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# Measurement invariance and Polish norms for the Perth Empathy Scale (PES)

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## Abstract

**Introduction:** *Originally developed in English, the Perth Empathy Scale (PES) is a 20-item self-report measure of empathy, designed to assess cognitive empathy and affective empathy across both negative and positive emotions. Recently, the Polish version of the PES was introduced, which demonstrated strong psychometric properties.*

**Material and methods:** *In the present study, we aimed (1) to further examine the psychometrics of the Polish PES, with a focus on measurement invariance testing, and (2) to facilitate use of the scale by providing norms for Polish adults. Our sample included 1112 Polish-speaking adults aged 18–77 years, recruited from the general community in Poland. The PES's factor structure and measurement invariance were verified with confirmatory factor analysis. Internal consistency reliability coefficients were assessed, and percentile rank norms were calculated.*

**Results:** *The Polish version of the PES demonstrated strong factorial validity, with support for the intended 4-factor structure, and invariance across females and males. The PES scores showed good to excellent internal consistency reliability. There were gender differences in PES scores, with higher empathy in females than in males. Due to this, Polish percentile rank norms for the PES were presented for females and males separately.*

**Conclusions:** *Overall, as in the first Polish study on the PES, the scale further demonstrated strong psychometric performance.*

**Keywords: affective empathy, cognitive empathy, empathy, factor structure, measurement invariance, negative emotions, percentile rank, Perth Empathy Scale, positive emotions, questionnaire**

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## Introduction

Empathy is a multidimensional construct, comprising 2 main dimensions: cognitive empathy (i.e. the ability to recognise another person's emotions) and affective empathy (i.e. the tendency to experience another person's emotions) [1]. These 2 dimensions can be assessed across both positive and negative emotions, thus producing 4 main empathy subdimensions: (1) "cognitive empathy for positive emotions", (2) "cognitive empathy for negative emotions", (3) "affective empathy for positive emotions", and (4) "affective empathy for negative emotions" [1].

The Perth Empathy Scale (PES) is a recently developed self-report measure of cognitive empathy and affective empathy, across positive and negative emotions [1]. The scale consists of 20 items, with 4 theoretically meaningful subscales: "negative-cognitive empathy", "positive-cognitive empathy", "negative-affective empathy", and "positive-affective empathy". Two composite scores, "general affective empathy" and "general cognitive empathy", as well as a total score ("general empathy") representing an overall level of empathy, can be also calculated [1].

To date, the psychometric properties of the original English [1], Polish [2], and Chinese [3] language ver-

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sions of the PES have been examined. The English [1] and Chinese [3] versions supported a 3-factor model, comprising a general cognitive empathy factor and valence-specific affective empathy factors (i.e. negative affective empathy and positive affective empathy). Thus, in those data, a valence distinction was more important for affective empathy than cognitive empathy. In a first Polish validation study of the PES, Larionow and Preece [2] supported a theoretically informed 4-factor model of the PES (corresponding to the 4 subscales, albeit the valence-specific cognitive empathy factors were highly correlated), and indicated its strong convergent validity (i.e. positive associations of PES scores with emotional intelligence) and divergent validity (i.e. positively valenced PES subscales and anxiety and depression symptoms were not correlated), as well as discriminant validity against people's current level of anxiety and depression symptoms, thus supporting that the PES assesses an empathy construct that was statistically separable from current levels of these symptoms. The test-retest reliability of the PES was supported in Polish [2] and Chinese [3] validation studies, indicating that the PES evaluates an empathy construct as a relatively stable trait. Measurement invariance across females and males was examined by Brett *et al.* [1], who supported the gender invariance of the scale. In all the above-described language versions of the PES, internal consistency reliability for PES subscale and composite scores were good [1–3], and the questionnaire has empirically demonstrated good clinical utility [2, 3]. Even though the number of existing reports on the psychometric properties of the PES are limited to English [1], Polish [2], and Chinese [3] versions, these language adaptations have so far all shown good psychometric performance, highlighting a clear multidimensional nature of the empathy construct and demonstrating its clinical relevance.

The aim of this study was to expand on the previous Polish study [2] by examining the measurement invariance of the Polish PES across females and males (to explore if comparisons between males and females with the PES are meaningful), and to present Polish norms for this scale to facilitate score interpretation. We anticipated that the 4-factor correlated model of the PES would be a good fit to the data and would be invariant across females and males.

## Material and methods

### Procedure

This study was approved by the Ethics Committee of the Faculty of Psychology of the Kazimierz Wielki University (No. 1/13 June 2022). All participants provided their written informed consent digitally. The study was anonymous and voluntary, and there was no reimbursement for the respondents. Participants from the general population in Poland were recruited via social media pages to complete an online survey administered via the Google Forms platform.

### Participants

Our total sample consisted of 2 subsamples of Polish adults. The first subsample (n = 318) was from the first Polish PES paper, with data collection between April 2022 and April 2023 [2], and thus has previously been published. The second subsample (n = 794) was derived from our larger and ongoing research project on empathy and its mental health correlates (i.e. alexithymia, psychopathology symptoms, and well-being). The data collection of the second subsample took place between October 2023 and February 2024. None of the second subsample data have been published previously. To maximise our sample size to provide comprehensive Polish PES norms and measurement invariance testing, we combined the data on the first and second subsamples, resulting in the final sample of 1112 Polish-speaking adults. These 2 subsamples were not statistically significantly different in terms of their age (as indicated by Student's *t*-test) or their scores on any PES subscale [as indicated by a multivariate analysis of variance (MANOVA)].

Of our sample of 1112, the gender ratio was 636 females, 468 males, 6 non-binary, 1 transgender male, and 1 unidentified gender. Their ages ranged from 18 to 77 years (mean = 28.39, standard deviation = 12.85). People with a higher education degree made up 29.14% of the respondents, those with secondary education 57.91%, those with vocational education 6.21%, and those with primary education 6.74%. In terms of relationship status, 50.45% were single, and 49.55% were in a relationship.

### Measures

Participants completed a demographic questionnaire and a short battery of psychometric self-report measures (i.e. questionnaires for measuring alexithymia, psychopathology symptoms, and well-being, which were used as correlates of empathy in our ongoing research project on empathy and mental health outcomes). The main measure was the Polish version of the Perth Empathy Scale (PES) [2]. As mentioned previously, the PES is a 20-item self-report measure of empathy. It consists of 4 subscales (i.e. "negative affective empathy", "positive affective empathy", "negative cognitive em-

pathy", and "positive cognitive empathy"), which can also be combined into various composite scores (i.e. "general affective empathy" and "general cognitive empathy", which assess their respective components of empathy across both valence domains), and a total score ("general empathy") as an overall marker of empathy. Items are scored on a 5-point scale, ranging from 1 ("almost never") to 5 ("almost always"). Higher scores indicate higher levels of empathy.

### Analytic strategy

*R* v. 4.3.1 with the *lavaan* statistical package was used for confirmatory factor analysis and measurement invariance testing. *JASP* v. 0.18.3.0 was used for all other analyses.

### Factor structure and measurement invariance

Using confirmatory factor analysis, we examined the 4-factor correlated model of the PES that was supported in the first Polish PES study [2]. To maximise cross-cultural comparability of the factor analytic studies of the PES, we also tested the 3-factor model, comprising a general cognitive empathy factor and valence-specific affective empathy, which was the best fit in some previous studies [3]. The estimation method was maximum likelihood with robust standard errors and the Satorra-Bentler scaled test statistic.

Model goodness-of-fit was judged based on the following fit index values: root mean square error of approximation (RMSEA), standardised root mean square residual (SRMR), comparative fit index (CFI), and Tucker–Lewis index (TLI). RMSEA and SRMR values ≤ 0.08 indicate acceptable fit, and values ≤ 0.06 excellent fit. CFI and TLI values ≥ 0.90 indicate acceptable fit, and values ≥ 0.95 excellent fit [4].

Measurement invariance (with configural, metric, and scalar invariance models) was examined across females and males. Models were compared in terms of the CFI; an absolute difference in CFI (ΔCFI) of less than 0.01 supports invariance across the configural, metric, and scalar levels [5].

### Internal consistency reliability

Cronbach's alpha coefficients (α) and McDonald's omega values (ω) were calculated, with values ≥ 0.70 considered as acceptable, ≥ 0.80 as good, and ≥ 0.90 as excellent [6].

### Demographic differences

Pearson correlations between PES scores and age were calculated. We compared the four PES subscale scores across females and males using a MANOVA, and follow-up analyses of variance (ANOVAs). To control for multiple testing, we applied a Bonferroni correction; hence, a new *p*-value of 0.013 (0.05/4 = 0.013) was considered as statistically significant.

### Norms

We calculated percentile rank norms [7] for PES scores.

## Results

### Descriptive statistics

Table 1 presents descriptive statistics for PES subscale and composite scores. Descriptive statistics at the item level are also presented in Table 2.

**Table 1.** Descriptive statistics and internal consistency reliability coefficients for the PES

| PES scores | Total sample (n = 1112) | | | | | | Females (n = 636) | | Males (n = 468) | |
|---|---|---|---|---|---|---|---|---|---|---|
| | α | ω | M | SD | Skewness | Kurtosis | M | SD | M | SD |
| Subscales | | | | | | | | | | |
| Negative cognitive empathy | 0.88 | 0.89 | 18.80 | 4.49 | –0.65 | 0.23 | 19.43 | 4.06 | 17.97 | 4.91 |
| Positive cognitive empathy | 0.87 | 0.87 | 19.00 | 4.32 | –0.67 | 0.33 | 19.40 | 4.04 | 18.49 | 4.65 |
| Negative affective empathy | 0.78 | 0.78 | 12.56 | 4.16 | 0.37 | –0.10 | 13.25 | 4.15 | 11.60 | 3.99 |
| Positive affective empathy | 0.82 | 0.82 | 14.60 | 4.48 | –0.02 | –0.34 | 15.06 | 4.50 | 13.97 | 4.39 |
| Composites | | | | | | | | | | |
| General cognitive empathy | 0.93 | 0.93 | 37.80 | 8.47 | –0.66 | 0.38 | 38.83 | 7.75 | 36.46 | 9.21 |
| General affective empathy | 0.85 | 0.85 | 27.16 | 7.56 | 0.09 | 0.17 | 28.31 | 7.54 | 25.58 | 7.32 |
| General empathy (total score) | 0.91 | 0.90 | 64.96 | 13.64 | –0.47 | 0.65 | 67.15 | 13.02 | 62.04 | 13.97 |

α — Cronbach's alpha; ω — McDonald's omega; M — mean; PES — Perth Empathy Scale; SD — standard deviation.

**Table 2.** Descriptive statistics of PES items and completely standardised item factor loadings from confirmatory factor analysis of the 4-factor PES model with 3 error terms (n = 1112)

| PES subscales | Item number | Statements (original English/Polish) | M | SD | Skewness | Kurtosis | Factor loadings (all ps < 0.001) |
|---|---|---|---|---|---|---|---|
| Negative cognitive empathy | 1 | "Just by seeing or hearing someone, I know if they are feeling sad". / "Widząc lub słysząc kogoś, wiem, czy czuje się smutny". | 3.92 | 0.99 | –0.85 | 0.44 | 0.770 |
| | 5 | "Just by seeing or hearing someone, I know if they are feeling angry". / "Widząc lub słysząc kogoś, wiem, czy czuje się zły". | 4.05 | 1.01 | –1.02 | 0.61 | 0.739 |
| | 9 | "Just by seeing or hearing someone, I know if they are feeling scared". / "Widząc lub słysząc kogoś, wiem, czy czuje się przestraszony". | 3.59 | 1.16 | –0.49 | –0.59 | 0.772 |
| | 13 | "Just by seeing or hearing someone, I know if they are feeling disgusted". / "Widząc lub słysząc kogoś, wiem, czy czuje się zniesmaczony". | 3.57 | 1.14 | –0.49 | –0.55 | 0.785 |
| | 17 | "Just by seeing or hearing someone, I know if they are feeling embarrassed". / "Widząc lub słysząc kogoś, wiem, czy czuje się zakłopotany". | 3.68 | 1.13 | –0.63 | –0.30 | 0.828 |
| Positive cognitive empathy | 3 | "Just by seeing or hearing someone, I know if they are feeling happy". / "Widząc lub słysząc kogoś, wiem, czy czuje się szczęśliwy". | 3.97 | 0.94 | –0.81 | 0.51 | 0.743 |
| | 7 | "Just by seeing or hearing someone, I know if they are feeling amused". / "Widząc lub słysząc kogoś, wiem, czy czuje się rozbawiony". | 4.09 | 0.96 | –1.12 | 1.16 | 0.781 |
| | 11 | "Just by seeing or hearing someone, I know if they are feeling calm". / "Widząc lub słysząc kogoś, wiem, czy czuje się spokojny". | 3.62 | 1.12 | –0.51 | –0.48 | 0.729 |
| | 15 | "Just by seeing or hearing someone, I know if they are feeling enthusiastic". / "Widząc lub słysząc kogoś, wiem, czy czuje się pełen zapału". | 3.71 | 1.14 | –0.69 | –0.21 | 0.771 |
| | 19 | "Just by seeing or hearing someone, I know if they are feeling proud". / "Widząc lub słysząc kogoś, wiem, czy czuje się dumny". | 3.62 | 1.16 | –0.57 | –0.47 | 0.767 |
| Negative affective empathy | 2 | "When I see or hear someone who is sad, it makes me feel sad too". / "Kiedy widzę lub słyszę kogoś, kto czuje się smutny, to sprawia, że ja też czuję się smutna/y". | 3.06 | 1.14 | –0.08 | –0.66 | 0.600 |
| | 6 | "When I see or hear someone who is angry, it makes me feel angry too". / "Kiedy widzę lub słyszę kogoś, kto czuje się zły, to sprawia, że ja też czuję się zła/y". | 2.41 | 1.13 | 0.58 | –0.35 | 0.538 |
| | 10 | "When I see or hear someone who is scared, it makes me feel scared too". / "Kiedy widzę lub słyszę kogoś, kto czuje się przestraszony, to sprawia, że ja też czuję się przestraszona/y". | 2.29 | 1.13 | 0.64 | –0.31 | 0.706 |
| | 14 | "When I see or hear someone who is disgusted, it makes me feel disgusted too." / "Kiedy widzę lub słyszę kogoś, kto czuje się zniesmaczony, to sprawia, że ja też czuję się zniesmaczona/y." | 2.37 | 1.10 | 0.54 | –0.37 | 0.704 |
| | 18 | "When I see or hear someone who is embarrassed, it makes me feel embarrassed too." / "Kiedy widzę lub słyszę kogoś, kto czuje się zakłopotany, to sprawia, że ja też czuję się zakłopotana/y." | 2.44 | 1.20 | 0.52 | –0.64 | 0.695 |

↓

**Table 2 cont.** Descriptive statistics of PES items and completely standardised item factor loadings from confirmatory factor analysis of the 4-factor PES model with 3 error terms (n = 1112)

| PES subscales | Item number | Statements (original English/Polish) | M | SD | Skewness | Kurtosis | Factor loadings (all ps < 0.001) |
|---|---|---|---|---|---|---|---|
| Positive affective empathy | 4 | "When I see or hear someone who is happy, it makes me feel happy too". / "Kiedy widzę lub słyszę kogoś, kto czuje się szczęśliwy, to sprawia, że ja też czuję się szczęśliwa/y". | 3.21 | 1.14 | –0.24 | –0.72 | 0.740 |
| | 8 | "When I see or hear someone who is amused, it makes me feel amused too". / "Kiedy widzę lub słyszę kogoś, kto czuje się rozbawiony, to sprawia, że ja też czuję się rozbawiona/y". | 3.44 | 1.12 | –0.40 | –0.54 | 0.704 |
| | 12 | "When I see or hear someone who is calm, it makes me feel calm too". / "Kiedy widzę lub słyszę kogoś, kto czuje się spokojny, to sprawia, że ja też czuję się spokojna/y". | 2.92 | 1.23 | –0.02 | –0.96 | 0.661 |
| | 16 | "When I see or hear someone who is enthusiastic, it makes me feel enthusiastic too". / "Kiedy widzę lub słyszę kogoś, kto czuje się pełen zapału, to sprawia, że ja też czuję się pełna/pełen zapału". | 2.69 | 1.18 | 0.20 | –0.83 | 0.690 |
| | 20 | "When I see or hear someone who is proud, it makes me feel proud too". / "Kiedy widzę lub słyszę kogoś, kto czuje się dumny, to sprawia, że ja też czuję się dumna/y". | 2.34 | 1.20 | 0.61 | –0.52 | 0.675 |

M — mean; PES — Perth Empathy Scale; SD — standard deviation.

### Factor structure and measurement invariance

Our confirmatory factor analysis indicated that the 4-factor correlated PES model was a nearly acceptable fit to the data (RMSEA = 0.083, SRMR = 0.046, CFI = 0.895, and TLI = 0.878); however, the covariance matrix of latent variables was not positive definite, indicating a presence of a Heywood case. Then, we analysed the modification indices, and added 3 error terms between items 11 and 12, 15 and 16, and 13 and 14. This resolved the Heywood case, resulting in our final 4-factor correlated model with these 3 error terms. Adding errors between is theoretically reasonable between items with conceptual and wording similarities [8], as it was in our case, because each of these 2 items within these 3 pairs of items refer to the same emotions (Tab. 2). This final model was an acceptable fit to the data (RMSEA = 0.070, SRMR = 0.042, CFI = 0.927, and TLI = 0.913). All PES items loaded well on their intended factors (factor loadings from 0.538 to 0.828, all *ps* < 0.001; Tab. 2). Estimated correlations between the subscales of the 4-factor PES model with 3 error terms are presented in Supplementary Table 1.

We also tested the 3-factor model, which was an unacceptable fit to the data (RMSEA = 0.089, SRMR = 0.053, CFI = 0.874, and TLI = 0.857). Hence, we suggested that the final 4-factor correlated model with the 3 correlated error terms was the best model in our data. Therefore, this model was used for testing measurement invariance across females and males.

We examined measurement invariance of our final 4-factor correlated model (with the 3 correlated error terms) across females and males: configural invariance model (RMSEA = 0.068, SRMR = 0.044, CFI = 0.928, and TLI = 0.915), metric invariance model (RMSEA = 0.069, SRMR = 0.051, CFI = 0.924, and TLI = 0.915), and scalar invariance model (RMSEA = 0.068, SRMR = 0.052, CFI = 0.922, and TLI = 0.916). The difference in CFI values between metric and configural levels was –0.004, and between scalar and metric levels it was –0.002. These results therefore suggested that the PES was invariant across females and males in these data.

## Internal consistency reliability

The PES subscale and composite scores all showed acceptable to excellent internal consistency reliability (α and ω ≥ 0.78; Tab. 1).

## Demographic differences

Our MANOVA revealed statistically significant differences in the 4 PES subscale scores between females and males, $F$ (1,1102) = 15.09, $p < 0.001$. A series of ANOVAs indicated that females scored significantly higher than males on all PES subscale scores: negative cognitive empathy, $F(1,1102) = 29.01$, $p < 0.001$, partial $\eta^2 = 0.03$; positive cognitive empathy, $F(1,1102) = 12.26$, $p < 0.001$, partial $\eta^2 = 0.01$; negative affective empathy, $F(1,1102) = 43.77$, $p < 0.001$, partial $\eta^2 = 0.04$; and positive affective empathy, $F(1,1102) = 16.15$, $p < 0.001$, partial $\eta^2 = 0.01$. Thus, females reported higher empathy in all aspects assessed by the PES.

Regarding age, in females, Pearson correlations between PES subscale/composite scores and age were statistically significant only for positive cognitive empathy ($r = 0.08$, $p = 0.038$) and positive affective empathy scores ($r = 0.10$, $p = 0.015$), indicating that older females tended to have higher levels of empathy ability across positive emotions. In males, age was not statistically significantly associated with any PES subscale/composite scores.

## Norms

We calculated percentile rank norms for all PES subscale and composite scores in females and males separately, as well as in the total sample (Suppl. Tab. 2–7).

## Discussion

The aim of the study was to examine whether the Polish PES was invariant across females and males, and to present Polish norms for this self-report empathy measure. Our results indicated that the scale has strong factorial validity, as expressed in the 4-factor correlated model. This supports and complements the conclusions presented in the first Polish validation study [2], now expanded in this study with a much larger sample. In our analyses, we also showed that the Polish PES was invariant across females and males, indicating capacity for meaningful comparisons of PES scores across different gender categories. These results are in line with previous evidence on the gender invariance of the original English version of the PES [1].

Our results indicated that PES scores, including all the subscale and composite scores, had good internal consistency reliability, supporting previous findings on the different language versions of the PES [1–3]. Taken together the evidence on psychometrics of the PES in the first Polish study [2], and in this one, it can be concluded that the scale presents a comprehensive, valid, and reliable measure of empathy, which can be confidently recommended for use among Polish adults.

Regarding demographic differences, there were statistically significant gender differences in empathy levels, with females tending to have higher levels of empathy in all PES subscales. Overall, this echoes the findings of the first Polish study on the PES [2], with the similar and low effect sizes for these gender differences.

In the first Polish PES study with a smaller sample, Larionow and Preece [2] indicated no statistically significant correlations between age and PES scores. In this study, we used more advanced methodology and examined these correlations among females and males separately. We noted that older females had higher levels of cognitive empathy and affective empathy across positive emotions, with no age/empathy relationships observed in males. This may indicate that in females, with age, the ability to understand and experience of the other's positive emotions grows. This is in contrast with some previous studies on empathy (see for review [9, 10]), which indicated that cognitive empathy decreased with age, and with mixed results for affective empathy. The different measures used may explain these differences. As for specific age-gender relationships with emotional variables, in most cases across our group's large body of previous studies on age and emotional variables in Polish adults (e.g. alexithymia [11], emotional reactivity [12], well-being and psychopathology symptoms [13]), we have noted a general trend of improved well-being and emotional status in females with age, but not in males. It seems that this trend may be applicable for empathy too, suggesting a positive shift to a more adaptive emotional life with age in females. This is in line with some literature review on emotional aging, indicating that older people often have the same or even better social and emotional functioning in everyday life, characterised by fewer stressful events compared to younger people [14].

As for a lack of significant improvements in males' empathy levels with age, we can provide only a tentative explanation. Compared to females, on average males can have higher levels of externally oriented thinking and alexithymia [15, 16], which can

be expressed in paying less attention to their own emotional life. This in turn might lead also to fewer improvements in the ability to understand others' emotional states.

## PES norms and their practical applications

Due to the presence of gender differences in empathy levels, we calculated PES norms for females and males separately, as well as for the total sample, in the interest of completeness (see Suppl. Tab. 2–7). We used percentile rank norms, with a percentile rank score of ≤ 15 indicating a low level of measured characteristics, with percentile rank scores from 16 to 84 indicating an average level, and scores of ≥ 85 indicating a high level [17]. In our first Polish PES study [2], we showed that negative affective empathy was a strong positive predictor of anxiety and depressive symptoms, whereas positive affective empathy was a negative predictor of these symptoms. Hence, assessing these dimensions of empathy could be clinically significant. Therefore, we present below 2 cut-off scores for these 2 clinically important subscale scores. For the total sample (Suppl. Tab. 6), a negative affective empathy raw score of ≥ 17 (which acted as percentile rank scores of ≥ 85, with high levels of negative affective empathy), and/or a positive affective empathy score of ≤ 10 (which acted as percentile rank scores of ≤ 15, with low levels of positive affective empathy) could be treated as indicators of a greater risk for development of psychopathology symptoms.

As we calculated gender-specific PES norms, we encourage readers to use these gender-specific norms in research and practice. Such norms are key for facilitating the interpretation of empathy profiles. For example, PES norms can be used in research on empathy and related emotional constructs, including emotional intelligence [18]. Being a multidimensional measure of empathy, the PES evaluates cognitive empathy and affective empathy across positive and negative emotions separately. Hence, the PES can provide detailed empathy profiles, which may help to direct targeted interventions. Clinically, the PES can also be applied in psychotherapeutic practice for planning and evaluating the effectiveness of therapeutic interventions, tracking patients' progress in developing empathy abilities. Current data suggest that high levels of negative affective empathy and/or low levels of positive affective empathy, in particular, can contribute to higher levels of psychopathology symptoms; thus, these elements of an empathy profile may indicate the need for emotion regulation skills training. Other data have also indicated that patients with major depressive disorder have lower empathy scores in all PES subscales than healthy controls [3], thus supporting the clinical relevance of the PES.

As a further example, PES norms may be used in career counselling or employee recruitment decisions. Empathy is a significant factor in effective interpersonal communication [19], and thus can meaningfully influence workplace performance. Moreover, in the social psychology or forensic areas, the PES could be applied in research on social (e.g. prosocial activities) or anti-social behaviours such as violence or aggression. Use of the PES could help to elicit the role that empathy (or lack of empathy) across various domains plays in these behaviours.

Overall, by assessing the empathy construct across both valence domains, and for both cognitive empathy and affective empathy, the PES has strong potential to now enable more comprehensive examinations of the empathy construct and enhance understanding of a wide range of related emotional phenomena. For example, use of the PES has already contributed to the development and testing of the valence-specific empathy imbalance hypothesis of autism, highlighting how empathy difficulties associated with autistic traits can differ depending on the domain of empathy and the valence of the emotion [20].

## Limitations and future directions

Whilst we believe that our paper provides a significant contribution to the field of empathy, our analyses were limited because we did not include clinical samples and therefore did not test the psychometric performance of the Polish PES in clinical groups. Hence, such testing would be beneficial in future studies. Also, to date, no studies have examined the relationships between PES scores and positive psychological variables (e.g. well-being), and therefore future research in this area would be beneficial.

## Conclusions

In this study, we examined the empathy construct in Polish adults, with a particular focus on its measurement invariance across gender and the calculation of Polish norms to aid score interpretation. The PES

demonstrates good psychometric properties, and invariance across females and males. Overall, the Polish version of the PES seems to be a psychometrically sound and comprehensive measure of the multidimensional empathy construct, which should have good utility in future research and practice.

## Article information and declarations

### Data availability statement

The data that support the findings of this study are available from the corresponding author upon reasonable request.

### Ethics statement

This study was approved by the Ethics Committee of the Faculty of Psychology of the Kazimierz Wielki University (No. 1/13 June 2022). All participants provided their written informed consent digitally. The study was anonymous and voluntary, and there was no reimbursement for the respondents.

### Author contributions

**Paweł Larionow** (85%): conceptualisation, formal analysis, data curation, investigation, methodology, writing, reviewing and editing, and project administration. **Karolina Mudło-Głagolska** (5%): data curation, and investigation. **David A. Preece** (10%): writing, reviewing, and editing. All authors approved the final article and agreed to the authorship order.

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### Conflict of interest

The authors state no conflict of interest.

### Supplementary material

Supplementary Tables 1–7 can be found at the end of the article, after the references.

## References

1. Brett JD, Becerra R, Maybery MT, et al. The psychometric assessment of empathy: development and validation of the Perth empathy scale. Assessment. 2023; 30(4): 1140–1156, doi: 10.1177/10731911221086987, indexed in Pubmed: 35435013.
2. Larionow P, Preece DA. The Perth Empathy Scale: psychometric properties of the Polish version and its mental health correlates. Eur J Investig Health Psychol Educ. 2023; 13(11): 2615–2629, doi: 10.3390/ejihpe13110182, indexed in Pubmed: 37998072.
3. Ye Q, Liu Y, Zhang S, et al. Cross-cultural adaptation and clinical application of the Perth Empathy Scale. J Clin Psychol. 2024; 80(7): 1473–1489, doi: 10.1002/jclp.23643, indexed in Pubmed: 38236207.
4. Hu L, Bentler P. Cutoff criteria for fit indexes in covariance structure analysis: Conventional criteria versus new alternatives. Struct Equ Model. 1999; 6(1): 1–55, doi: 10.1080/10705519909540118.
5. Cheung G, Rensvold R. Evaluating goodness-of-fit indexes for testing measurement invariance. Struct Equ Model. 2002; 9(2): 233–255, doi: 10.1207/s15328007sem0902_5.
6. Groth-Marnat G. Handbook of Psychological Assessment (5th ed.). John Wiley & Sons Inc, Hoboken 2009.
7. Baumgartner T. Tutorial: calculating percentile rank and percentile norms using SPSS. Meas Phys Educ Exerc Sci. 2009; 13(4): 227–233, doi: 10.1080/10913670903262769.
8. Bollen K, Lennox R. Conventional wisdom on measurement: a structural equation perspective. Psychol Bull. 1991; 110(2): 305–314, doi: 10.1037/0033-2909.110.2.305.
9. Beadle JN, de la Vega CE. Impact of aging on empathy: review of psychological and neural mechanisms. Front Psychiatry. 2019; 10: 331, doi: 10.3389/fpsyt.2019.00331, indexed in Pubmed: 31244684.
10. Guariglia P, Palmiero M, Giannini AM, et al. The key role of empathy in the relationship between age and social support. Healthcare (Basel). 2023; 11(17), doi: 10.3390/healthcare11172464, indexed in Pubmed: 37685497.
11. Larionow P, Preece D, Mudło-Głagolska K. The Polish version of the Perth Alexithymia Questionnaire-Short Form (PAQ-S): psychometric properties and norms. Journal of Sexual and Mental Health. 2023; 21(0), doi: 10.5603/jsmh.97351.
12. Larionow P, Preece D, Mudło-Głagolska K. Psychometric Properties of the Polish Version of the Perth Emotional Reactivity Scale. Int J Cogn Ther. 2023; 16(3): 460–478, doi: 10.1007/s41811-023-00172-2.
13. Larionow P. Anxiety and depression screening among Polish adults in 2023: Depression levels are higher than in cancer patients. Psychiatria. 2023, doi: 10.5603/psych.97199.
14. Charles ST, Carstensen LL. Social and emotional aging. Annu Rev Psychol. 2010; 61: 383–409, doi: 10.1146/annurev.psych.093008.100448, indexed in Pubmed: 19575618.
15. Koppelberg P, Kersting A, Suslow T. Alexithymia and interpersonal problems in healthy young individuals. BMC Psychiatry. 2023; 23(1): 688, doi: 10.1186/s12888-023-05191-z, indexed in Pubmed: 37735376.
16. Peng W, Yang H, Liu Q, et al. Measurement invariance and latent mean differences of the 20-item Toronto Alexithymia Scale across genders and across clinical and non-clinical samples. Pers Individ Differ. 2019; 151: 109466, doi: 10.1016/j.paid.2019.06.009.
17. Flanagan DP, Caltabiano LF. Test scores: a guide to understanding and using test results. In: Canter AS, Paige LZ, Roth MD. et al.. ed. helping children at home and school II: handouts for families and educators. National Association of School

Psychologists, Bethesda 2004: 81–84.
18. McNulty JP, Politis Y. Empathy, emotional intelligence and interprofessional skills in healthcare education. J Med Imaging Radiat Sci. 2023; 54(2): 238–246, doi: 10.1016/j.jmir.2023.02.014, indexed in Pubmed: 37032263.
19. Byrne M, Campos C, Daly S, et al. The current state of empathy, compassion and person-centred communication training in healthcare: An umbrella review. Patient Educ Couns. 2024; 119: 108063, doi: 10.1016/j.pec.2023.108063, indexed in Pubmed: 38008647.
20. Brett J, Becerra R, Whitehouse A, et al. The valence-specific empathy imbalance hypothesis of autism: The role of autistic traits, alexithymia, emotion dysregulation, and gender differences. Pers Individ Differ. 2024; 218: 112493, doi: 10.1016/j.paid.2023.112493.

**Supplementary Table 1.** Estimated correlations between the subscales of the 4-factor PES model with 3 error terms (n = 1112)

| PES subscales | Negative cognitive empathy | Positive cognitive empathy | Negative affective empathy | Positive affective empathy |
|---|---|---|---|---|
| Negative cognitive empathy | – | | | |
| Positive cognitive empathy | 0.960 | – | | |
| Negative affective empathy | 0.393 | 0.345 | – | |
| Positive affective empathy | 0.411 | 0.572 | 0.647 | – |

PES — Perth Empathy Scale. All estimated correlations are statistically significant (all $p < 0.001$).

**Supplementary Table 2.** Percentile rank norms for PES subscale scores for females (n = 636)

| Negative cognitive empathy | | Positive cognitive empathy | | Negative affective empathy | | Positive affective empathy | |
|---|---|---|---|---|---|---|---|
| Raw score | PR | Raw score | PR | Raw score | PR | Raw score | PR |
| 5 | 0.3 | 5 | 0.2 | 5 | 1.0 | 5 | 1.3 |
| 6 | 0.8 | 6 | 0.6 | 6 | 3.2 | 6 | 3.2 |
| 7 | 0.9 | 7 | 0.7 | 7 | 6 | 7 | 4.6 |
| 8 | 0.9 | 8 | 0.9 | 8 | 10 | 8 | 6 |
| 9 | 1.1 | 9 | 1.1 | 9 | 16 | 9 | 8 |
| 10 | 1.8 | 10 | 2.0 | 10 | 22 | 10 | 13 |
| 11 | 2.9 | 11 | 3.5 | 11 | 31 | 11 | 19 |
| 12 | 4.6 | 12 | 5 | 12 | 41 | 12 | 25 |
| 13 | 7 | 13 | 7 | 13 | 51 | 13 | 33 |
| 14 | 10 | 14 | 9 | 14 | 60 | 14 | 41 |
| 15 | 14 | 15 | 14 | 15 | 68 | 15 | 50 |
| 16 | 20 | 16 | 20 | 16 | 76 | 16 | 58 |
| 17 | 26 | 17 | 26 | 17 | 82 | 17 | 66 |
| 18 | 33 | 18 | 33 | 18 | 87 | 18 | 74 |
| 19 | 41 | 19 | 41 | 19 | 91 | 19 | 81 |
| 20 | 53 | 20 | 53 | 20 | 94 | 20 | 86 |
| 21 | 64 | 21 | 65 | 21 | 95.7 | 21 | 90 |
| 22 | 71 | 22 | 72 | 22 | 96.9 | 22 | 93 |
| 23 | 77 | 23 | 79 | 23 | 98.2 | 23 | 95.6 |
| 24 | 83 | 24 | 84 | 24 | 98.7 | 24 | 96.9 |
| 25 | 93 | 25 | 93 | 25 | 99.4 | 25 | 98.8 |

PR — percentile rank.

**Supplementary Table 3.** Percentile rank norms for PES subscale scores for males (n = 468)

| Negative cognitive empathy | | Positive cognitive empathy | | Negative affective empathy | | Positive affective empathy | |
|---|---|---|---|---|---|---|---|
| Raw score | PR | Raw score | PR | Raw score | PR | Raw score | PR |
| 5 | 1.0 | 5 | 0.9 | 5 | 3.0 | 5 | 2.4 |
| 6 | 2.4 | 6 | 1.8 | 6 | 9 | 6 | 5 |
| 7 | 3.2 | 7 | 2.4 | 7 | 14 | 7 | 7 |
| 8 | 4.1 | 8 | 3.4 | 8 | 19 | 8 | 9 |
| 9 | 5 | 9 | 4.3 | 9 | 27 | 9 | 13 |
| 10 | 8 | 10 | 5 | 10 | 37 | 10 | 19 |
| 11 | 10 | 11 | 7 | 11 | 48 | 11 | 26 |
| 12 | 12 | 12 | 9 | 12 | 57 | 12 | 33 |
| 13 | 15 | 13 | 13 | 13 | 65 | 13 | 42 |
| 14 | 19 | 14 | 17 | 14 | 73 | 14 | 50 |
| 15 | 25 | 15 | 22 | 15 | 80 | 15 | 59 |
| 16 | 32 | 16 | 28 | 16 | 85 | 16 | 66 |
| 17 | 39 | 17 | 34 | 17 | 90 | 17 | 72 |
| 18 | 47 | 18 | 40 | 18 | 93 | 18 | 80 |
| 19 | 55 | 19 | 48 | 19 | 95.8 | 19 | 87 |
| 20 | 64 | 20 | 60 | 20 | 97.5 | 20 | 92 |
| 21 | 72 | 21 | 70 | 21 | 99.0 | 21 | 96.2 |
| 22 | 77 | 22 | 76 | 22 | 99.4 | 22 | 97.5 |
| 23 | 82 | 23 | 81 | 23 | 99.5 | 23 | 98.4 |
| 24 | 87 | 24 | 86 | 24 | 99.6 | 24 | 98.7 |
| 25 | 94 | 25 | 94 | 25 | 99.8 | 25 | 99.4 |

PR — percentile rank.

**Supplementary Table 4.** Percentile rank norms for PES composite scores for females (n = 636)

| General cognitive empathy | | General affective empathy | | General empathy | | | |
|---|---|---|---|---|---|---|---|
| Raw score | PR | Raw score | PR | Raw score | PR | Raw score | PR |
| 10 | 0.2 | 10 | 0.6 | 20 | 0.1 | 61 | 30 |
| 11 | 0.5 | 11 | 1.4 | 21 | 0.2 | 62 | 32 |
| 12 | 0.6 | 12 | 2.0 | 22 | 0.2 | 63 | 34 |
| 13 | 0.6 | 13 | 2.6 | 23 | 0.2 | 64 | 37 |
| 14 | 0.6 | 14 | 3.1 | 24 | 0.3 | 65 | 40 |
| 15 | 0.7 | 15 | 4.0 | 25 | 0.6 | 66 | 44 |
| 16 | 0.9 | 16 | 5 | 26 | 0.6 | 67 | 47 |
| 17 | 0.9 | 17 | 6 | 27 | 0.6 | 68 | 51 |
| 18 | 0.9 | 18 | 8 | 28 | 0.6 | 69 | 55 |
| 19 | 1.0 | 19 | 10 | 29 | 0.6 | 70 | 58 |
| 20 | 1.6 | 20 | 12 | 30 | 0.7 | 71 | 61 |
| 21 | 2.2 | 21 | 16 | 31 | 0.8 | 72 | 64 |
| 22 | 2.5 | 22 | 20 | 32 | 0.9 | 73 | 67 |
| 23 | 3.2 | 23 | 24 | 33 | 1.0 | 74 | 70 |
| 24 | 4.2 | 24 | 28 | 34 | 1.1 | 75 | 72 |
| 25 | 5 | 25 | 33 | 35 | 1.1 | 76 | 74 |
| 26 | 6 | 26 | 39 | 36 | 1.3 | 77 | 77 |
| 27 | 7 | 27 | 43 | 37 | 1.6 | 78 | 80 |
| 28 | 9 | 28 | 47 | 38 | 1.8 | 79 | 82 |
| 29 | 10 | 29 | 54 | 39 | 2.0 | 80 | 85 |
| 30 | 13 | 30 | 60 | 40 | 2.4 | 81 | 87 |
| 31 | 16 | 31 | 65 | 41 | 3.1 | 82 | 89 |
| 32 | 19 | 32 | 70 | 42 | 3.8 | 83 | 90 |
| 33 | 22 | 33 | 75 | 43 | 4.2 | 84 | 92 |
| 34 | 25 | 34 | 79 | 44 | 4.8 | 85 | 93 |
| 35 | 28 | 35 | 82 | 45 | 6 | 86 | 93 |
| 36 | 32 | 36 | 85 | 46 | 6 | 87 | 94 |
| 37 | 37 | 37 | 88 | 47 | 7 | 88 | 95.0 |
| 38 | 41 | 38 | 90 | 48 | 8 | 89 | 95.8 |
| 39 | 46 | 39 | 92 | 49 | 9 | 90 | 97.0 |
| 40 | 53 | 40 | 94 | 50 | 10 | 91 | 98.0 |
| 41 | 60 | 41 | 95.3 | 51 | 11 | 92 | 98.2 |
| 42 | 64 | 42 | 96.3 | 52 | 12 | 93 | 98.3 |
| 43 | 69 | 43 | 97.1 | 53 | 14 | 94 | 98.6 |
| 44 | 74 | 44 | 97.6 | 54 | 15 | 95 | 98.7 |
| 45 | 77 | 45 | 98.1 | 55 | 17 | 96 | 98.9 |
| 46 | 80 | 46 | 98.4 | 56 | 18 | 97 | 99.1 |
| 47 | 83 | 47 | 98.7 | 57 | 20 | 98 | 99.1 |
| 48 | 86 | 48 | 98.7 | 58 | 22 | 99 | 99.1 |
| 49 | 88 | 49 | 98.7 | 59 | 24 | 100 | 99.5 |
| 50 | 94 | 50 | 99.4 | 60 | 28 | – | – |

PR — percentile rank.

**Supplementary Table 5.** Percentile rank norms for PES composite scores for males (n = 468)

| General cognitive empathy | | General affective empathy | | General empathy | | | |
|---|---|---|---|---|---|---|---|
| Raw score | PR | Raw score | PR | Raw score | PR | Raw score | PR |
| 10 | 0.9 | 10 | 1.7 | 20 | 0.7 | 61 | 41 |
| 11 | 1.7 | 11 | 4.1 | 21 | 1.5 | 62 | 44 |
| 12 | 1.7 | 12 | 5 | 22 | 1.5 | 63 | 47 |
| 13 | 1.8 | 13 | 6 | 23 | 1.5 | 64 | 51 |
| 14 | 2.2 | 14 | 7 | 24 | 1.8 | 65 | 54 |
| 15 | 2.7 | 15 | 8 | 25 | 2.4 | 66 | 57 |
| 16 | 3.0 | 16 | 10 | 26 | 2.6 | 67 | 61 |
| 17 | 3.3 | 17 | 12 | 27 | 2.6 | 68 | 64 |
| 18 | 3.8 | 18 | 15 | 28 | 2.7 | 69 | 68 |
| 19 | 4.7 | 19 | 18 | 29 | 2.8 | 70 | 72 |
| 20 | 5 | 20 | 23 | 30 | 3.0 | 71 | 74 |
| 21 | 6 | 21 | 26 | 31 | 3.4 | 72 | 77 |
| 22 | 8 | 22 | 30 | 32 | 4.0 | 73 | 81 |
| 23 | 9 | 23 | 35 | 33 | 4.4 | 74 | 83 |
| 24 | 10 | 24 | 41 | 34 | 4.5 | 75 | 85 |
| 25 | 11 | 25 | 46 | 35 | 4.6 | 76 | 87 |
| 26 | 13 | 26 | 51 | 36 | 5 | 77 | 89 |
| 27 | 15 | 27 | 56 | 37 | 6 | 78 | 90 |
| 28 | 18 | 28 | 61 | 38 | 6 | 79 | 91 |
| 29 | 20 | 29 | 67 | 39 | 6 | 80 | 93 |
| 30 | 24 | 30 | 72 | 40 | 7 | 81 | 94 |
| 31 | 27 | 31 | 77 | 41 | 8 | 82 | 94 |
| 32 | 29 | 32 | 81 | 42 | 8 | 83 | 95 |
| 33 | 31 | 33 | 86 | 43 | 9 | 84 | 95.9 |
| 34 | 35 | 34 | 90 | 44 | 9 | 85 | 96.8 |
| 35 | 39 | 35 | 92 | 45 | 10 | 86 | 97.5 |
| 36 | 43 | 36 | 93 | 46 | 12 | 87 | 98.2 |
| 37 | 47 | 37 | 95 | 47 | 13 | 88 | 98.6 |
| 38 | 53 | 38 | 95.6 | 48 | 15 | 89 | 98.8 |
| 39 | 58 | 39 | 96.3 | 49 | 16 | 90 | 98.9 |
| 40 | 63 | 40 | 97.2 | 50 | 17 | 91 | 98.9 |
| 41 | 68 | 41 | 98.1 | 51 | 20 | 92 | 99.0 |
| 42 | 72 | 42 | 98.7 | 52 | 22 | 93 | 99.4 |
| 43 | 75 | 43 | 99.1 | 53 | 23 | 94 | 99.6 |
| 44 | 79 | 44 | 99.5 | 54 | 25 | 95 | 99.6 |
| 45 | 81 | 45 | 99.6 | 55 | 27 | 96 | 99.6 |
| 46 | 83 | 46 | 99.6 | 56 | 29 | 97 | 99.7 |
| 47 | 85 | 47 | 99.6 | 57 | 31 | 98 | 99.8 |
| 48 | 87 | 48 | 99.6 | 58 | 33 | 99 | 99.8 |
| 49 | 90 | 49 | 99.6 | 59 | 36 | 100 | 99.9 |
| 50 | 95.4 | 50 | 99.8 | 60 | 38 | – | – |

PR — percentile rank.

**Supplementary Table 6.** Percentile rank norms for PES subscale scores for the total sample (n = 1112)

| Negative cognitive empathy | | Positive cognitive empathy | | Negative affective empathy | | Positive affective empathy | |
|---|---|---|---|---|---|---|---|
| Raw score | PR | Raw score | PR | Raw score | PR | Raw score | PR |
| 5 | 0.6 | 5 | 0.5 | 5 | 1.8 | 5 | 1.8 |
| 6 | 1.4 | 6 | 1.1 | 6 | 6 | 6 | 4.1 |
| 7 | 1.9 | 7 | 1.4 | 7 | 9 | 7 | 6 |
| 8 | 2.2 | 8 | 1.9 | 8 | 14 | 8 | 8 |
| 9 | 2.9 | 9 | 2.4 | 9 | 20 | 9 | 10 |
| 10 | 4.3 | 10 | 3.3 | 10 | 28 | 10 | 15 |
| 11 | 6 | 11 | 4.7 | 11 | 38 | 11 | 22 |
| 12 | 8 | 12 | 7 | 12 | 47 | 12 | 29 |
| 13 | 10 | 13 | 9 | 13 | 57 | 13 | 37 |
| 14 | 14 | 14 | 12 | 14 | 65 | 14 | 45 |
| 15 | 19 | 15 | 17 | 15 | 73 | 15 | 53 |
| 16 | 25 | 16 | 24 | 16 | 80 | 16 | 61 |
| 17 | 32 | 17 | 29 | 17 | 85 | 17 | 69 |
| 18 | 39 | 18 | 36 | 18 | 89 | 18 | 76 |
| 19 | 47 | 19 | 44 | 19 | 93 | 19 | 83 |
| 20 | 58 | 20 | 56 | 20 | 95.5 | 20 | 89 |
| 21 | 68 | 21 | 67 | 21 | 97.1 | 21 | 93 |
| 22 | 74 | 22 | 74 | 22 | 98.0 | 22 | 95.2 |
| 23 | 80 | 23 | 80 | 23 | 98.7 | 23 | 96.8 |
| 24 | 85 | 24 | 85 | 24 | 99.1 | 24 | 97.7 |
| 25 | 94 | 25 | 93 | 25 | 99.6 | 25 | 99.1 |

PR — percentile rank.

**Supplementary Table 7.** Percentile rank norms for PES composite scores for the total sample (n = 1112)

| General cognitive empathy | | General affective empathy | | General empathy | | | |
|---|---|---|---|---|---|---|---|
| Raw score | PR | Raw score | PR | Raw score | PR | Raw score | PR |
| 10 | 0.5 | 10 | 1.1 | 20 | 0.4 | 61 | 35 |
| 11 | 1.0 | 11 | 2.5 | 21 | 0.7 | 62 | 37 |
| 12 | 1.0 | 12 | 3.4 | 22 | 0.7 | 63 | 40 |
| 13 | 1.1 | 13 | 4.0 | 23 | 0.7 | 64 | 43 |
| 14 | 1.3 | 14 | 4.7 | 24 | 0.9 | 65 | 46 |
| 15 | 1.5 | 15 | 6 | 25 | 1.3 | 66 | 50 |
| 16 | 1.8 | 16 | 7 | 26 | 1.4 | 67 | 53 |
| 17 | 1.9 | 17 | 9 | 27 | 1.4 | 68 | 57 |
| 18 | 2.2 | 18 | 11 | 28 | 1.5 | 69 | 60 |
| 19 | 2.6 | 19 | 13 | 29 | 1.5 | 70 | 64 |
| 20 | 3.2 | 20 | 17 | 30 | 1.7 | 71 | 67 |
| 21 | 3.9 | 21 | 20 | 31 | 1.9 | 72 | 70 |
| 22 | 4.7 | 22 | 24 | 32 | 2.2 | 73 | 73 |
| 23 | 6 | 23 | 29 | 33 | 2.4 | 74 | 76 |
| 24 | 6 | 24 | 34 | 34 | 2.5 | 75 | 78 |
| 25 | 7 | 25 | 39 | 35 | 2.6 | 76 | 80 |
| 26 | 9 | 26 | 44 | 36 | 2.8 | 77 | 82 |
| 27 | 11 | 27 | 48 | 37 | 3.2 | 78 | 84 |
| 28 | 12 | 28 | 53 | 38 | 3.5 | 79 | 86 |
| 29 | 14 | 29 | 59 | 39 | 3.8 | 80 | 88 |
| 30 | 17 | 30 | 65 | 40 | 4.3 | 81 | 90 |
| 31 | 21 | 31 | 70 | 41 | 5 | 82 | 91 |
| 32 | 23 | 32 | 75 | 42 | 6 | 83 | 92 |
| 33 | 26 | 33 | 80 | 43 | 6 | 84 | 93 |
| 34 | 30 | 34 | 84 | 44 | 7 | 85 | 94 |
| 35 | 33 | 35 | 86 | 45 | 8 | 86 | 95.1 |
| 36 | 37 | 36 | 89 | 46 | 9 | 87 | 95.9 |
| 37 | 42 | 37 | 91 | 47 | 10 | 88 | 96.5 |
| 38 | 46 | 38 | 93 | 48 | 11 | 89 | 97.1 |
| 39 | 51 | 39 | 94 | 49 | 12 | 90 | 97.8 |
| 40 | 58 | 40 | 95.3 | 50 | 13 | 91 | 98.4 |
| 41 | 64 | 41 | 96.5 | 51 | 15 | 92 | 98.6 |
| 42 | 68 | 42 | 97.3 | 52 | 16 | 93 | 98.8 |
| 43 | 72 | 43 | 98.0 | 53 | 18 | 94 | 99.0 |
| 44 | 76 | 44 | 98.4 | 54 | 19 | 95 | 99.1 |
| 45 | 79 | 45 | 98.7 | 55 | 21 | 96 | 99.2 |
| 46 | 81 | 46 | 98.9 | 56 | 23 | 97 | 99.3 |
| 47 | 84 | 47 | 99.1 | 57 | 25 | 98 | 99.4 |
| 48 | 87 | 48 | 99.1 | 58 | 27 | 99 | 99.4 |
| 49 | 89 | 49 | 99.1 | 59 | 29 | 100 | 99.7 |
| 50 | 95 | 50 | 99.6 | 60 | 32 | – | – |

PR — percentile rank.