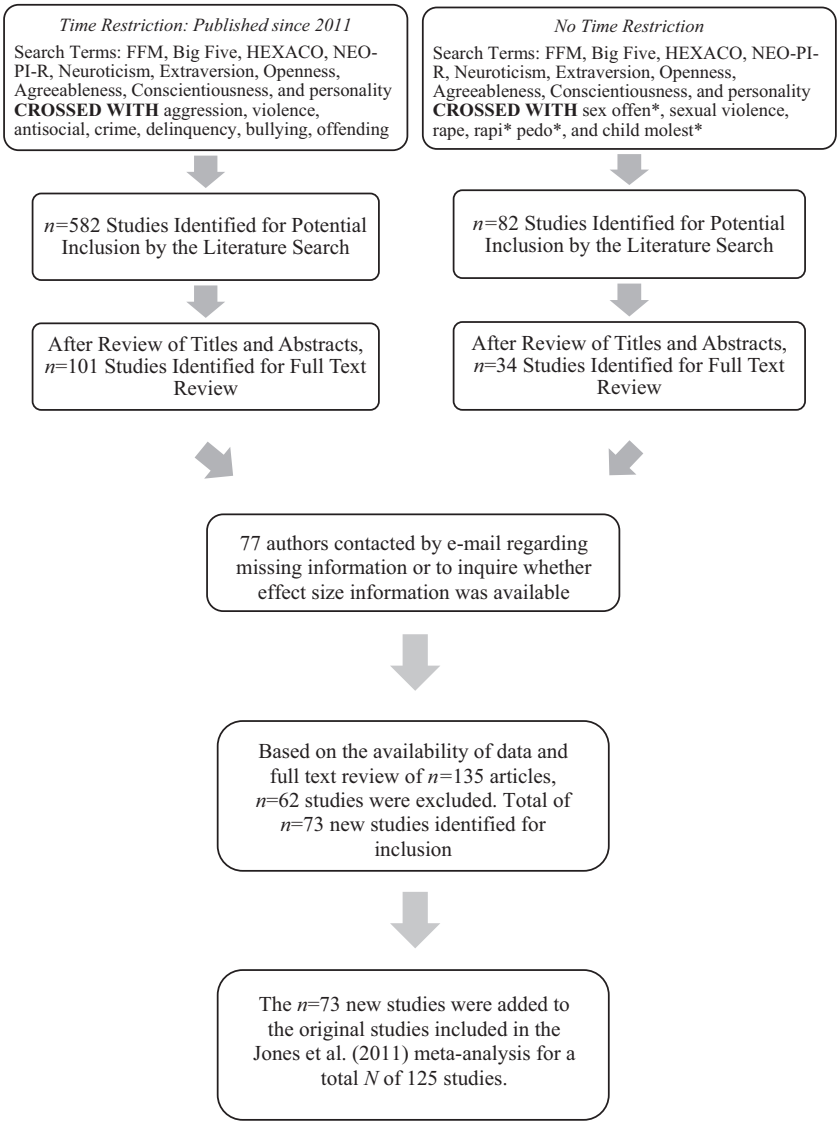

Fig. 1. Flow Chart of Search and Study Inclusion Process for New Studies.

aggression, the average correlation across the three outcomes was taken, and the average correlation was the sample's single effect size it contributed to the broad antisocial behavior outcome. If a sample only reported one effect size, the single effect size was used for the broad antisocial outcome. Thus, all samples contributed effect sizes to the broad antisocial behavior outcome for at least one FFM domain. The same approach was used for the average aggression outcome, but only correlations derived from measures of aggression were used (e.g., non-violent antisocial behavior effect sizes were excluded).

In addition to the broader antisocial and aggressive behavior outcomes, we also examined an outcome designated as “general aggression”. The outcome designated “general aggression” was used for samples that reported results for aggression measures that assessed multiple domains of aggression within a single measure. An example would be correlations between the FFM domains and the total score from the Buss-Perry Aggression Questionnaire (Buss & Perry, 1992), which includes content related to physical aggression, verbal aggression, and trait anger.

5.3. Coded Information

To examine potential moderators, demographic information (average age, ethnic composition of sample, percentage of males in the sample, etc.), FFM measure used (e.g., NEO-PI-R, NEO-FFI, BFI, etc.), source of information for independent and dependent variables (self-report, observer report, official records, etc.), type of sample (prison sample, college sample, MTurk sample, etc.), and whether the data were published or unpublished was coded for each study. An independent coder reviewed 19 randomly selected studies from the 73 newly included studies. The independent coder extracted the coding information for each study along with the effect sizes for each study. There was very high agreement between the independent coders for both the quantitative effect sizes ($ICC = 0.97$) and qualitative study information (99% agreement across all qualitative information).

5.4. Bayesian meta-analysis[5]

Our Bayesian meta-analytical approach proceeded in two steps. First, we re-analyzed the data from Jones et al. (2011) using partially disattenuated correlational effect sizes and Bayesian meta-analytic

[5] A more in-depth description of how random-effects meta-analytical models are represented within a Bayesian framework can be found in the supplementary materials and in Zhang, Jiang, Liu, and Oh (2017).

methods. This required specification of priors for β (estimated population effect size) and τ^2 (estimated heterogeneity for population effect size), the two parameters of most interest to meta-analysts. Given that our approach in analyzing the 2011 data was similar to that of running the analyses before the results were known, we utilized what are referred to as "uninformed priors." Uninformed priors are prior distributions for parameter values that do not strictly limit what effect size values are most probable, reflecting a state of ignorance regarding expectations about the most likely effect size estimate. In cases where uninformed priors are used and there is sufficient data, the data are said to "overwhelm" the prior and entirely dictate the posterior distribution. Uninformed priors were used for both β and τ^2. Specifically, we specified generic, diffuse priors of $\beta \sim N(0, 10^6)$ and $\tau^2 \sim IG(.001, .001)$ which result in the posterior distributions of β and τ^2 being entirely driven by the data. It should be noted that in some cases, particularly diffuse priors that allow for even weak credibility to be assigned to impossible values (e.g., a correlation above 1) can result in a posterior distribution that assigns credibility to unlikely or even impossible values. However, this problem arises when the data are particularly sparse, and very diffuse priors have little to no effect when the available data is substantial, as is the case in the present meta-analysis (Betancourt, 2017).[6]

In the second step, all new data (i.e., data not included in the 2011 meta-analysis) were then analyzed. The priors for the effect size estimates at the second step were taken from the posterior distributions from the first step, a process referred to as Bayesian updating. The updated posterior distributions for the FFM effect sizes derived from the second step of our analyses then reflect our knowledge about the effect size given all available data. The specified prior distributions for each FFM domain and study outcome can be seen in Supplementary Table S2. However, we chose a priori to specify separate priors for Neuroticism's relations with reactive and relational aggression outcomes based on research that has shown that Neuroticism tends to show moderate positive relations with these outcomes (e.g., Miller et al., 2012) compared to the small positive relation specified by our priors for Neuroticism's relation with the other study outcomes. We also chose to specify uninformative priors for all FFM domains [i.e., $\beta \sim N(0, 10^6)$] when analyzing the child molestation outcome due to its apparent divergence from other forms of antisocial behavior, as described in a previous footnote. The prior distribution for all estimates of τ^2 was specified as $IG(.001, .001)$. Inverse variance weights were used to weight the effect sizes drawn from each sample.

All analyses were completed using the 'R2OpenBUGS' package (Sturtz, Ligges, & Gelman, 2005) and RStudio (Version 0.99.093; R Studio Team, 2015), an interface for the R statistical software program (R Core Team, 2016). R2OpenBUGS allows for users to specify a Bayesian model in R, and this information is then passed to OpenBUGS (Lunn, Spiegelhalter, Thomas, & Best, 2009) which uses Markov Chain Monte Carlo (MCMC; Craiu & Rosenthal, 2014) sampling to arrive at an estimated posterior distribution. For MCMC sampling, two chains were generated, each with a burn-in period of 1000 and a total of 30,000 iterations following the burn-in. Start values specified for the two Markov chains for β were 0.50 and − 0.50 and start values for τ^2 were 1.00 and 0.00 in order to ensure that posterior estimates were not sensitive to start values for β and τ^2.

All figures were created using the "ggmcmc" (Fernández-i-Marín, 2016) and "ggplot2" (Wickham, 2009) packages. Because the Bayesian methods employed in the present study are relatively novel in personality and clinical research, we conducted the same analyses using traditional frequentist random-effects models in the 'metafor' package (Viechtbauer, 2010) in order to compare our Bayesian results to typical meta-analytic results. We utilized the DerSimonian and Laird (1986) estimator to estimate τ^2 for these analyses.

6. Results

6.1. Convergence diagnostics

Before interpreting the posterior parameter estimates for our models, all MCMC chains were checked for convergence using the Gelman-Rubin statistic (G-R; Gelman & Rubin, 1992) as well as visual examination of trace plots. A representative trace plot using Agreeableness' posterior effect size with the general antisocial outcome can be seen in Fig. S1 in the supplementary materials, and shows clear convergence among the chains. Trace plots and Gelman-Rubin statistics for all estimated posterior distributions were in the acceptable range across FFM domains for nearly all study outcomes (Gelman, Carlin, Stern, & Rubin, 2014).

However, for particular domain relations with certain outcomes, our models resulted in surprisingly large estimates of τ^2 compared to other domains. This was the case for Neuroticism, Agreeableness, and Conscientiousness' relations with the general aggression outcome and Agreeableness' relation with sexual aggression. As a result of the large τ^2 values observed for these effect size estimates, priors for these effect sizes were adjusted to be only partially informative[7] in order to examine if the informed priors were too restrictive, and in turn, limiting credible effect sizes as indicated by the new data. The use of partially informative priors led to notable decreases in τ^2 estimates and therefore we report results based on the use of the partially informative priors for these effect sizes.

6.2. Updating evidence regarding the average antisocial and aggression outcomes

The posterior distributions of the FFM domain effect sizes for step 1 analyses, along with the updated posteriors based on the inclusion new data, are presented in Fig. 2 (average antisocial behavior outcome) and 3 (average aggressive behavior outcome). The FFM domains are approximately equivalent in the rank-order relations with the average antisocial and aggression outcomes: Agreeableness showed the strongest negative relations with both the antisocial and aggression outcomes (posterior effect sizes[8] of −0.38 and − 0.39, respectively) followed by Conscientiousness (posterior effect sizes of −0.22 and − 0.20). Neuroticism showed similarly strong relations to these outcomes compared to Conscientiousness, with the exception that Neuroticism's relations were positive (posterior effect sizes of 0.15 and 0.18). Both Extraversion and Openness showed trivial relations with the antisocial and aggressive behavior outcomes (posterior effect size range = −0.06 to 0.00).

Both Figs. 2 and 3 show that as more data are taken into consideration, the certainty about which effect sizes are most likely becomes stronger, with narrower HDIs across the domains. For example, the top panel of Fig. 2 (based on data from Jones et al., 2011) shows that the posterior distribution of Agreeableness' effect size for the average antisocial behavior included −0.45 as a credible value based on the available data, falling within the 95% HDI of the posterior. After taking into account additional data, a value of −0.45 falls outside the credible range of effect size values, and the available information

[6] Nonetheless, we examined if using a less diffuse prior that concentrated probability between −1 and 1 had any effect on the posterior estimates. The results showed that the change in prior had essentially no effect on posterior estimates for our analyses at step 1.

[7] In order to utilize partially informative priors, the same point estimate from Supplementary Table S2 was used, but the standard deviation was expanded to 0.15 compared to the more stringent standard deviations observed in Supplementary Table S2.

[8] All reported effect sizes are the modal effect size from the MCMC estimated posterior distribution.

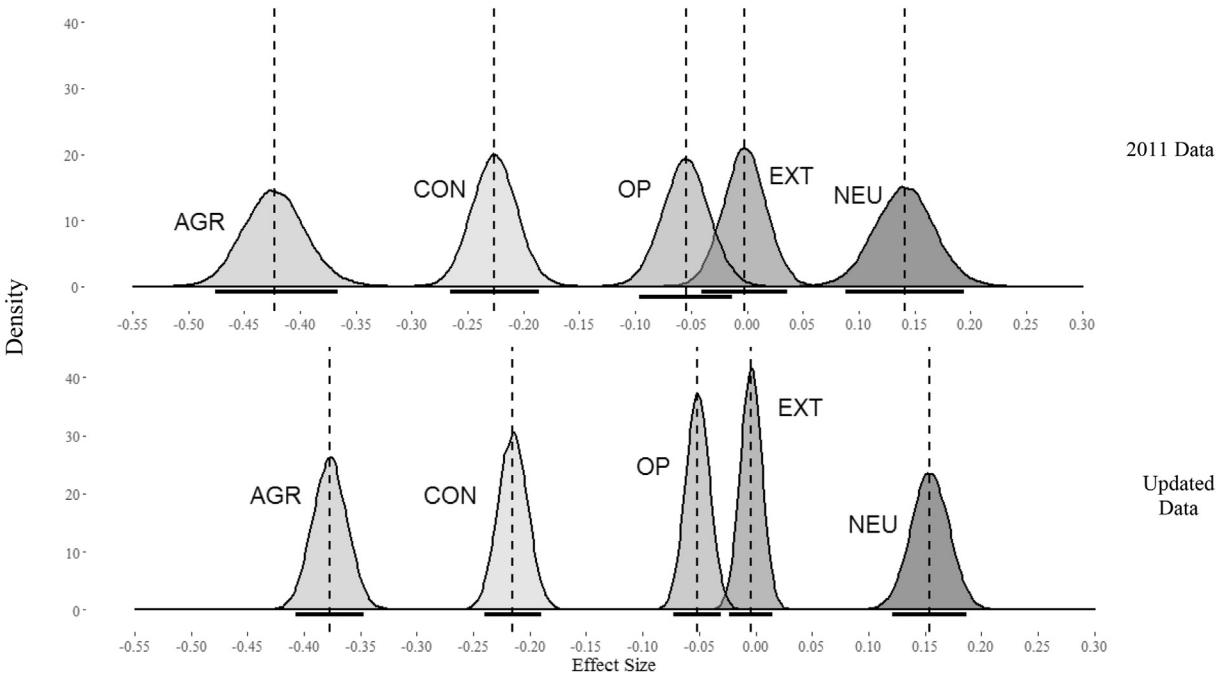

Fig. 2. Updating FFM Posterior Distributions for Average Antisocial Behavior Outcome. Note: Dotted line denotes the modal effect size value of the posterior distribution; the solid black bar beneath the posterior distribution covers the 95% highest density interval (HDI) of the posterior distribution; Top panel shows results for the 2011 data only, bottom panel shows the updated meta-analytic results; all effect sizes are based on partially disattenuated correlations.

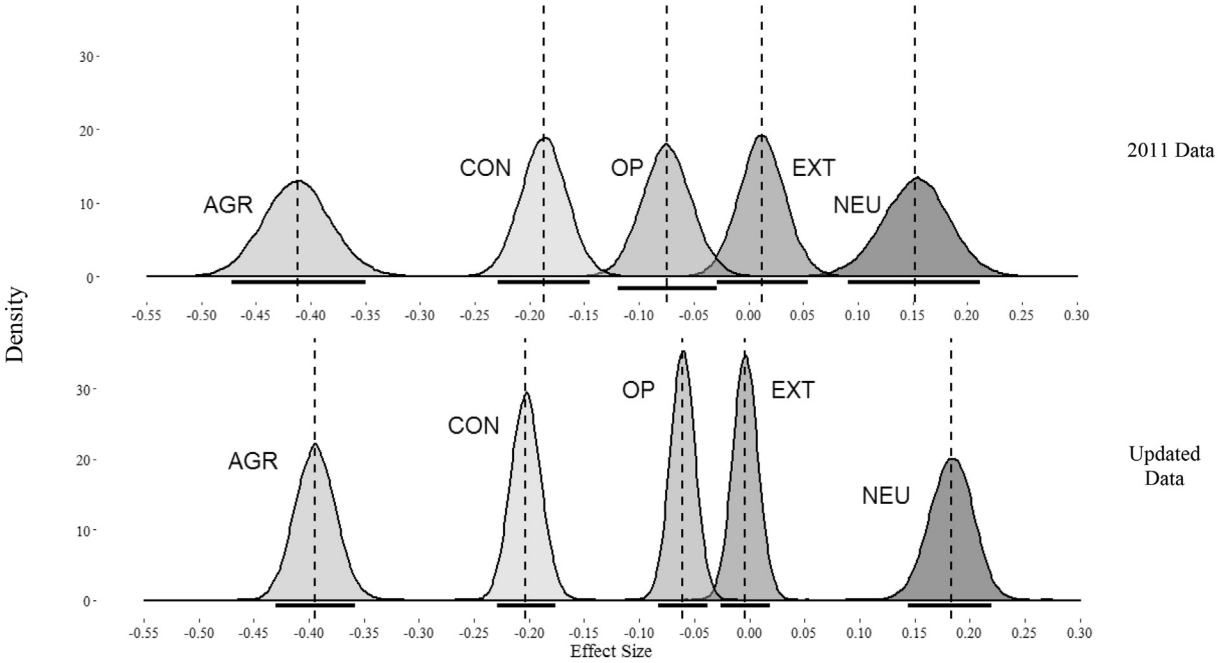

Fig. 3. Updating FFM Posterior Distributions for Average Aggressive Behavior Outcome. Note: Dotted line denotes the modal effect size value of the posterior distribution; the solid black bar beneath the posterior distribution covers the 95% highest density interval (HDI) of the posterior distribution; Top panel shows results for the 2011 data only, bottom panel shows the updated meta-analytic results; all effect sizes are based on partially disattenuated correlations.

[9] All discussion of effect sizes and results are in reference to the results from the Bayesian analyses, unless stated otherwise. The primary purpose of including traditional meta-analytic results is to compare and contrast them with the Bayesian results.

Table 1
Meta-analytic effect sizes for FFM domains.

			Traditional Random-effects Meta-analysis		Bayesian Random-effects Meta-analysis				
	k	N	Weighted ES	95% Conf. Interval	Posterior ES	95% HDI	τ^2 Estimate		I^2
							Bayesian	DerS-L	
Antisocial Behavior (Average)									
Neuroticism	129	58,217	**0.16**	0.12 to 0.19	0.15	0.12 to 0.19	0.033	0.027	92%
Extraversion	125	57,042	0.00	−0.02 to 0.02	0.00	−0.02 to 0.02	0.006	0.008	78%
Openness	125	57,042	**−0.05**	−0.07 to −0.03	−0.05	−0.07 to −0.03	0.008	0.011	83%
Agreeableness	133	59,096	**−0.38**	−0.42 to −0.35	−0.38	−0.41 to −0.35	0.042	0.052	96%
Conscientiousness	128	58,179	**−0.22**	−0.24 to −0.19	−0.22	−0.24 to −0.19	0.023	0.016	89%
Aggressive Behavior (Average)									
Neuroticism	94	32,708	**0.19**	0.15 to 0.22	0.18	0.14 to 0.22	0.035	0.034	92%
Extraversion	90	31,533	0.00	−0.03 to 0.02	0.00	−0.03 to 0.02	0.006	0.009	77%
Openness	90	31,533	**−0.06**	−0.09 to −0.04	−0.06	−0.08 to −0.04	0.006	0.008	73%
Agreeableness	97	33,321	**−0.40**	−0.44 to −0.36	−0.39	−0.43 to −0.36	0.050	0.053	95%
Conscientiousness	93	32,670	**−0.21**	−0.23 to −0.18	−0.20	−0.23 to −0.18	0.016	0.013	82%
General Aggression									
Neuroticism	17	8202	**0.38**	0.28 to 0.48	0.35	0.24 to 0.45	0.068	0.060	96%
Extraversion	17	8202	−0.04	−0.10 to 0.02	0.00	−0.04 to 0.03	0.017	0.015	87%
Openness	17	8202	**−0.06**	−0.10 to −0.02	−0.07	−0.10 to −0.03	0.007	0.006	72%
Agreeableness	17	8202	**−0.55**	−0.64 to −0.46	−0.53	−0.61 to −0.43	0.078	0.070	97%
Conscientiousness	17	8202	**−0.31**	−0.37 to −0.25	−0.30	−0.37 to −0.24	0.020	0.020	90%
Physical Aggression									
Neuroticism	47	13,999	**0.15**	0.11 to 0.20	0.15	0.12 to 0.19	0.018	0.018	84%
Extraversion	44	12,188	−0.04	−0.07 to −0.01	−0.02	−0.05 to 0.00	0.005	0.014	60%
Openness	44	12,188	**−0.06**	−0.10 to −0.02	−0.07	−0.10 to −0.04	0.013	0.014	79%
Agreeableness	48	14,380	**−0.41**	−0.47 to −0.36	−0.40	−0.44 to −0.37	0.040	0.052	93%
Conscientiousness	45	13,152	**−0.18**	−0.22 to −0.14	−0.18	−0.21 to −0.16	0.013	0.014	79%
Relational Aggression									
Neuroticism	12	4234	**0.28**	0.21 to 0.34	0.28	0.21 to 0.34	0.013	0.011	77%
Extraversion	10	3693	−0.04	−0.11 to 0.04	0.00	−0.04 to 0.04	0.010	0.010	75%
Openness	10	3693	−0.09	−0.15 to −0.02	−0.08	−0.12 to −0.04	0.007	0.007	68%
Agreeableness	12	4234	**−0.39**	−0.47 to −0.30	−0.39	−0.43 to −0.35	0.028	0.029	90%
Conscientiousness	12	4234	**−0.21**	−0.27 to −0.15	−0.19	−0.23 to −0.16	0.008	0.007	68%
Reactive Aggression									
Neuroticism	15	7253	**0.32**	0.26 to 0.38	0.32	0.25 to 0.38	0.022	0.013	86%
Extraversion	15	7253	−0.02	−0.07 to 0.04	0.00	−0.03 to 0.04	0.010	0.010	81%
Openness	15	7253	−0.03	−0.07 to 0.02	−0.05	−0.09 to −0.02	0.007	0.005	69%
Agreeableness	16	7426	**−0.38**	−0.44 to −0.33	−0.39	−0.43 to −0.35	0.022	0.013	86%
Conscientiousness	16	7426	**−0.24**	−0.28 to −0.20	−0.21	−0.24 to −0.17	0.007	0.004	65%
Proactive Aggression									
Neuroticism	15	7253	**0.10**	0.04 to 0.15	0.12	0.08 to 0.16	0.009	0.009	80%
Extraversion	15	7253	0.02	−0.04 to 0.08	0.02	−0.02 to 0.05	0.010	0.009	80%
Openness	15	7253	**−0.12**	−0.16 to −0.07	−0.10	−0.13 to −0.06	0.006	0.005	69%
Agreeableness	16	7426	**−0.47**	−0.52 to −0.42	−0.42	−0.46 to −0.38	0.019	0.015	87%
Conscientiousness	16	7426	**−0.29**	−0.34 to −0.23	−0.20	−0.24 to −0.17	0.027	0.012	85%
Verbal Aggression									
Neuroticism	16	4488	**0.16**	0.06 to 0.26	0.15	0.10 to 0.19	0.027	0.038	91%
Extraversion	15	4374	0.05	−0.02 to 0.12	0.02	−0.01 to 0.06	0.013	0.015	80%
Openness	15	4374	−0.01	−0.10 to 0.09	−0.06	−0.10 to −0.02	0.040	0.028	88%
Agreeableness	16	4488	**−0.51**	−0.57 to −0.44	−0.49	−0.55 to −0.41	0.034	0.032	89%
Conscientiousness	15	4374	**−0.19**	−0.26 to −0.13	−0.19	−0.22 to −0.15	0.014	0.014	79%
Sexual Aggression									
Neuroticism	5	1282	0.10	−0.04 to 0.24	0.10	−0.01 to 0.25	0.041	0.020	83%
Extraversion	5	1282	−0.01	−0.19 to 0.17	0.01	−0.03 to 0.05	0.036	0.036	89%
Openness	5	1282	−0.04	−0.15 to 0.06	−0.07	−0.11 to −0.03	0.011	0.008	66%
Agreeableness	5	1282	**−0.22**	−0.29 to −0.15	−0.26	−0.37 to −0.17	0.011	0.002	31%
Conscientiousness	5	1282	−0.14	−0.31 to 0.02	−0.18	−0.22 to −0.14	0.041	0.032	88%
Child Molestation									
Neuroticism	5	354	**0.38**	0.27 to 0.49	0.38	0.23 to 0.52	0.021	0.005	26%
Extraversion	5	354	**−0.22**	−0.41 to −0.01	−0.22	−0.46 to 0.07	0.086	0.044	74%
Openness	5	354	−0.25	−0.47 to 0.01	−0.24	−0.53 to 0.09	0.131	0.072	83%
Agreeableness	5	354	**0.42**	0.18 to 0.61	0.41	0.07 to 0.67	0.156	0.072	83%
Conscientiousness	5	354	**−0.21**	−0.40 to −0.01	−0.21	−0.46 to 0.06	0.084	0.040	73%
Bullying									
Neuroticism	11	4389	0.08	−0.01 to 0.17	0.12	0.07 to 0.17	0.026	0.019	88%
Extraversion	11	4389	0.05	0.00 to 0.10	0.03	−0.01 to 0.06	0.007	0.005	65%
Openness	11	4389	**−0.08**	−0.13 to −0.02	−0.08	−0.11 to −0.04	0.007	0.006	67%
Agreeableness	12	4648	**−0.32**	−0.39 to −0.23	−0.37	−0.41 to −0.32	0.023	0.021	88%

(*continued on next page*)

Table 1 (*continued*)

			Traditional Random-effects Meta-analysis		Bayesian Random-effects Meta-analysis				
	k	N	Weighted ES	95% Conf. Interval	Posterior ES	95% HDI	τ^2 Estimate		I^2
							Bayesian	DerS-L	
Conscientiousness	11	4389	**−0.21**	−0.26 to −0.16	−0.19	−0.22 to −0.16	0.005	0.005	62%
Non-violent Antisocial Behavior									
Neuroticism	16	7223	**0.15**	0.08 to 0.22	0.14	0.10 to 0.19	0.019	0.019	89%
Extraversion	15	6726	−0.03	−0.08 to 0.02	−0.01	−0.04 to 0.02	0.006	0.006	73%
Openness	15	6726	−0.03	−0.07 to 0.02	−0.04	−0.07 to −0.01	0.005	0.005	66%
Agreeableness	16	7223	**−0.34**	−0.40 to −0.27	−0.38	−0.42 to −0.34	0.025	0.022	90%
Conscientiousness	16	7223	**−0.28**	−0.33 to −0.23	−0.24	−0.27 to −0.21	0.013	0.011	82%

Note: Bolded effect sizes indicate that the effect is significant at $p < .05$; k = number of independent samples included in effect size calculation; N = number of total participants across samples; Weighted ES = traditional meta-analytic effect size; 95% CI = 95% confidence interval; Posterior ES = modal effect size from the posterior distribution; 95% HDI = 95% highest density interval; DerS-L = DerSimonian & Laird estimator; all effect sizes are based on partially disattenuated correlations.

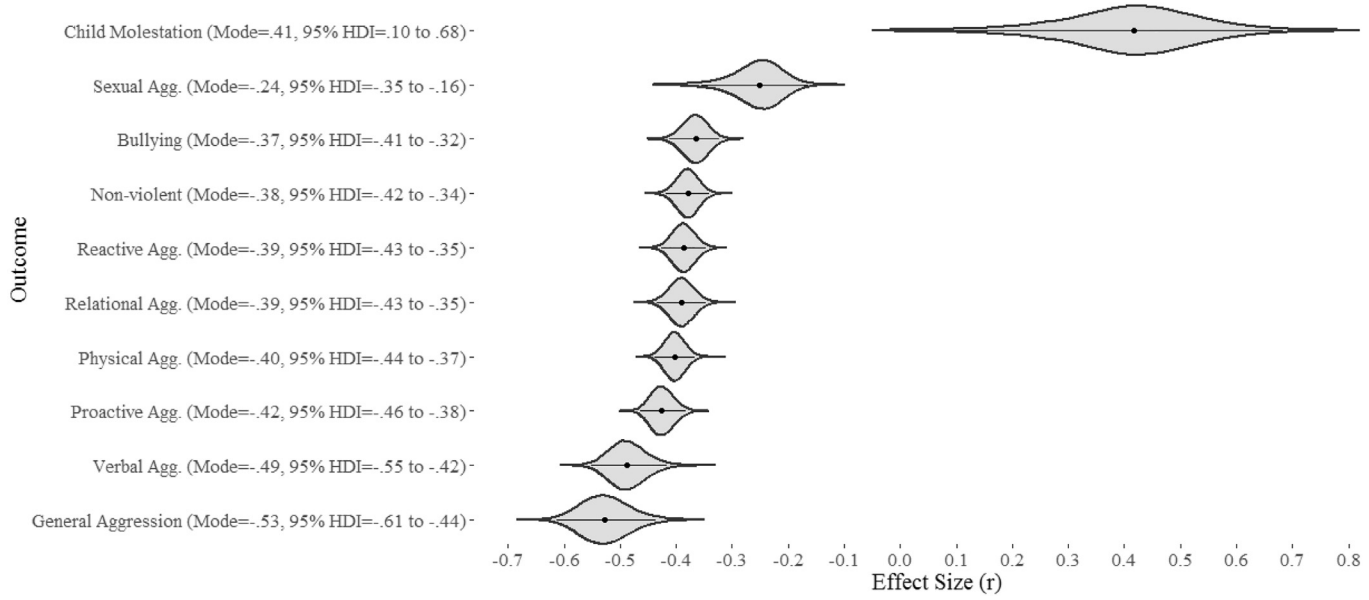

Fig. 4. Posterior Density Distributions for Agreeableness' Relations with Study Outcomes.
Note: Mode = Modal effect size value of the posterior distribution; HDI = Highest density interval; the solid black bar beneath the posterior distribution covers the 95% highest density interval of the posterior effect size distribution; Non-violent = non-violent antisocial behavior; Agg. = Aggression; all effect sizes are based on partially disattenuated correlations.

suggests that the most credible values now fall between −0.40 and − 0.35. The same pattern of is also seen for the other FFM domains.

6.3. FFM domains and subtypes of antisocial behavior

Summaries of the domain effect sizes across the variety of antisocial outcomes for both the traditional and Bayesian meta-analyses can be seen in Table 1.[9] Agreeableness' negative effect size was consistent across the various antisocial outcomes, with the exception of the child molestation outcome, where Agreeableness showed a moderate *positive* relation (see Fig. 4). Agreeableness consistently showed moderate to large negative relations with the other eleven antisocial outcomes, ranging from −0.26 to −0.53. Conscientiousness showed a similar pattern to Agreeableness, though its negative relations were smaller in magnitude. Additionally, Conscientiousness' relation with child molestation did not show a marked departure from its other relations as was the case for Agreeableness. For Conscientiousness, the posterior effect sizes for the eleven outcomes ranged from −0.18 to −0.30 (See Fig. 5).

Neuroticism showed a consistent positive relation with the twelve outcomes, though there was greater variability in Neuroticism's effect sizes. Specifically, Neuroticism's posterior effect sizes ranged from 0.12 (Bullying) to 0.38 (Child molestation). Neuroticism's strongest positive relations were observed for the general and reactive aggression outcomes, as well as the child molestation outcome with effect sizes of ranging from 0.27 to 0.38 (Fig. 6).

Last, Extraversion and Openness were also fairly consistent in their relations with the various outcomes, but their relations were in most cases, close to zero. Extraversion's posterior effect sizes ranged from −0.22 to 0.03 while Openness' posterior effect sizes ranged from −0.24 to −0.01. Although Openness' posterior relations were mostly small in magnitude, they showed a consistent negative relation with a variety of antisocial behaviors. Estimates of τ^2 are also displayed in Table 1, and across outcomes, there was notable variability in effect size estimates, which is underscored by the I^2 values, all of which show

[9] All discussion of effect sizes and results are in reference to the results from the Bayesian analyses, unless stated otherwise. The primary purpose of including traditional meta-analytic results is to compare and contrast them with the Bayesian results.

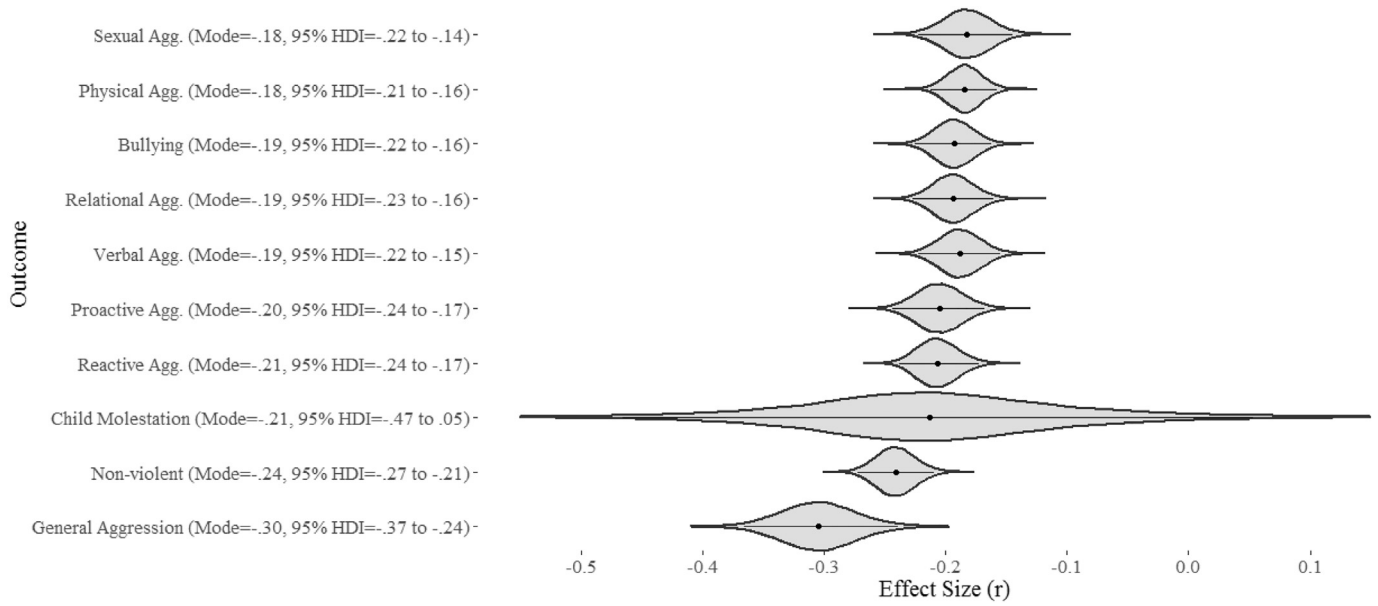

Fig. 5. Posterior Density Distributions for Conscientiousness' Relations with Study Outcomes.
Note: Mode = Mode effect size value of the posterior distribution; HDI = Highest density interval; the solid black bar beneath the posterior distribution covers the 95% highest density interval of the posterior effect size distribution; Non-violent = non-violent antisocial behavior; Agg. = Aggression; all effect sizes are based on partially disattenuated correlations.

moderate to high degrees of heterogeneity in domain effect sizes (Higgins et al., 2003).

6.4. Moderator analyses

We examined whether type of sample (Child vs. Late-adolescent/Adult, Prison vs. Non-prison, and College vs. Community), type of FFM measure used (NEO based vs. other), and whether the data was from a published or unpublished study moderated the observed posterior effect sizes for the FFM domains. Because there was relatively little variability in the levels of these moderators within the more specific antisocial outcomes included in the present study, we chose to focus on the average antisocial and aggression outcomes, which ensured adequate variability in moderator levels for the analyses. In order to conduct Bayesian moderator analyses, priors were specified for the effect sizes at each level of the moderator. For example, in order to examine the posterior effect sizes of Neuroticism's relation with the average antisocial outcome for prison vs. non-prison samples, priors needed to be specified for the effect size for prison samples as well as for non-prison samples. In all cases, broad priors (identical to the priors used for the 2011 data) were specified such that the posterior distribution was determined entirely by the data.

The results of the moderator analyses for the FFM domains can be seen in Table 2. Moderator effects tended to be small in magnitude, ranging from −0.08 to 0.13 across the domains. The largest moderation effects were observed for Agreeableness and Conscientiousness' effect

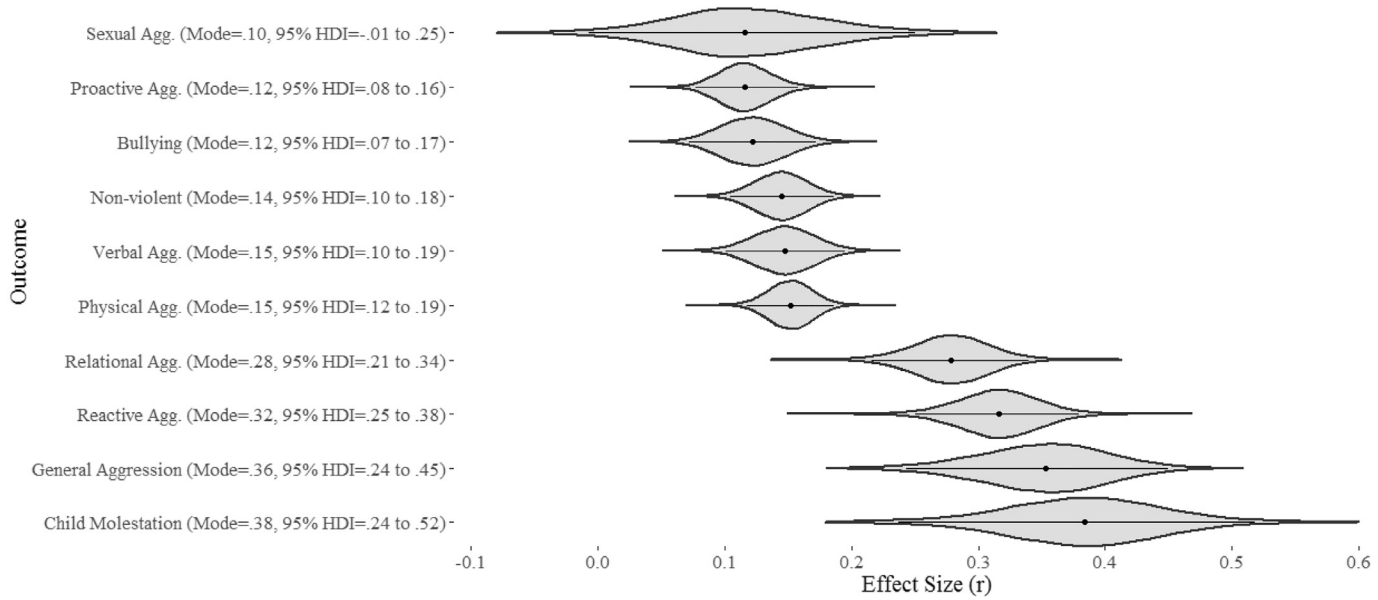

Fig. 6. Posterior Distributions for Neuroticism's Relations with Study Outcomes. Note: Mode = Mode effect size value of the posterior distribution; HDI = Highest density interval; the solid black bar beneath the posterior distribution covers the 95% highest density interval of the posterior effect size distribution; Non-violent = non-violent antisocial behavior; Agg. = Aggression; all effect sizes are based on partially disattenuated correlations.

Table 2
Moderator analyses results.

	Child (1) vs. Adult (0)	Prison (1) vs. Non-prison (0)	Community (1) vs. College Samples (0)	NEO-Based (1) vs. Non-NEO (0)	Unpublished (1) vs. Published (0)
Antisocial Behavior					
Neuroticism	0.01	0.03	−0.06	0.00	−0.07
Extraversion	−0.01	−0.01	0.00	−0.02	−0.03
Openness	−0.08	−0.02	0.00	0.07	0.10
Agreeableness	−0.01	0.12	−0.02	0.03	0.11
Conscientiousness	−0.08	0.13	0.01	0.05	0.04
Aggression					
Neuroticism	−0.01	0.02	−0.04	−0.03	−0.08
Extraversion	−0.02	−0.01	−0.01	−0.03	−0.03
Openness	−0.07	0.03	0.00	0.05	0.04
Agreeableness	0.09	0.09	0.00	0.04	0.12
Conscientiousness	−0.05	0.05	0.03	0.07	0.05

Note: All displayed moderator effects are the differences between the modes of the posterior distributions for the moderator variables coded as “1” and “0”.

sizes. In regard to Agreeableness' posterior effect sizes for the average antisocial behavior outcome, its posterior effect size was less negative among prison samples (by 0.12) and when the effect size was based on unpublished data (by 0.11). Similar results were observed for Agreeableness' posterior relations with the average aggression outcome, including when child samples were compared to non-child samples (Agreeableness' posterior effect size was less negative by 0.09 in child samples for the aggression outcome).

In regard to Conscientiousness' posterior effect size for the average antisocial outcome, Conscientiousness' effect size was less negative in prison samples compared to non-prison samples (by 0.13). For the average aggression outcome, Conscientiousness' posterior effect size showed the largest degree of moderation when the effect size was derived from samples that had utilized a NEO-based measure compared to other types of FFM measures (the effect size was less negative by 0.07). The plotted posterior distributions for the larger moderator effects for Agreeableness and Conscientiousness can be seen in Supplementary Figs. S2 and S3.

6.5. Discussion

The present meta-analysis aimed to summarize the available literature on the FFM's relation to a variety of antisocial outcomes using Bayesian meta-analytic methods. Based on previous work, we hypothesized that Agreeableness and Conscientiousness would be the most robust correlates of nearly all forms of antisocial behavior. The meta-analytic results provided support for these hypotheses, and highlight important directions for future research.

6.6. Utility of Bayesian meta-analytic methods

When comparing the present results using Bayesian meta-analytic methods to traditional meta-analysis results in Table 1, a few results are worth mentioning. First, when examining the average antisocial and aggressive behavior outcomes, the results from both approaches are nearly identical both in point estimates and interval estimates. However, this should not be taken to mean that the two approaches are interchangeable, as the substantive interpretations from the data are quite different. As previously mentioned, probabilistic statements can only be applied to the Bayesian results. Second, the intervals provided by the two approaches have very different interpretations despite their similarities in numerical range. If researchers are interested in making inferences about the range of the most probable effect sizes given the present data, only the HDIs are suited for such inferences.

A practical benefit of Bayesian approaches is also seen when comparing the Bayesian results to results from traditional meta-analytic methods. As previously noted, the updated posterior effect sizes for the average antisocial and aggression outcomes were computed by utilizing priors derived from an analysis of the Jones et al., 2011 data, and then analyzing the new data taken from studies published since 2011. In other words, Bayesian meta-analytic methods allow for greater efficiency in updating meta-analytic information—instead of needing to gain access to or manually record all previous study information, one would only need the point estimate(s) and variability around the point estimate(s) to sufficiently represent previous study information. This information would be easily accessible in any published meta-analysis and, in turn, could substantially decrease the amount of time needed to incorporate previous meta-analytic information into an updated meta-analysis.[10] Thus, updating meta-analytic results through the use of priors has the potential to eliminate many hours of manual data entry.

6.7. FFM domains and antisocial behaviors

Across the antisocial outcomes included in the domain level analyses, Agreeableness and Conscientiousness demonstrated negative relations with antisocial behavior, though Agreeableness' relations were consistently larger than those of Conscientiousness. Thus, the meta-analytic results strongly suggest that descriptive research on the FFM and antisocial behavior will find significant negative relations between these domains and antisocial behavior, regardless of what manifestation of antisocial behavior is under investigation. However, the results also suggest that the magnitude of these domain relations may differ for particular outcomes related to antisocial behavior. The clearest example of this was the divergent relations for child molestation outcomes.

Recent work that has examined the categorization of child molesters provides important insight into our present findings. In their critique of previous attempts to classify child molesters into subcategories, Marshall et al. (2014) highlight that previous subtyping schemes have either used criteria that give rise to heterogeneous subgroups or result in low agreement on which group an individual belongs to (e.g., incest offenders versus nonfamilial offenders). Offering a potential solution, Marshall et al. (2014) highlight that the modus operandi of the majority of child molesters involves the use of non-coercive strategies such as “grooming” which in turn requires perpetrators to develop a seemingly nurturing relationship with the victim. The authors note that this method is more characteristic of child molesters who have molested relatives or who are acting in some type of caretaking role (e.g., stepfather). A divergent method, found for the minority of child molesters, involves a lack of grooming behaviors and is more likely to be characterized by a use of force or coercive tactics. This method of offending is more characteristic of perpetrators who do not know their victims. The authors offer that distinguishing between “affiliative” and “non-affiliative” child molesters can be a useful method for addressing the observed heterogeneity within the broader category of child molesters.

Though the authors focus on the modus operandi and abusive context as useful ways of distinguishing child molesters, the present data suggest that personality-based evidence may offer complementary support for the affiliative versus non-affiliative distinction. Namely, it appears that the child molester samples included in our analyses are of the affiliative type. In turn, an FFM conceptualization of child molesters would suggest that the specific tactics of child molesters may depend on levels of Agreeableness, with affiliative child molesters expected to score higher on Agreeableness compared to non-affiliative child molesters. Non-affiliative child molesters may resemble typical sex-

[10] See Higgins, Thompson, and Spiegelhalter (2009) for a comprehensive review of how one can go from frequentist meta-analytic results to a Bayesian prior.

offenders in their personality profiles, while they diverge from typical sex-offenders in the age of their victims.

Our meta-analytic results also suggest that Neuroticism and Extraversion may also serve as relevant personality characteristics for child molestation. Whether these latter two FFM domains can serve to distinguish between child molester subtypes is a potential direction for future research. The large effect size for Neuroticism is consistent with previous work that has found that child molester samples report a wide degree of deficits that fall under the umbrella of Neuroticism. These deficits include general anxiety (Nunes, Mcphail, & Babchishin, 2011), self-consciousness in social and evaluative situations (Overholser & Beck, 1986), and feelings of loneliness (Seidman, Marshall, Hudson, & Robertson, 1994).

Ultimately, the FFM framework can serve as a useful tool to bridge the gap between general personality models and assessment of child molesters. In fact, it offers a more parsimonious, dimensional classification system that can elucidate what traits may be common to all types of child molesters (e.g., high Neuroticism) and what traits may help differentiate child molesters from one another in regard to offending behaviors (e.g., varying levels of Agreeableness). However, additional data are needed to more fully elucidate the FFM profile of child molesters. FFM assessments that incorporate facet scales may be particularly helpful in this regard, as such assessments allow researchers to examine more specific traits within the domains as well as explore potential heterogeneity within the broader domains.[11] Such work can also be connected to the expanding literature on the FFM and pathological personality. For example, we compared the FFM facet profile for the child molestation outcome to a meta-analytic FFM facet profile of dependent personality disorder (see Table 2; Miller & Lynam, 2008). Dependent personality disorder is a personality disorder included in the DSM-5 that is characterized by a strong need or desire to be taken care of by others leading to notable levels of submissive and clingy behavior (American Psychiatric Association, 2013). The profile comparison was conducted using an intraclass correlation (r_{ICC}), which takes into account profile elevation, scatter, and shape (Furr, 2010). The two profiles were very strongly related ($r_{ICC} = 0.90$), which raises the question whether insights from research on dependent personality disorder can inform research that has focused on individual differences among child molesters.

Three other aggression outcomes deserve mention in regard to the observed domain effect sizes: general aggression, relational aggression, and reactive aggression. In regard to general aggression, Agreeableness and Neuroticism's effect sizes showed notable increases in magnitude compared to their effect sizes for other outcomes, as did Conscientiousness. Importantly, the posterior effect sizes for these three domains were estimated after having to adjust the priors due to abnormally large τ^2 estimates. The most straightforward explanation for the inflated τ^2 estimates is that the prior based on the effect size of the average aggression outcome was not appropriate for the general aggression outcome. In other words, the general aggression outcome is qualitatively different from the average aggression outcome. One possible reason for the differences is that measures in the general aggression outcome include content that is itself more trait-like resulting in predictor-criterion overlap, and in turn, inflated effect size estimates.

Measures that fit under the category of general aggression tended to be diffuse in their coverage of "aggressive" behaviors. For example, correlations between the FFM domains and the total score of the Buss-Perry AQ (BPAQ) ($k = 6$) were included as effect sizes for the general aggression outcome. The BPAQ and similar broad-based measures of trait aggression assess a range of content including temper tantrums, argumentativeness, irritability, and trait hostility. The BPAQ specifically includes subscales labeled Anger and Hostility with items that assess more trait-like qualities (e.g., "I am an even tempered person") compared to the other BPAQ subscales that include items which assess aggressive behavior explicitly (e.g., "If somebody hits me, I hit back"). Thus, there is likely significant criterion-predictor overlap for both Neuroticism and Agreeableness, with features of Agreeableness related to trusting others being inversely related to hostility towards others. Ultimately, we suggest that researchers avoid using such broad measures of aggression that include trait-related content as they will result in inflated estimates of the relation between personality traits and aggression.

While Neuroticism was relatively unimportant to proactive forms of aggression, there was a noticeable increase in its relation to reactive and relational aggression, providing further support for the importance of traits related to negative affect and their relation to particular forms of aggressive behavior. The present results are also consistent with research that has highlighted that reactive and relational aggression are more closely tied to affective reactivity and distress compared to other forms of aggression (e.g., Miller et al., 2012; Reardon et al., 2018).

Last, both Extraversion and Openness were largely unimportant to any type of antisocial behavior. Though the present results are consistent with other research in regard to Openness (e.g., Decuyper, De Pauw, De Fruyt, De Bolle, & De Clercq, 2009), Extraversion's lack of importance is likely masking heterogeneity within the broader domain (Watson, Stasik, Ellickson-Larew, & Stanton, 2015). As Jones et al. (2011) found in their meta-analysis of the FFM facets relations with antisocial outcomes, the facets within Extraversion show conflicting relations such that the E1 (Warmth) and E6 (Positive Emotions) tend to show negative relations with antisocial behavior while the E5 (Excitement Seeking) facet is positively related to the same outcomes. This heterogeneity leads to small or null relations at the domain level. Ultimately, Extraversion's relevance to antisocial behavior is unlikely to appear at the domain level while Openness' relevance will remain consistent at both facet and domain levels.

6.8. Moderator results

The majority of the moderator results showed that the moderators did not have particularly notable influence on effect size estimates. However, the moderation of Conscientiousness' effect size with the average antisocial behavior outcome by prison versus non-prison samples deserves mention, given some evidence that participants in forensic samples seem to surprisingly report higher levels of Conscientiousness when compared to normative samples (Eriksson, Masche-no, & Dåderman, 2017). Other meta-analytic results that have examined mean individual differences among forensic populations have found similar results such that forensic samples report being less impulsive than controls (Spaans, Molendijk, de Beurs, Rinne, & Spinhoven, 2017). Taken together, the results suggest that the use of self-report measures of personality in forensic settings may require additional sources of information (e.g., informant reports) or the use of more neutral language for items assessing Conscientiousness, given that these scores are most likely to be affected by socially desirable responding (Bäckström, 2007).

Another potential explanation that has received little attention in the forensic literature is what comparisons forensic populations are using when evaluating their own personality. If offenders are more likely to compare themselves to other offenders (likely the most salient comparison), as opposed to non-offenders in the general population, it may result in inflated perceptions of one's own level of self-control if the comparison is to highly disinhibited and/or antagonistic individuals more likely to be found in forensic populations. This explanation is

[11] Of the 5 samples examined for domain analyses, 2 samples (*Ns* of 93 and 44) also reported facet level data. Though the results should be interpreted with caution given the limited data, the facet scales were meta-analyzed and the results highlight important heterogeneity within the domains (See Supplementary Materials; Table S4). For example, child molestation was negatively related to the Trust (A1) facet, but was positively related to the Modesty (A5) and Tender-mindedness (A6) facets.

consistent with research on the reference group effect (Heine, Lehman, Peng, & Greenholtz, 2002), and research on the reference group effect may also offer some potential solutions to this issue. For example, when discussing what to do when faced with potential reference group problems, Heine et al. (2002) suggest including more specific instructions on whom the respondents should compare themselves to (e.g., other prisoners or to the average, non-incarcerated adult). Given the independent results of two meta-analyses that have found counter-intuitive mean differences (or lack thereof), future examination of the validity of self-reported personality in forensic populations is needed.

6.9. Implications for future research on antisocial behavior and personality

The present meta-analysis underscores the utility of examining personality domains that are relatively homogenous (Smith, McCarthy, & Zapolski, 2009). For example, examining the relationship between antisocial behavior and a personality dimension which blends Agreeableness and Conscientiousness traits (e.g., the Psychoticism dimension from the PEN model) will mask important differences between the two types of traits and their respective relations with antisocial behavior. Our results show that Agreeableness' relations with most antisocial outcomes is about twice the magnitude of Conscientiousness'—an important difference that would be difficult to examine if the domains were not assessed independently.

The results also have important implications for broader models of aggressive behavior. Specifically, the results suggest that models of aggressive behavior must consider the role of traits that fall within the domains of (low) Agreeableness and (low) Conscientiousness as fundamental etiological components of what makes certain individuals more likely to be aggressive. Indeed, the present results complement a large amount of research that has examined some of the more specific traits related to antisocial behavior including callous-unemotional traits (Frick, Ray, Thornton, & Kahn, 2014; Mann, Briley, Tackett, Tucker-Drob, & Harden, 2015), and sensation seeking/impulsigenic traits (Mann, Paul, Tackett, Tucker-Drob, & Harden, 2017). This work has shown that more specific traits that can be considered to fall under the umbrella of FFM Agreeableness (callous-unemotional traits; Assary, Salekin, & Barker, 2015; Sherman, Lynam, & Heyde, 2014) may show even more substantial relations with varying forms of antisocial behavior. Though antagonistic traits tend to be well captured by the domain of Agreeableness (though important content related to trait anger resides within Neuroticism), disinhibitory traits span multiple domains (e.g., Whiteside & Lynam, 2001). As a result, we argue that important insights are more likely to be provided by measurement approaches that allow for examination of more elemental aspects of the FFM domains (e.g., Vize, Miller, & Lynam, 2018), frequently assessed by facet scales available in particular FFM or FFM related measures (e.g., the HEXACO-PI-R; Lee & Ashton, 2004).

Other research, such as the work of Robinson, Wilkowski, and their colleagues (e.g., Meier & Robinson, 2004; Wilkowski, Robinson, & Meier, 2006) has provided examples of merging social cognitive and individual differences approaches to understanding the more fundamental processes that may make it more likely for certain individuals to become aggressive. For example, Wilkowski et al. (2006) found that less agreeable individuals view antisocial stimuli for longer periods of time and show difficulty disengaging from such stimuli. On the other hand, more agreeable individuals tended to have difficulty disengaging from positive stimuli. The authors argue that such processes may help explain more “downstream” agreeableness outcomes, such as aggression. However, much of this work has focused on reactive forms of aggression that rely heavily on affective arousal. Future work can explore more proactive forms of aggression and also non-violent antisocial behavior, which despite its qualitative divergence from aggression, has nearly identical personality correlates.

It is also worth noting that the present results have solely focused on main effects of the FFM domains, and did not examine trait by trait interactions. Additional variance in antisocial and aggressive behavior outcomes may be accounted for by interactions among the FFM domains, particularly the interaction of traits related to (low) Agreeableness and (low) Conscientiousness. Indeed, when both antagonistic and disinhibitory traits are present in an individual, it is likely that their antagonistic dispositions are far more likely to be expressed in aggressive or antisocial ways due to the lack of inhibitory capabilities.

The present results also provide suggestion for clinical research and practice. First, the meta-analytic results help explain why more multidimensional clinical constructs like antisocial personality disorder (APD), narcissistic personality disorder (NPD), and borderline personality disorder (BPD) demonstrate relations with antisocial behavior outcomes. The alternative model for personality disorders included in Section III of the DSM-5 (American Psychiatric Association, 2013) characterizes each of the above personality disorders as being composed of traits related to antagonism, disinhibition, and negative affectivity (though negative affectivity is only represented within BPD).[12] Our data indicate that the broader PDs' relations with antisocial behaviors are likely a direct result of how much antagonistic, disinhibitory, and negative affectivity content is included within each of the PDs. In regard to antagonistic traits in DSM-5 Section III, APD contains four traits from the broader domain: manipulativeness, callousness, deceitfulness, and hostility. NPD contains the two traits of grandiosity and attention seeking, and BPD one trait: hostility. Although Section III NPD is entirely represented by the two antagonistic traits, APD and BPD both contain additional traits related to disinhibition while BPD also contains a significant trait content related to negative affectivity. Thus, based on the present meta-analytic data, one could make a variety of predictions about how each of the PDs should map onto antisocial behavior outcomes. Of the three personality disorders, BPD contains less antagonistic content compared to NPD and APD while containing significantly more content related to negative affectivity. In turn, the present results suggest that one would expect BPD to show limited relations to proactive forms of aggression while being positively related to reactive and relational forms of aggression. The available literature on BPD and aggressive behavior supports this hypothesis (e.g., Critchfield, Levy, Clarkin, & Kernberg, 2008).

Concerning NPD and APD, both PDs contain significantly more antagonism within their DSM-5 Section III conceptualization compared to BPD. In turn, our data would suggest that both of these PDs should show relatively robust relations with a variety of antisocial behaviors, with APD showing the most robust relations due to the inclusion of additional traits related to disinhibition that are not included within NPD. Additionally, APD also includes greater mean levels of antagonism compared to NPD and BPD. These predictions are strongly supported in the empirical literatures on both NPD and APD (e.g., Gilbert, Daffern, Talevski, & Ogloff, 2015; Rasmussen, 2016).

Ultimately, the present results suggest that clinical nosologies will be able to tap into clinically relevant antisocial behavior so long as there is sufficient antagonistic content included in any given mental disorder. Thus, the current results also inform other nosologies outside of DSM-5 Section III, like the recently proposed Hierarchical Taxonomy of Psychopathology (HiTOP; Kotov et al., 2017). The goal of the HiTOP consortium is to provide a more empirically supported hierarchical classification system of mental disorders, highlighting six *spectra* that encompass psychopathology. Of most relevance to the present results are the disinhibited externalizing and antagonistic externalizing spectra, which are more specific spectra of the broader *super-spectrum* of externalizing. The HiTOP classification also highlights that the two

[12] Importantly, the NPD conceptualization within the DSM-5 is typically understood to be representative of grandiose narcissism, as opposed to vulnerable narcissism. Vulnerable narcissism has been shown to contain a significant amount of neuroticism and shows very similar empirical relations to BPD (Miller et al., in press).

spectra of externalizing (antagonistic and disinhibited) are important correlates of antisocial behavior. Our current meta-analytic results suggest that at a general level, antagonism and disinhibition related traits are indeed most important to antisocial behavior but that the former is a more robust correlate than the latter (which is sometimes missed in models that use fewer domains and thus collapse the two dimensions into one broader domain, often termed [perhaps misleadingly] disinhibition). Although not explored in depth yet, it is possible that NIMH's Research Domain Criteria (RDoC; Insel et al., 2010) includes overlapping constructs via its "social processes" and "cognitive systems" domains that appear at least partially overlapping with Agreeableness/antagonism and Conscientiousness/disinhibition, respectively. It is important to note, however, that our results also show that neuroticism evinces moderate positive relations with specific forms of antisocial behavior, namely reactive and relational aggression. Thus, for nosologists interested in greater predictive specificity, antagonism and disinhibition may not tell the whole story for fine grained antisocial outcomes even though they may be necessary and sufficient in understanding the trait correlates of general antisocial behavior.

The present results also have implications for prevention research and clinical practice. First, targeted intervention programs designed to reduce aggressive or antisocial behavior may benefit from incorporating FFM personality risk factors (e.g., low Agreeableness and low Conscientiousness related traits) into their assessment of individuals at risk, which may enhance accuracy in determining which individuals are identified as "high-risk" (Wilson & Lipsey, 2007). Previous work has shown that trait-targeted interventions can produce positive outcomes. For example, individuals high in sensation-seeking were found to be more responsive to public service announcements specifically designed to be more engaging to such individuals (Harrington, Palmgreen, & Donohew, 2014). Given that Agreeableness was the most robust correlated of antisocial behavior, targeted interventions for young individuals low in Agreeableness-related traits will likely be most beneficial, and recent preliminary work that has utilized such an approach appears promising (Kimonis et al., 2018).

Relatedly, empirical work has begun to examine if and how personality may change over time following intervention (Roberts et al., 2017; Roberts, Hill, & Davis, 2017). First, research has shown that people generally report *wanting* to change particular personality attributes, with individuals wanting to increase their emotional stability (i.e., wanting lower levels neuroticism) and conscientiousness in particular (Hudson & Roberts, 2014). When examining maladaptive personality traits (as measured by the PID-5), recent evidence suggests that antagonistic and disinhibited individuals acknowledge their problematic levels of these traits and the associated impairment they experience due to these traits and report a desire for reduced levels (i.e., Miller et al., in press; Sleep, Lamkin, Lynam, Campbell, & Miller, 2018).

Recent longitudinal work has shown that interventions aimed at having individuals develop specific, tangible goals for what they would like to change about their personality are able to bring about moderate levels of personality change (Hudson & Fraley, 2015; Roberts, Luo, et al., 2017). Hudson & Fraley (2015; Study 2) found that for individuals who were encouraged to develop specific weekly goals related to their desired personality change, these individuals were able to increase their level of self-reported Extraversion, emotional stability, and Conscientiousness over the course of 15 weeks compared to a control group. Importantly, similar changes were not observed for Agreeableness. In their meta-analytic examination of personality change brought about by intervention, Roberts, Luo, et al. (2017) found moderate effect sizes due to intervention efforts, but these effects were most notable for Extraversion and emotional stability. Again, changes in Agreeableness were negligible.

So what bearing do these results have on treatment of individuals who may display the traits that increase the risk of antisocial behavior? First, it suggests some optimism regarding interventions aimed at personality change. This optimism notwithstanding, more work is needed in order to determine if the changes brought about by such interventions are clinically relevant and meaningful. Furthermore, Hudson and Fraley (2015) found that changes were most notable for individuals that expressed a high desire to change in the first place. This suggests that most clinical interventions aimed at personality change will likely need to start at increasing motivation to change. Such techniques are incorporated in popular treatment interventions like motivational interviewing (MI; Miller & Rollnick, 2012). Fortunately, preliminary evidence (e.g., Miller et al., in press) suggests that individuals with higher levels of maladaptive traits may be, at worst, ambivalent about changing such traits.

Next, recent models have been put forward for specific interventions that may bring about personality trait change. Of most relevance is the Sociogenomic Trait Intervention Model (STIM; Roberts, Hill, & Davis, 2017), which has been developed to bring about changes in trait Conscientiousness. Roberts, Hill, and Davis (2017) argue for the use of behavioral activation (BA) interventions to increase the frequency of conscientious behaviors, which in turn make way for long-term changes in trait Conscientiousness. Thus, combinations of MI techniques to first identify motivations to change and implementing BA methods to bring about such change appears to be a promising approach for bringing about change to personality traits implicated in antisocial behavior. It is likely that treatment approaches aimed at changing any of the fundamental dimensions of personality, if successful, would have broad, transdiagnostic effects given the substantial personality – psychopathology relations (e.g., Kotov, Gamez, Schmidt, & Watson, 2010).

Importantly, much of the recent work on the effects of interventions on personality change have provided evidence that trait Agreeableness may prove more difficult to change. Such results give rise to important questions regarding interventions for antisocial behavior. First, more research is needed to better understand *why* Agreeableness may be less likely to change compared to other traits. Compared to Conscientiousness, Agreeableness is more interpersonal in nature and thus it may be harder to develop behavioral activation interventions for such behaviors. For example, some agreeable behaviors (e.g., being kinder to others, increasing one's honesty) are likely harder to "activate" compared to conscientious behaviors (e.g., being more organized and planful). Relatedly, it may be harder for individuals to develop specific goals for agreeable behaviors compared to conscientious behaviors. Finally, given the oft-times aversive interpersonal qualities of antagonistic individuals, it may be difficult to evoke change due in part to cumulative and interactional continuity processes (e.g., Caspi, Bem, & Elder, 1989). Given Agreeableness' importance when it comes to antisocial behavior, future research is needed that focuses on some of the processes that may make agreeable traits more difficult to change within a therapeutic context.

6.10. Limitations

There are two notable limitations to the current meta-analysis. First, the majority of outcomes relied on self-reported antisocial behavior (approximately 79% of included samples). Criticisms have been leveled at the over-reliance on self-reported behavior (Baumeister, Vohs, & Funder, 2007), and future work on relations between personality and antisocial behavior is likely to benefit from incorporating a broader assessment approach that is less dependent on self-reported outcomes and personality instruments. That being said, there is evidence that the same traits are critical correlates of these outcomes (e.g., aggression) when using only behavioral measures of the outcomes (e.g., Hyatt, Zeichner, & Miller, 2018).

Second, though we included a variety of antisocial behavior outcomes, there is likely a good deal of overlap among outcomes given that they are all different manifestations of antisocial behavior. In a recent meta-analysis of the FFM facets and antisocial behavior (Vize et al., 2018), there was notable overlap among the antisocial outcomes in terms of their facet profiles (r_{ICC} range = 0.80 to 0.92). Though

qualitative descriptions of aggression and antisocial behavior subtypes underscore differences (e.g., hitting someone is different than knowingly spreading false rumors about someone), meta-analytic results suggest moderate to large interrelations among antisocial behavior outcomes. Nonetheless, the present results indicate that the various forms of antisocial behavior are not completely isomorphic—non-trivial variability was observed among FFM effect sizes depending on the outcome under investigation. For example, Neuroticism's effect sizes for reactive and relational aggression were notably larger compared to Neuroticism's effect sizes for bullying and physical aggression.

6.11. Conclusion

The present meta-analysis provides a clear picture of what FFM domains are likely to be most important to various forms of antisocial behavior. As highlighted above, a variety of implications for future research, including prevention and clinical research, stem from the robust relations observed in the present meta-analysis. Ultimately, it is reasonable to suggest that personality research ought to move beyond mere descriptive work on the FFM and antisocial behavior and towards other avenues of research. Indeed, recent work has cogently argued that integrating multiple avenues of personality research and moving beyond descriptive work is essential in order to move towards an explanatory science (Baumert et al., 2017). These points are relevant to work on the FFM and antisocial behavior, and can serve as a useful framework for future research that looks to empirically examine *how* particular FFM domains come to be robust correlates of antisocial behaviors.

Declaration of interests

We wish to confirm that there are no known conflicts of interest associated with this publication and there has been no significant financial support for this work that could have influenced its outcome. We confirm that the manuscript has been read and approved by all named authors and that there are no other persons who satisfied the criteria for authorship but are not listed. We further confirm that the order of authors listed in the manuscript has been approved by all of us.

We confirm that we have given due consideration to the protection of intellectual property associated with this work and that there are no impediments to publication, including the timing of publication, with respect to intellectual property. In so doing we confirm that we have followed the regulations of our institutions concerning intellectual property.

We understand that the Corresponding Author is the sole contact for the Editorial process (including Editorial Manager and direct communications with the office). He/she is responsible for communicating with the other authors about progress, submissions of revisions and final approval of proofs. We confirm that we have provided a current, correct email address which is accessible by the Corresponding Author.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.cpr.2018.09.001.

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