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Does Eysenck's personality model capture psychosis-proneness? A systematic review and meta-analysis

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ABSTRACT

Eysenck's model of personality (PEN) was one of the most influential personality models in the 20th century. A unique characteristic of this model is the claim of psychosis-proneness being incorporated into it as one of its three basic traits - Psychoticism. The main goal of this systematic review and meta-analysis is to find out the associations between PEN traits and a diverse set of operationalizations of psychosis-proneness (PP). We set the benchmark for assuming their distinctness to a correlation coefficient amounting to 0.40. A systematic review has been conducted, yielding 350 correlations of interest. By computing inverse sampling variance weighted mean correlation coefficients, we found the following associations between psychosis-proneness and Psychoticism, Extraversion, and Neuroticism, respectively: 0.21, −0.09, and 0.30. All prediction intervals around the three mean effect sizes do include zero, suggesting that psychosis-proneness is only marginally captured by the PEN model. Moderator analyses further demonstrated this distinctness and the lack of phenotypic validity of the Psychoticism scale/construct.

1. Introduction

In his still influential[2] model of personality, Hans Eysenck postulated the existence of three basic, broad personality traits i.e., Neuroticism (N), Introversion-Extraversion (E) and Psychoticism (P) (Eysenck, 1952, 982; Eysenck & Eysenck, 1976). Eysenck's personality model was the first and the only one to articulate psychosis-proneness (PP) as a trait-like dispositional source of normal personality variations. Specifically, Eysenck's P was conceptualized as a continuum of psychosis-proneness/psychotic diathesis/liability to psychosis ranging from the indices of good socialization, empathy, and conformism - defining the negative pole of the dimension - through impulsivity, hostility, aggressiveness, and psychopathy to schizoidity, unipolar depression, affective disorders, schizoaffective disorders and schizophrenia - defining its positive pole. In one of its latest model operationalizations (Jackson, Furnham, Forde, & Cotter, 2000), P consists of risk-taking, impulsiveness, irresponsibility, manipulativeness, sensation-seeking, tough-mindedness, and practicalness. Eysenck's N and E are conceptualized similarly (but not identically) to the corresponding dimensions in the Big Five model variants. Trait N comprises anxiety, inferiority, dependence, guilt, hypochondria, unhappiness, and obsessiveness, while E contains sociability, activity, assertiveness,

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[2] A superficial search on Google scholar revealed that from 2007 to 2016 Eysenck HJ was mentioned around 24,200 times, McCrae RR around 37,600, Cloninger R around 17,900, and Ashton MC 5150 times (syntagmas Eysenck('s)…/Big Five…/Cloninger('s)…/HEXACO… …personality theory/model were mentioned 246, 1953, 87 and 265 times respectively, for the same period).

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dogmatism, expressiveness, ambition, and aggression (Eysenck, Barrett, Wilson, & Jackson, 1992; Jackson et al., 2000).

Our previous meta-analyses (Knežević et al., 2016; Lazarević et al., 2016) demonstrated that proneness to psychotic-like experiences/psychosis is not adequately represented within either the Big Five or Cloninger's Psychobiological model of personality. If we accept that PP indicates an important dispositional source of normal personality variations, Eysenck's model fills the gap since it postulates the existence of such a liability to psychosis as one of the three basic sources of personality variations. If the P scale measures PP, one would expect it to correlate substantially with various models/measures of psychotic-like phenomena. In line with this, we formulate our *first hypothesis*: we expect a substantial meta-analytically estimated correlation between Psychoticism and PP models/measures, while correlations between the remaining two personality traits (Neuroticism and Extraversion) and PP are expected to be low. The expectation of low correlations of PP with N and E is in accordance with our previously mentioned meta-analytical findings (where the absolute value of these correlations was below 0.30). The criteria on what should be considered substantial (indicating critical conceptual overlap) and low (indicating separateness of the constructs) will be elaborated later. The obvious advantage of the meta-analytical approach in capturing the correlation between Psychoticism and PP (beyond the one generally characterizing meta-analyses - the possibility to adequately address the issue of sampling error) is that it guarantees a wide representation of PP indicators (because many multidimensional models of PP are included), thus minimizing the chances to miss the correlation if it exists.

The validity of the P scale, however, has been repeatedly questioned. It was demonstrated that P encompasses a variety of weakly related phenomena (e.g., Howarth, 1986), the genetic variance of which was unrelated or even negatively related, indicating that different etiological mechanisms were involved (Heath & Martin, 1990). The specificity and construct validity of the P scale was further criticized by Claridge (1983) and Claridge et al. (1996), and its predictive validity by Chapman, Chapman, and Kwapil (1994). Many validation studies found that P predominantly captured various aspects of uncontrolled aggressiveness (low Agreeableness and low Conscientiousness in Big Five terminology) and psychopathy, rather than a predisposition towards psychosis (Claridge, 1983; Costa & McCrae, 1992; Goldberg & Rosolack, 1994; Momirović & Kostić, 1998; Zuckerman, 1989, 2005). If these authors were right in arguing that Eysenck's P is just a combination of low A and low C, bearing in mind the results from previous meta-analyses reporting low meta-analytical correlations between these two traits and the PP domain (Knežević et al., 2016; Lazarević et al., 2016; Samuel & Widiger, 2008; Saulsman & Page, 2004), one should expect low correlations between Psychoticism and PP. Taking these considerations into account we formulate an *alternative hypothesis*: none of the traits within Eysenck's personality model will account for a substantial amount of variance in PP measures, i.e., all meta-analytically estimated correlations between PEN traits and PP measures are expected to be low. If obtained, the finding of a low meta-analytically estimated correlation between P and PP would seriously question the validity of Eysenck's P scale and the adequacy of his conceptualization of PP. Here, we would like to emphasize that unlike the majority of previous validation studies showing that P is *too heterogeneous* and *too close to some other traits* to be a valid measure of PP, in our approach we tested its validity in a more straightforward manner – by investigating its relationships with various accepted PP measures.

If one - regardless of P not showing substantial correlations with various measures of PP - wishes to defend it as a conceptualization of PP, she/he could argue that these "phenotypic correlations" are not the *conditio sine qua non* of its validity if the genetic correlations can be documented between P and PP. In other words, if the genetic component of Psychoticism is shown to be related to the genetic components of various measures of PP, their phenotypic unrelatedness would not be detrimental to the claim of validity of P (van Kampen, 2009). However, the evidence supporting the genetic correlations between P and PP measures seems to be weak at best (van Kampen, 1993). Considering this evidence, the absence of substantial phenotypic correlations between Psychoticism and PP can be interpreted as detrimental to the claim of validity of Psychoticism.

1.1. On the definition of the PP domain

We have previously defined PP as a general multidimensional liability to psychosis, but how can we ensure that this domain is adequately represented? We assume that the inclusion of numerous constructs containing the prefix "schizo", such as schizotypy, schizoidness and schizophrenia guarantees adequate representation of the domain. Indeed, it seems that various symptom models, designed under these umbrella terms, capture the entire spectrum of psychotic-like phenomena ranging from non-clinical levels to the level characterizing individuals with schizophrenia. To illustrate with an example, only four models that can be found searching for "schizo" (Chapman, Chapman, Kwapil, Eckblad, & Zinser, 1994; Lindenmayer et al., 2004; Mason, Claridge, & Williams, 1997; Raine, 1991) capture the following variety of PP symptom clusters: ideas of reference, magical thinking, unusual perceptual experiences, eccentric behavior, odd speech, constricted affect, suspiciousness, excessive social anxiety, cognitive disorganization, introvertive and physical anhedonia, depression, mania, and impulsive nonconformity. Although - together with Markon (2010) or Andresen (2000) - we acknowledge the unexpected broadness of the domain, our data (Knežević, Savić, Kutlešić, & Opaćić, 2017) clearly demonstrated that some of the contents usually considered as PP aspects are in fact primary indicators of some other dispositions (e.g., social anhedonia is a primary indicator of low Extraversion, and physical anhedonia is entirely unrelated to PP).

However, our position is that no content suggested by various PP models should be excluded from this analysis: we prefer the conclusions on PEN - PP relations to be independent of particular conceptualizations of the later. Thus, the meta-analytical approach to test the validity of P seems to be a fair one: taking into account many multidimensional PP models and not excluding any of their subdimensions/contents makes the P - PP correlation more likely to appear. Furthermore, the inclusion of those behavioral aspects that are supposedly only marginally related or unrelated to the PP domain, enables - through moderator analyses - a more refined investigation of its relations with PEN traits.

1.2. Disintegration - a model serving as a theoretical basis for building specific hypotheses on the relations between PEN and PP

Recently, psychosis-proneness has been conceptualized as a broad, hierarchically organized, multidimensional behavioral disposition comprising 9 subdimensions: General Cognitive/Executive Impairment, Perceptual Distortions, Enhanced Awareness, Apathy/Depression, Paranoia, Mania, Flattened Affect, Somatic Dysregulations, and Magical Thinking. This trait was named Disintegration (Knežević et al., 2017) and a Disintegration factor was found to be separate from the Big Five traits. Unlike Krueger and his associates, who conceptualize Psychoticism as a trait underlying only abnormal personality variations (their inclination to view psychoticism as extreme Openness in normal personality variations is visible in Dilchert, Ones, & Krueger, 2015), we postulate Disintegration as a dimension accounting for both normal and abnormal personality variations, and clearly separate from all Big Five traits.

One of the advantages of the proposed model over other existing models of schizotypy/PP is its comprehensiveness. Namely, the Disintegration model subsumes most of the PP models suggested so far: the two factor model (positive and negative symptoms - Kay, Opler, & Fiszbein, 1987), three factor models (disorganization, positive and negative symptoms — Buchanan & Carpenter, 1994, or depression,

positive and negative symptoms — Stefanis et al., 2002), the four factor model (positive symptoms, negative symptoms, depression and mania, van Os et al., 1999), a recently proposed four-factor model (reality distortion, disorganization, inexpressivity and apathy/asociality, Kotov et al., 2016[3]), the five factor models (disorganization, positive symptoms, negative symptoms, depression and mania — Lindenmayer et al., 2004, or disorganization, paranoia, negative symptoms, depression and mania — Serretti & Olgiati, 2004) or Raine's (1991) model based on DSM-III-R criteria of schizotypal personality disorder (ideas of reference, magical thinking, unusual perceptual experiences, eccentric behavior, odd speech, constricted affect, suspiciousness - practically all aspects except excessive social anxiety and absence of friends). It is important to stress that the Disintegration model is a broad one, but it is explicit in excluding social (introvertive) and physical anhedonia (which are parts of many PP models), as well as impulsive nonconformity.[4]

The reason for introducing the empirical model of Disintegration here is to use it as an "orienting tool", i.e. to rely on it when developing precise expectations regarding the differential relations of PEN traits with certain PP aspects. For example, given that the Disintegration model assumes Social Anhedonia to be primarily an aspect of E and only secondarily an aspect of PP, we expect to find significantly larger correlations of E with Social Anhedonia than with core PP aspects. In other words, we expect that certain PP aspects actually not belonging to PP space (i.e. not being specified by the Disintegration model) correlate with the corresponding personality traits much stronger than the core PP aspects.

Once again, it should be emphasized that the Disintegration model is not used as a criterion for the inclusion/exclusion of any of the PP contents. That is, all PP models found in the literature search are included in this meta-analysis, while the Disintegration model serves only as a conceptual tool to predict, understand and interpret the findings.

As already stated, the central feature of the Disintegration model is the idea of continuity of PP across general and clinical populations, which is based on compelling evidence (e.g. Hanssen, Krabbendam, Vollema, Delespaul, & Van Os, 2006; Johns & van Os, 2001). Therefore, we do not expect a fundamental change in the structure of PEN- PP correlations across these populations apart from what one would expect as a consequence of the range restriction of personality scores in clinical populations or the differences in typical study designs on these two populations.

There is, on the other hand, overwhelming evidence on the difference (evident not only in symptomatology, but in etiology, premorbid characteristics, course, outcome, and possibly, biology and genetics) of the two types of PP indices – so-called positive and negative symptoms (Andreasen, Flaum, Swayze, Tyrrell, & Arndt, 1990; Crow, 1980). The dichotomy has been reflected in the two-dimensional classification of PP indices (Kay et al., 1987), and the subsequent multi-dimensional ones (e.g. Buchanan & Carpenter, 1994; Lindenmayer et al., 2004; Stefanis et al., 2002). Because the Disintegration model does not see Social Anhedonia - one of the core negative symptoms – as part of the PP domain but as a primary indicator of E, one of our expectation is that personality correlates of negative and positive symptoms will be different. Namely, we expect to find clear evidence of stronger presence of low E in negative than in positive symptoms, and stronger presence of N in positive, than in negative symptoms (Knežević et al., 2016; Lazarević et al., 2016).

Although there is evidence on the robust, small to moderate relationship between PP and N (discussed later in the text), anxiety as a typical N indicator is rarely conceptualized as part of PP, the O-LIFE model (Claridge, 1997) being exceptional in that sense. Namely, the preponderance of indices of anxiety and vulnerability in the Cognitive Disorganization subscale makes it a primary measure of anxiety/neuroticism and a poor PP indicator, as was already noticed (Cochrane, Petch, & Pickering, 2010). Therefore, a substantial correlation of this particular scale with N is expected. More precise expectations based on these considerations and findings are developed later in the text.

1.3. Criteria for what should be considered substantial/low overlap between PEN traits and PP

As the empirical benchmark for concluding that PP variance is not accounted for by any of the three Eysenck's traits in a substantive sense, we have set the bar at a meta-analytically estimated mean correlation of 0.40. This benchmark was based on the meta-analytically summarized correlations among the Big Five traits (Mount, Barrick, Scullen, & Rounds, 2005; Rushton & Irwing, 2008; van der Linden, te Nijenhuis, & Bakker, 2010). We relied on these correlations because the Big Five model is the most influential and the most researched personality model, setting the standards for an adequate taxonomy of personality (John & Srivastava, 1999). For example, in one of these meta-analytic studies it was shown that several uncorrected Big Five trait intercorrelations fell in the range from 0.40 to 0.50, and yet these traits were considered to be separate dispositions (Rushton & Irwing, 2008). These authors found the following uncorrected correlations (90% confidence intervals were also given) being above the absolute values of 0.40: between N and A (−0.44; from −0.34 to −0.52); N and C (−0.44; from −0.34 to −0.54), E and O (0.41; from 0.32 to 0.50), and A and C (0.41; from 0.27 to 0.54). Therefore, coefficients below the absolute value of 0.40 would be treated as indicating separateness of the PEN traits from the PP domain. In other words, correlations below 0.40 would be considered too low to indicate a substantial conceptual overlap between the domains. Coefficients below 0.30 (strict benchmark) would speak even more conclusively on the separateness of PP from the PEN traits. Conversely, if PEN and PP share a substantive amount of variance - which would indicate their conceptual overlap - the correlation should be above the benchmark of 0.40 (a correlation above 0.50 would be treated as indicating a large conceptual overlap between the two constructs).

1.4. Specific hypotheses on the relations between PEN and PP based on the previous evidence and Disintegration model

Apart from the alternative hypothesis central to the relations between PEN and PP described in the Introduction section, we have formulated the following hypotheses that will be tested through moderator analyses:

1) The claim that the PEN model does not capture PP adequately will be further supported if demonstrated that the obtained correlations of PEN with PP are, at least to some extent, built on the correlations with those aspects of PP that can actually be questioned as belonging to the PP domain. According to the Disintegration model,

[3] However, our model is somewhat different from their more detailed, 6 to 12-factor variants of this model, mostly in how certain contents are emphasized. This is understandable given that their model was based on clinical ratings, while ours was based on the self-report on psychotic-like indices.

[4] Nearly one thousand items based on the broad spectrum of indicators used in various operationalizations of psychotic-like phenomena were administered to a sample of senior high school students (n = 2780). A series of factor analyses yielded 12 factors: the aforementioned 9 factors plus Physical Anhedonia, Rigid Conscientiousness, and Social Anhedonia. However, Physical Anhedonia and Rigid Conscientiousness were practically orthogonal to the higher-order Disintegration factor and consequently excluded from the model. Although Social Anhedonia had substantial positive loading on Disintegration, in all subsequent analyses including new samples (Knežević et al., 2017) it was unambiguously demonstrated that Social Anhedonia was primarily an indicator of low Extraversion, (which was in line with the findings of Watson et al. (2008), and Ashton and Lee (2012), while *all* other factors were strong, primary indicators of general Disintegration factor, not other personality traits (coming as a surprise to many).

social anhedonia, physical anhedonia, and impulsive nonconformity are not part of the PP domain. If Costa and McCrae (and other previously mentioned authors) are right in claiming that P is predominantly a blend of low A and low C, its correlation with impulsive nonconformity should be significantly stronger than with relevant PP content. Similarly, if low E is the primary source of anhedonic tendencies, we expect E to correlate significantly stronger with anhedonic tendencies (especially social anhedonia) than with the relevant PP content.

2) The content of the Cognitive Disorganization scale within the O-LIFE instrument (Mason, Linney, & Claridge, 2005) and relevant empirical evidence (Cochrane et al., 2010) suggest that, rather than PP, this scale measures anxiety/neuroticism. Understandably, if it is a measure of N instead of PP, treating it as a measure of PP can produce a distorted picture of N - PP relations. We expect a significantly higher correlation between N and O-LIFE Cognitive Disorganization subscale than between N and all other PP measures. It is important to emphasize that this moderation is aimed at testing the validity of a specific measure of Cognitive Disorganization (O-LIFE), not at questioning the position of Cognitive Disorganization within the PP space.
3) In line with the previous evidence on the differential relations of positive and negative PP symptomatology with other variables, we expect a strong moderator effect of the positive/negative symptoms variable on personality - PP correlations. In line with our previous (Knežević et al., 2016) findings, we expect a stronger N - PP correlation in the case of positive symptoms, and a stronger E - PP correlation in the case of negative symptoms.
4) We expect that studies relying on Cohen's *d* as a measure of effect size will show stronger relations with PEN traits than studies using *r* as a measure of effect size. Studies reporting Cohen's *d* are typically designed to compare individuals with the diagnosis of schizophrenia with healthy controls. Since groups diagnosed with schizophrenia (and almost all other clinical groups, Malouff, Thorsteinsson, & Schutte, 2005) occupy not only extreme levels of PP continuum, but tend to have high N, and predominantly low E, A and C scores, we expect an inflation of PEN - PP effect sizes in studies based on contrasting groups.
5) We expect larger N - PP correlations to be found in non-clinical populations than in clinical. Generally, the variability of N and PP in clinical samples should be smaller compared to non-clinical ones, because these two variables are expected to be particularly pronounced in the clinical population. Consequently, N - PP correlation should be smaller in clinical samples, because of the range restriction effect. This expectation is in accordance with the findings of Lazarević et al. (2016) and Saulsman and Page (2004). In any case, we do not expect an increase in the PP – PEN correlation over 0.40 depending on the type of subpopulation investigated.
6) We expect the correlation between PEN and PP to be lower in students compared to non-students or mixed samples (students and non-students). The old intuition that student populations are not representative for the general population in many respects, and that they tend to be exclusive in many domains of mental functioning has recently been documented by Henrich, Heine, and Norenzayan (2010). Therefore, the expected smaller PP variability in student populations should lead to attenuation of correlations with PEN, again via the range restriction effect.
7) We expect that, compared to studies using self-reports, studies using ratings to measure PP will show lower correlations with personality measures because PEN measures are based on self-reports. As the correlation coefficient reflects both the true correlation between measures and the correlations between the methods of assessment, the presence of the same method variance will make this coefficient larger compared to the situation when different methods are used (Cote & Buckley, 1987).

A detailed description of how our moderator variables have been constructed is given in section “Moderator analyses”. It is important to note that we do not expect any of these moderated correlations to exceed our benchmark correlation of 0.40.

2. Method

2.1. Inclusion and exclusion criteria

To be included in the meta-analysis, studies had to meet the following criteria: (1) each study needed to include a measure of at least one of the PEN traits, as assessed by some of the PEN instruments; (2) the studies needed to include an instrument assessing any symptom-cluster postulated to be a part of a PP model with perceptual/cognitive distortions as its core content. We have decided to include a broader range of phenomena regardless of the segment of the continuum to which they belong (e.g., subclinical or clinical forms), the clinical picture within which they were presented in clinical samples (e.g., schizophrenia or schizotypal personality disorder), and whether they were confined only to the core symptoms of perceptual/cognitive distortions or were more inclusive in this respect, given that the core symptoms were present. The concept of PP is best captured by a spectrum of phenomena listed under the models labeled by words with the prefix ‘schizo-’; (3) all studies needed to report zero-order correlations between PEN domains and PP, or means and standard deviations of the PEN domains for clinical and control groups in studies comparing these groups; (4) we limited our search to adult samples; (5) we searched for all studies published in peer-reviewed journals before December 2016. No language, geographical or cultural restrictions were imposed.

2.2. Literature search strategy and study selection

The literature search was conducted within the following bibliographic databases: EBSCO, PsycNET, ScienceDirect, SpringerLink, Oxford Journals, Wiley Library, Cambridge Journals, HighWire, JSTOR, Open Access Archives, and SAGE Journals. To ensure an exhaustive search for the studies of interest, “schizo*” was searched in the title, abstract, and/or keywords of the paper, while “Eysenck” was searched throughout the whole text. In addition, we have inspected one published review paper (Berenbaum & Fujita, 1994) in search for references not located in the primary search. Fig. 1 depicts all stages of the search process.

The final dataset for this meta-analysis includes 55 manuscripts reporting 350 effects sizes from 56 studies. Details about the included studies can be found in Table 1 in the PsychArchives electronic supplementary materials (http://dx.doi.org/10.23668/psycharchives.2352), along with the list of studies which were excluded from the analyses, and publication bias analyses, suggesting absence of the systematic file-drawer tendency in the synthesized literature.

2.3. Coding procedure

Studies were coded by all authors of this report. All coders are experts in the field of personality psychology: two are senior lecturers in the field of individual differences and the rest have Ph.D. in the psychology of individual differences. Each report was coded by one person. However, for a small number of studies, where coding was not straightforward (e.g. the number of participants on which effect sizes were calculated was not clear), at least three coders examined the manuscript in detail until a final agreement was reached. In addition to targeted effect sizes, information about potential moderators was also extracted, namely manuscript-level, sample-level, and effect-size-level variables. Manuscript-level variables encompass the names of the authors, the journal name, the year of publication, the language of the study, and country of the first author. Sample-level variables refer to characteristics inherent to the sample used for computing correlation

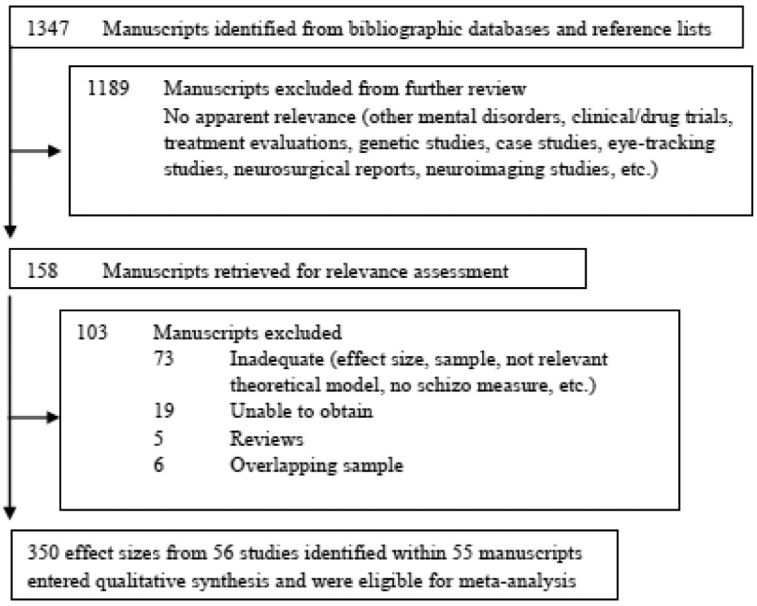

Fig. 1. The selection process of studies included in the meta-analysis.

estimates, that is the mean age of the sample, country of the sample, clinical versus non-clinical sample, student versus non-student sample, and language within which the study had been conducted in the sample (English versus non-English). Effect-size-level variables refer to the characteristics of the scale used to assess both PEN personality traits and the PP domain, the sub-dimension of Disintegration assessed (positive, negative, other), and whether the data were obtained from self-reports or expert ratings. The dataset is available in the PsychArchives electronic supplementary materials (http://dx.doi.org/10.23668/psycharchives.2352).

2.4. Moderator analyses

The following moderators were included in order to test the 7 specific hypotheses formulated in the section "Specific hypotheses on the relations between PEN and PP based on previous evidence and the Disintegration model":

1) "Relevant vs. irrelevant schizo* content". In accordance with the empirical evidence on which the Disintegration model is based, PP content can be classified as relevant and irrelevant. By irrelevant content, we refer to any content for which classification into the PP domain is questionable. More specifically, social anhedonia, impulsive nonconformity, and physical anhedonia all fall into the category of irrelevant PP content, because these domains are expected to be induced by different personality traits, and thus, should have differential correlations with them. In line with this, this moderator variable has four categories: (1) relevant PP phenomena, (2) social anhedonia, (3) impulsive nonconformity and (4) physical anhedonia. If our first hypothesis is correct, the variable "relevant vs. irrelevant schizo* content" should have a significant moderation effect in the direction specified by this hypothesis: P scale should have a higher correlation with impulsive nonconformity than with the relevant PP content, while E scale should have a higher correlation with social/physical anhedonia than with the relevant PP content.
2) "O-LIFE Cognitive Disorganization scale vs. other schizo* scales". This variable has two categories, the first containing only Cognitive Disorganization scale from O-LIFE instrument and the second, containing all other schizo* scales. This variable is aimed to test our second hypothesis, the one postulating that the Cognitive disorganization scale is, in fact, a measure of N, not PP. If this expectation is correct, the correlation of Cognitive Disorganization scale with N should be substantial, i.e. above the value of 0.40.
3) "Type of symptoms". This variable has three categories, positive symptoms, negative symptoms, and symptoms that could not be classified into either of the previous two categories. Based on our previous meta-analytical findings, this variable is expected to have a strong moderator effect: the N - PP correlation should be noticeably stronger in the case of positive PP symptoms, while the (absolute) E - PP correlation should be stronger in the case of negative symptoms, as specified by our third hypothesis.
4) "Type of effect size" having two categories, one containing correlation as a measure of effect size and the other containing Cohen's d. In accordance with our fourth hypothesis, larger effects should be obtained for Cohen's *d*s, because they are based on contrasting extreme groups.
5) "Type of sample: clinical vs. nonclinical". This variable classifies all effects into three categories: those obtained on clinical samples, those obtained on nonclinical samples, and those obtained by contrasting these two groups. Smaller effects are expected in clinical samples in the case of N - PP correlation having in mind the reasons mentioned in the formulation of our fifth hypothesis.
6) "Type of sample: student vs. non-student". This variable has three categories: students, non-students and students, and non-students combined. Generally, smaller effects are expected in student samples because of the expected range restriction of PP scores, as posited by our sixth hypothesis.
7) "Type of assessment". This moderator has two categories, self-report PP and expert rating of PP. Larger effects are expected in the case of self-report measures of PP because this correlation contains not only the true PEN - PP correlations but also the common method effects as explained in the justification given for our seventh hypothesis.

2.5. Analytical strategy

To compute overall mean correlations for each bivariate relationship of interest (PP and each of the PEN traits), the extracted effect sizes

were synthesized using a Hedges/Olkin-type random-effects model (e.g. Hedges & Olkin, 1985; Raudenbush, 2009). Most of the effect sizes (304/350) were reported as zero-order correlations and extracted, along with corresponding sample sizes, directly from the manuscripts. For the studies comparing clinical and nonclinical groups studies reporting mean differences and the respective variances, we used the esc-Package for R[5] to convert 46 standardized mean differences into zero-order correlation coefficients.

In the meta-analytic approach used, i.e. in random effects Hedges/Olkin-type meta-analyses, observed effect sizes are synthesized using a weighted mean procedure, with the inverse sampling variances of each correlation coefficient serving as weights. This procedure ensures that more precise correlations, i.e., those associated with smaller sampling variances, are assigned a larger weight when computing the overall mean correlation across all studies considered. In addition, the estimated amount of 'true' variability (T-square) around the estimated mean correlation coefficient is being computed. As a next step, the homogeneity of the overall weighted mean is estimated, answering the question if, and to what extent, the variability between observed correlations can be explained by sampling error only, and/or by systematic differences among effect sizes. Three heterogeneity estimators are reported: (1) the Q statistic indicating heterogeneity if significant, (2) the I^2 statistic telling (in percents) how much of the total variability in the correlations can be attributed to heterogeneity among the true correlations, and (3) the H^2 statistic, a ratio of the total amount of variability in the observed correlations to the amount of sampling variability. When heterogeneity is present, moderator analyses are performed with the aim of explaining the variability among correlations. For an in-depth treatment of meta-analytic procedures, we recommend Bornstein, Hedges, Higgins, and Rothstein (2009), and Card (2011). The RMA function with zero-order correlations along with the corresponding sample sizes as input, implemented in the R[6] package metafor, Version 2.0.0 (Viechtbauer, 2010) was used. The RMA function provides a general framework for fitting various meta-analytic models that are typically used in practice. Moderator analyses were performed with the aid of mixed-effects meta-regressions with Knapp and Hartung (2003) adjustments implemented in metafor. The data, R script, and complete output are available as Electronic Supplementary Material (ESM) via PsychArchives http://dx.doi.org/10.23668/psycharchives.2352.

3. Results

3.1. Main results

As seen from Table 2, PP had a moderate mean correlation with Neuroticism (0.30), low with Psychoticism (0.21) and the lowest with Extraversion (−0.09). Although significant, all correlations were far below 0.40, the benchmark value for regarding PP as being separate from PEN personality traits. Even the 95% confidence intervals fell within the stricter threshold for separateness, set at 0.30, except for the N - PP correlation (from 0.26 to 0.33). Moreover, all prediction intervals, encompassing the range of possible effect sizes in 95% of all populations (Borenstein, Higgins, Hedges, & Rothstein, 2017), include zero.

3.2. Results of the moderator analyses

The heterogeneity (indicated by Q and H^2 heterogeneity estimators) was found to be substantial for all three correlations, slightly higher in the case of N and E, than P (Table 2). For example, the percentage of total variation across studies due to heterogeneity other than chance (I^2) was 94% for both N and E, and 89% for P, suggesting that the true correlations differed between the studies. Therefore, moderator analyses, i.e. meta-regressions were performed for all three pairs of PEN and PP relations.

Mixed-effects meta-regressions showed that the chosen moderator variables explained 16% of heterogeneity in the case of P, 40% in the case of E, and 45% in the case of N. The following variables were found to significantly moderate PP - PEN correlations: "relevant vs. irrelevant PP content", "O-LIFE Cognitive Disorganization scale vs. other schizo* scales", "positive vs. negative symptoms", "clinical vs. nonclinical samples", and "type of effect size". The PEN – PP relations were not found to be conditional upon the type of method of assessment (self-report scales vs. clinical rating) or samples (student vs. non-student) used.

The first moderator - "Relevant vs. irrelevant PP content" turned out to be the most important moderator – the one influencing all three correlations. It was demonstrated that P correlated more with PP when the latter was measured by impulsive nonconformity scales (over the benchmark value of 0.40, indicating a substantial overlap between the two) than in cases when PP was measured by scales capturing relevant PP content, or by social/physical anhedonia scales. Extraversion, on the other hand, showed larger (absolute) correlations with social and physical anhedonia than with relevant PP content or impulsive nonconformity. Finally, N correlated more strongly with the relevant PP content than the irrelevant ones (social anhedonia, impulsive nonconformity, and physical anhedonia).

Regarding our second moderator - "O-LIFE Cognitive Disorganization scale vs. other schizo* scales" - when Cognitive Disorganization scale from O-LIFE was used to assess PP it increased the N - PP correlation to 0.50 (highly over the benchmark value of 0.40), compared with the case when scales other than Cognitive Disorganization were used (0.29).

Regarding the "type of symptoms" moderator, as expected, N - PP correlation was increased when positive PP symptoms were measured, while E - PP correlations (absolute value) showed an increase when negative PP symptoms were assessed. "Type of effect size" moderated the E – PP correlation, tending to be larger when Cohen's *d* was used as a measure of effect size, compared to the situations when the effect size was calculated as correlation.

"Type of sample: clinical vs. nonclinical vs. studies contrasting clinical and nonclinical samples" moderated the N - PP correlation in the predicted direction - the correlation was smaller in clinical samples. Both N - PP and E - PP measures of associations were increased in studies contrasting clinical and nonclinical samples, which was - at least to some extent - the consequence of these effect sizes being based on the contrasts between extreme PP groups.

Interestingly, year of publication turned out to be a significant moderator of E - PP correlation, in a way that the more recent studies reported stronger correlations. As high residual heterogeneity (Qe) coefficients show, even after introducing the proposed moderators, a significant amount of heterogeneity in PP - PEN correlations between studies remains unexplained.

4. Discussion

The most important finding of this meta-analysis is that none of the meta-analytically derived correlations between the measures of PP and Eysenck's PEN scales exceed 0.40, an empirically established benchmark for assuming their distinctness. It can be concluded that the PEN model does not capture PP variance substantially, i.e. not to the extent that conceptual similarity between any of the PEN traits and PP can be claimed. Although seven moderators were found to influence these correlations, there were only two cases in which a moderated correlation exceeded the benchmark - the correlation of P with impulsive nonconformity scales and the correlation of N with O-LIFE Cognitive Distortion scale. Importantly, both these cases were shown to reflect correlations between PEN and contents that could be easily questioned

[5] https://cran.r-project.org/web/packages/esc/esc.pdf.
[6] https://cran.r-project.org/web/packages/metafor/metafor.pdf.

Table 2
Summary of meta-analytic findings of correlations between psychosis proneness (PP) and Psychoticism-Extraversion-Neuroticism (PEN) traits.

PP and:	Meta-analytic summary statistics (random effects models)				Heterogeneity estimators			Summary of mixed-effects meta-regressions aimed at explaining heterogeneity using conceptual and study descriptors as moderators		
	n	k	Mean r (95% CI) and [prediction interval]	T^2 (95% CI)	Q_{total} (df, p)	I^2%	H^2	Model fit: R^2%	Residual heterogeneity: Q_e (df, p)	Statistically significant moderator findings ($p < .05$; mean values per moderator category are reported) Minimum *k* per moderator analysis for N: 88, for E: 80, for P: 105
N	37,080	111	0.30 (0.26, 0.33) [−0.08, 0.67]	0.04 (0.03, 0.06)	2180.51 (110, < 0.01)	93.98	16.60	44.58	405.19 (68, < 0.01)	1.Relevant/irrelevant schizo* content (relevant schizo* - social anhedonia - impulsive nonconformity - physical anhedonia) r |0.34| > r |0.18| = r |0.18| > r |0.05| 2. OLIFE Cognitive disorganization scale – all other schizo* scales r |0.50| > r |0.29| 3. Disintegration sub-dimension (positive - nonclassified - negative symptoms) r |0.38| > r |0.28| > r |0.13| 4. Type of sample (clinical - comparison of clinical and nonclinical - nonclinical) r |0.02| < r |0.30| = r |0.32|
E	35,648	103	−0.09 (−0.13, −0.05) [−0.49, 0.31]	0.04 (0.03, 0.06)	2225.08 (102, < 0.01)	93.92	16.44	40.05	385.10 (60, < 0.01)	1. Relevant/irrelevant schizo* content (relevant schizo - social anhedonia - impulsive nonconformity - physical anhedonia) r |−0.07| < r |−0.30| > r |0.15| < r |−0.23| 2. Disintegration sub-dimension (positive - nonclassified - negative symptoms) r |−0.02| < r |−0.11| < r |−0.21| 3. Type of effect size (r - Cohen's *d*) r |−0.07| < r |−0.22| 4. Type of sample (clinical - comparison of clinical and nonclinical - nonclinical) r |0.02| < r |−0.20| > r |−0.08| 5. Year of publication Stronger correlations by 0.04 for every ten incremental years
P	42,880	136	0.21 (0.18, 0.24) [−0.08, 0.50]	0.02 (−0.01, 0.03)	1934.76 (1435 < 0.01)	88.85	8.97	15.85	279.74 (84, < 0.01)	Relevant/irrelevant schizo* content (relevant schizo - social anhedonia - impulsive nonconformity - physical anhedonia) r |0.20| = r |0.19| < r |0.43| > r |0.08|

as being aspects of PP domain. The evidence of a substantial meta-analytically estimated correlation between Psychoticism and PP was not found. The correlation was only 0.21, being too small by any standard to justify the conceptual equivalence of Psychoticism and PP.

4.1. Problems with Eysenck's conceptualization of Psychoticism

Our first specific hypothesis stated that the relevant vs. irrelevant PP content would moderate the P - PP and E - PP correlations. By supporting this hypothesis, our results throw additional light on the issue of the validity of Psychoticism. Specifically, our results demonstrate a significant increase in the P - PP correlation when PP is measured by impulsive-nonconformity scales as compared with the situation when it is measured by core PP measures. This finding suggests a strong conceptual overlap between P and impulsive-nonconformity, in line with the claim that the P scale is a blend of low A and low C. To sum up: the correlation of Psychoticism with PP is low, and it increases significantly only when PP is represented by impulsive-nonconformity - a content whose conceptualization as an aspect of PP is problematic. Impulsive-nonconformity is not an aspect of PP according to the Disintegration model (and a large majority of PP models), but predominantly represents a blend of low A and low C; the fact that the correlation between impulsive nonconformity and P (0.43) is substantially higher than the one between relevant aspects of PP and P (0.20) supports our thesis that P primarily captures content which is marginal or largely irrelevant for PP.

To the best of our knowledge, this is the first meta-analytical evidence pointing to the phenotypic divergence of Eysenck's P scale from what is usually considered to be relevant content of PP. Given that PP was not based on a specific PP model but on a variety of them, including many subdimensions and contents, the meta-analytical approach seems to represent a fair test of the validity of Psychoticism. Still, it seems that Eysenck's conceptualization of the trait Psychoticism as a measure of PP did not pass the test.

Does absence of a substantial empirical overlap between psychosis-proneness and Psychoticism testify on the invalidity of the construct of Psychoticism?

Since the expected correspondence between the P scale and the variety of measures of PP at the phenotypic level has not been obtained, the only hope remaining for the preservation of the construct of Psychoticism lies in the so-called genotypic interpretation of P (van Kampen, 2009). According to the genotypic model, a high P score (meaning being high on callousness, impulsivity, nonconformity, egocentricity) is only related to a greater chance of being affected by a psychotic illness, not to the phenotypic manifestations of psychosis-proneness. Thus, the whole concept of Psychoticism relies upon the genetic connections between indices of impulsivity, aggression, and psychoses (Eysenck, 1972). As already stated, the empirical evidence does not seem to support the existence of such a connection (van Kampen, 1993). Generally, findings converge to the conclusion that both genetic and environmental structures of personality space are highly congruent with their phenotypic structure (Livesley, Jang, & Vernon, 1998). That is, there are no compelling arguments to believe that - unlike the genetic architecture of other traits - the genetic architecture of psychosis-proneness differs drastically from its phenotypic structure. To conclude, there is no convincing evidence on the advantage of using a scale measuring impulsive nonconformity to make valid conclusions about PP, neither at the phenotypic nor at the genotypic level.

4.2. On the relation between psychosis-proneness and Neuroticism

The highest meta-analytical correlation between PP and PEN was obtained with N ($r = 0.30$). This moderate correlation is slightly higher than the meta-analytically estimated correlations of PP with the Big Five model N ($r = 0.24$, Knežević et al., 2016), or Cloninger's Harm-Avoidance (a construct similar to N) ($r = 0.23$, Lazarević et al., 2016). Moreover, our moderator analyses showed that, in some instances, the correlation between Eysenck's measure of N and PP exceeds the value of 0.30. Namely, the correlation with N is increased when PP is measured by relevant PP symptoms (meaning all PP symptoms without impulsive nonconformity and social/physical anhedonia) ($r = 0.34$), when it is defined by positive symptoms ($r = 0.38$), and when PP measures are administered to non-clinical ($r = 0.32$) populations. When Cognitive Disorganization scale from O-LIFE is used to assess PP, this correlation rises to as much as 0.50, with the upper confidence level reaching 0.69! The last correlation, however, does not reflect the true N - PP correlation: it is the consequence of this scale's poor validity, i.e. the fact that Cognitive Disorganization from O-LIFE is not a measure of schizotypy, but "neurotic personality traits", as Cochrane et al. (2010, p. 153) have already stated. What is more important, this finding can, at least to some extent, explain the higher PP - N correlations found in this study compared to the study of Knežević et al. (2016) investigating Big Five - PP relations: O-LIFE was more frequently used as a measure of PP in studies investigating the relation between PEN personality model and PP (16% of all effects, this study) than in studies on the relation between Big Five personality model and PP (4% of all effects, Knežević et al., 2016).

Although not exceeding the value of 0.40 - set as the benchmark for considering two constructs separate from each other - the N - PP correlation indicates a level of overlap which is higher than in the case of other traits. We tend to see a part of this overlap as a consequence of the slight conceptual expansion of N. This applies to both Eysenck's N and Costa and McCrae's N, the former containing phenomena such as hypochondria and obsessiveness and the latter capturing most of the behavioral content of what is usually described as Borderline Personality Disorder (Larstone, Jang, Livesley, Vernon, & Wolf, 2002; Trull, 1992). Such conceptual expansion of N is understandable because of a personality model without Disintegration as its part and with N articulated strictly as fearfulness/anxiety/vulnerability would not be able to capture many important aspects of behavior, such as those characterizing personality disorders. When the articulation of N measure is shifted to HEXACO emotionality instead of instability (as in PEN and FFM models) its correlations with PP measures tend to become lower, below 0.20 (Knežević, Lazarević, Bosnjak, Keller, & Savic, 2019; Ashton & Lee, 2012). The persuasive empirical arguments based on lexical studies presented by Ashton et al. (2004), seem to justify their circumvention of the content of N to emotional vulnerability, i.e. fearfulness, anxiety, dependence, and sentimentality. It is our opinion that an upgraded model of basic personality space which includes PP/Disintegration will be able to capture many of the relevant behavioral contents, including those related to weakened reality testing, without the need to inflate the N domain to capture contents which are not its primary indicators.

4.3. Psychosis-proneness and Extraversion

The moderation analysis showed a significant increase in E - PP correlations when the latter is measured by social (-0.30) and physical anhedonia (-0.23) scales, compared to the situation when it is measured by relevant PP measures (-0.07). These results are also in line with expectations that can be derived from the proposed Disintegration model: social and physical anhedonia are not primarily indicators of PP but E; therefore, E is expected to correlate significantly higher with them than with relevant measures of PP. However, these correlations are not as large as the correlations between P and impulsive nonconformity, so the claim of equivalence between social/physical anhedonia and E is not as easy to make as it was in the case of P and impulsive nonconformity. These moderate correlations appear to reflect the generally low correlation between PP and Eysenck's E (-0.09). In our previous meta-analysis (Knežević et al., 2016) the highest correlation between personality traits and PP was obtained between PP and E (-0.27), and it even went up to -0.40 in the case of the negative PP

phenomena. The reason for the lower correlation between PP and Eysenck's E in comparison to the correlation between PP and lexically derived E may lie in the wider scope of the latter. It seems that the lexically derived E better captures the anhedonic aspects of behavior, which are part of many PP models. For example, positive emotions (indicating low anhedonia) are conceptualized as an aspect of E within the FFM, but not within Eysenck's model. Claiming that Social Anhedonia is not a primary indicator of PP (Knežević et al., 2017; Watson, Clark, & Chmielewski, 2008) might seem unusual given that social anhedonia predicted the development of schizophrenia-spectrum disorders over-and-above the prediction of their positive schizotypy symptoms such as perceptual distortion and magical thinking (Kwapil, 1998; Mishlove & Chapman, 1985). However, these findings can be easily reconciled if we assume that to explain schizophrenia-spectrum disorders constructs like Disintegration, Psychoticism (Krueger, Derringer, Markon, Watson & Skodol, 2012), or Oddity (Watson et al., 2008) are not sufficient – low Extraversion is necessary also. If multiple traits are necessary constituents of certain psychological/psychiatric conditions it does not follow that these traits reflect a unitary structure: they could be separate traits, independently contributing to such conditions.

4.4. Moderating the PEN-PP correlation by type of PP symptoms, samples, effect sizes, and assessment methods

We will now continue discussing other results of the moderator analyses, related to hypotheses three to seven. Our third hypothesis - that stronger correlation would be obtained for N- PP correlation in the case of positive symptoms, and for E - PP in the case of negative symptoms - was confirmed. Similar to what was found in (Knežević et al., 2016; Lazarević et al., 2016), positive/negative PP symptoms proved to be a potent moderator of the correlations between personality traits and PP. These findings further invigorated the conclusion from Knežević et al. (2016), that positive and negative PP "entail sufficiently distinct phenomena to lead to a differential pattern of correlations with almost all personality traits" (p. 220). These correlations were expected because N scale contains no items that are related to negative PP, while E scale contains many items highly similar to negative PP symptoms, such as social anhedonia.

Our data show that the type of effect size is a significant moderator for PP - E correlation. This finding is in line with our fourth hypothesis that studies using Cohen's *d* will show stronger correlations than studies using correlations. The use of Cohen's *d* reflects the fact that some groups were contrasted in such studies, typically groups with schizophrenic disorders and normal controls. As schizophrenic groups tend to be higher on N and lower on E (Malouff et al., 2005), this might explain the larger PEN - PP correlations in studies involving a group contrasting design.

Hypothesis five - positing that the N - PP correlation should be smaller in clinical populations in comparison to either non-clinical populations or studies contrasting clinical and non-clinical samples - was also confirmed. When moderating effects of the variable students vs. non-students were investigated, our (sixth) hypothesis was not supported.

When it comes to the type of assessment, i.e. self-report vs. expert ratings, our (seventh) hypothesis was also not confirmed.

Finally, the year of publication turned out to be a significant moderator of E – PP relationships. It appears that recent PP models tend to include contents that could be of more relevance for low E than PP. Having in mind that our meta-analysis is based on the extensive and exhaustive search of the existing literature (Fig. 1), there are no reasons to believe that there are systematic limitations on the generalizability of the findings.

As indicated by the high residual heterogeneity (Q_e) in Table 2, a substantial amount of heterogeneity remained unexplained even after including the moderators. However, since the focus of the study was the estimation of PEN – PP correlations, and not why estimations vary between studies, this heterogeneity that remained unexplained does not undermine our main conclusion.

5. Conclusions

The findings of this meta-analysis point to two major conclusions. First, Eysenck's P scale does not appear to be a valid measure of PP. We found little support for the claim that impulsiveness, irresponsibility, and manipulativeness - what the P scale predominantly measures - lie on the same phenotypic continuum as the typical indices of PP. On the contrary: the only substantial correlation that Eysenck's P scale had with any of the PP measures was with content like its own - impulsive nonconformity - the content whose conceptualization as part of PP does not appears to be correct.

Second, findings from this meta-analysis further corroborate the conclusion, based on two previous meta-analytical studies, that PP is not adequately represented by major personality models, regardless of whether their authors claim to be oriented towards normal (Big Five) or both normal and abnormal personality variations (Eysenck's PEN, Cloninger's model), or of whether they claim to measure PP directly (PEN) or indirectly, as aspects/segments of other traits (Openness in the Big Five model, and Self-transcendence in the Cloninger's model). It was also shown that at least part of the correlations between the PEN model and PP are due to current operationalizations of PP in many models containing behavioral aspects whose classification as aspects of PP is controversial. It was also demonstrated that part of the N - PP correlation estimated in this study can be ascribed to the frequent use of an instrument which intends to capture PP but taps anxiety/N instead (Cognitive Disorganization scale from O-LIFE). In short, the argument against including PP/Disintegration as a separate trait in the personality space, by claiming that the existing personality models already contain this domain or its most important aspects, appears to be empirically unsubstantiated.

Supplementary data to this article can be found online at http://dx.doi.org/10.23668/psycharchives.2352.

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