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To which world regions does the valence–dominance model of social perception apply?

Over the past 10 years, Oosterhof and Todorov's valence–dominance model has emerged as the most prominent account of how people evaluate faces on social dimensions. In this model, two dimensions (valence and dominance) underpin social judgements of faces. Because this model has primarily been developed and tested in Western regions, it is unclear whether these findings apply to other regions. We addressed this question by replicating Oosterhof and Todorov's methodology across 11 world regions, 41 countries and 11,570 participants. When we used Oosterhof and Todorov's original analysis strategy, the valence–dominance model generalized across regions. When we used an alternative methodology to allow for correlated dimensions, we observed much less generalization. Collectively, these results suggest that, while the valence–dominance model generalizes very well across regions when dimensions are forced to be orthogonal, regional differences are revealed when we use different extraction methods and correlate and rotate the dimension reduction solution.

Protocol registration

The stage 1 protocol for this Registered Report was accepted in principle on 5 November 2018. The protocol, as accepted by the journal, can be found at https://doi.org/10.6084/m9.figshare.7611443.v1.

People quickly and involuntarily form impressions of others based on their facial appearance[1–3]. These impressions then influence important social outcomes[4,5]. For example, people are more likely to cooperate in socioeconomic interactions with individuals whose faces are evaluated as more trustworthy[6], vote for individuals whose faces are evaluated as more competent[7], and seek romantic relationships with individuals whose faces are evaluated as more attractive[8]. Facial appearance can even influence life-or-death outcomes. For example, untrustworthy-looking defendants are more likely to receive death sentences[9]. Given that such evaluations influence profound outcomes, understanding how people evaluate others' faces can provide insight into a potentially important route through which social stereotypes impact behaviour[10,11].

Over the past decade, Oosterhof and Todorov's valence–dominance model[12] has emerged as the most prominent account of how we evaluate faces on social dimensions[5]. Oosterhof and Todorov identified 13 different traits (aggressiveness, attractiveness, caringness, confidence, dominance, emotional stability, unhappiness, intelligence, meanness, responsibility, sociability, trustworthiness and weirdness) that perceivers spontaneously use to evaluate faces when forming trait impressions[12]. From these traits, they derived a two-dimensional model of perception: valence and dominance. Valence, best characterized by rated trustworthiness, was defined as the extent to which the target was perceived as having the intention to harm the viewer[12]. Dominance, best characterized by rated dominance, was defined as the extent to which the target was perceived as having the ability to inflict harm on the viewer[12]. Crucially, the model proposes that these two dimensions are sufficient to drive social evaluations of faces. As a consequence, the majority of research on the effects of social evaluations of faces has focused on one or both of these dimensions[4,5].

Successful replications of the valence–dominance model have only been conducted in Western samples[13,14]. This focus on the West is consistent with research on human behaviour more broadly, which typically draws general assumptions from analyses of Western participants' responses[15]. Kline et al.[16] recently termed this problematic practice the Western centrality assumption and argued that regional variation, rather than universality, is probably the default for human behaviour.

Consistent with Kline et al.'s notion that human behaviour is best characterized by regional variation, two recent studies of social evaluation of faces by Chinese participants indicate that different factors underlie their impressions[17,18]. Both studies reported that Chinese participants' social evaluations of faces were underpinned by a valence dimension similar to that reported by Oosterhof and Todorov for Western participants, but not by a corresponding dominance dimension. Instead, both studies reported a second dimension, referred to as capability, which was best characterized by rated intelligence. Furthermore, the ethnicity of the faces rated only subtly affected perceptions[17]. Research into potential cultural differences in the effects of experimentally manipulated facial characteristics on social perceptions has also found little evidence that cultural differences in social perceptions of faces depend on the ethnicity of the faces presented[19–21]. Collectively, these results suggest that the Western centrality assumption may be an important barrier to understanding how people evaluate faces on social dimensions. Crucially, these studies also suggest that the valence–dominance model is not necessarily a universal account of social evaluations of faces and warrants further investigation in the broadest set of samples possible.

Although the studies described above demonstrate that the valence–dominance model is not perfectly universal, to which specific world regions it does and does not apply are open and important questions. Demonstrating differences between British and Chinese raters is evidence against the universality of the valence–dominance model, but it does not adequately address these questions. Social perception in China may be unique in not fitting the valence–dominance model because of the atypically high general importance placed on status-related traits, such as capability, during social interactions in China[22,23]. Indeed, Tan et al.[24] demonstrated face-processing differences between Chinese participants living in mainland China and Chinese participants living in nearby countries, such as Malaysia. Insights regarding the unique formation of social perceptions in other cultures and world regions are lacking.

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Only a large-scale study investigating social perceptions in many different world regions can provide such insights.

To establish the world regions to which the valence–dominance model applies, we replicated Oosterhof and Todorov's methodology[12] in a wide range of world regions (Africa, Asia, Australia and New Zealand, Central America and Mexico, Eastern Europe, the Middle East, the United States and Canada, Scandinavia, South America, the United Kingdom and Western Europe; see Table 1). Our study is the most comprehensive test of social evaluations of faces to date, including more than 11,000 participants. Participating research groups were recruited via the Psychological Science Accelerator project[25–27]. Previous studies compared two cultures to demonstrate regional differences[17,18]. In contrast, the scale and scope of our study allows us to generate the most comprehensive picture of the world regions to which the valence–dominance model does and does not apply.

We tested two specific competing predictions: (1) the valence–dominance model applies to all world regions; and (2) the valence–dominance model applies in Western-world regions, but not other world regions.

Table 1 | World regions, countries and localities of data collection

World region	Countries and localities
Africa	Kenya, (Nigeria) and South Africa
Asia	China, India, Malaysia, Taiwan and Thailand
Australia and New Zealand	Australia and New Zealand
Central America and Mexico	El Salvador and Mexico
Eastern Europe	Hungary, Lithuania, Poland, Russia, Serbia and Slovakia
The Middle East	Iran, Israel and Turkey
United States and Canada	Canada and the United States
Scandinavia	Denmark, (Finland), Norway and (Sweden)
South America	Argentina, Brazil, Chile, Colombia and Ecuador
United Kingdom	England, Scotland and Wales
Western Europe	Austria, Belgium, France, Germany, (Greece), Italy, the Netherlands, Portugal, Spain and Switzerland

We collected data from a minimum of 350 raters per world region based on the simulations described in the Methods. Countries in parentheses were added to the list after acceptance in principle of the stage 1 protocol. Ecuador was incorrectly classified as Central America and Mexico in our stage 1 submission, but has been classified as South America for analyses and in our stage 2 submission.

Results

Analysed dataset. Following the planned data exclusions (see the Supplementary Information for a breakdown of these exclusions; code 1.5), the analysed dataset is summarized in Table 2.

Main analysis (principal component analysis (PCA); code 2.1). Oosterhof and Todorov reported the results of a PCA with orthogonal components, no rotation and retaining components with eigenvalues of >1. We conducted an identical analysis and report: (1) the number of components extracted per the registered criteria; (2) whether the first and second components had the same primary pattern as Oosterhof and Todorov reported; and (3) the similarity of the first and second factors as quantified with a congruence coefficient.

We extracted the same number of components (two) as Oosterhof and Todorov in two world regions (Africa and South America) and a different number of components (three) in the other world regions (see Fig. 1). In the world regions where a third component was extracted, the trait ratings of unhappy and weird tended to have the highest loadings on that component, but those ratings also crossloaded on the first component. We hesitate to interpret or describe this component with any authority because it varied across world regions, consisted of crossloaded traits and explained only a small proportion of additional variance.

The primary pattern reported by Oosterhof and Todorov (a first component that correlated strongly with rated trustworthiness but not with rated dominance and a second component that correlated strongly with rated dominance but not with rated trustworthiness) was present in all world regions except Eastern Europe. In Eastern Europe, dominance was correlated with the first component more strongly than our registered criterion (i.e., that dominance would correlate weakly with the first component; $r < 0.5$). Figure 1 shows the full loading matrices for each region and Table 3 shows how these relate to our registered criteria.

We report Tucker's coefficient of congruence, ϕ, which quantifies the loading similarity of Oosterhof and Todorov's reported component to the corresponding component we extracted. However, it is important to interpret ϕ with caution when the numbers of components differ across the solutions being compared. When comparing loadings across solutions, an assumption is that the configuration of the traits to components is the same (that is, configural invariance). To the extent that the structures of the loading matrices differ across solutions, the comparability of the loadings is compromised (that is, loadings estimated from different dimensional spaces are not on the same scale). For world regions that did not have the same configuration of traits to components (that is, those with a different number of components extracted or a different primary pattern observed), ϕ was uninterpretable. This is because the differences in configuration across the two solutions were conflated with the loading differences.

Our analyses indicated that the first component was equal to the first component in Oosterhof and Todorov's original study for all world regions ($\phi > 0.95$). The second component was equal to ($\phi > 0.95$) or fairly similar to ($\phi > 0.85$) the second component reported by Oosterhof and Todorov in all of the world regions except Asia ($\phi = 0.848$). Table 4 summarizes these results.

Together, these results suggest that the valence–dominance model generalizes across world regions when using an identical analysis to that used in Oosterhof and Todorov's original study. Thus, the results of our PCA support prediction 1 (that the valence–dominance model will apply to all world regions) but not prediction 2 (that the valence–dominance model will apply in Western-world regions but not other world regions). However, we note here that in most world regions we extracted a third component not extracted in the original study: that Eastern Europe did not demonstrate the same primary pattern and that ϕ should be interpreted with caution for all world regions except Africa and South America.

Robustness analyses (exploratory factor analysis (EFA); code 2.2). Following our analysis plan, we conducted additional robustness analyses that directly addressed criticisms of the type of statistical analyses used by Oosterhof and Todorov (see ref. [28] for a discussion of these criticisms). These robustness analyses employed EFA with an oblimin rotation as the model and used parallel analysis to identify the number of factors to extract. The goal of an EFA with an oblimin rotation is to simplify the loading matrix and yield interpretable factors.

We conducted this analysis on Oosterhof and Todorov's original data and found a similar result to their PCA solution: two factors extracted, with factor 1 characterized by a high loading for trustworthiness and factor 2 characterized by a high loading for dominance.

Table 2 | Number of participants per region and Cronbach's α values following data quality checks and exclusions

Region	Aggressive	Attractive	Caring	Confident	Dominant	Emotionally stable	Intelligent	Mean	Responsible	Sociable	Trustworthy	Unhappy	Weird
Western Europe	$\alpha=0.978$ $n=152$	$\alpha=0.991$ $n=147$	$\alpha=0.976$ $n=136$	$\alpha=0.985$ $n=156$	$\alpha=0.973$ $n=150$	$\alpha=0.981$ $n=141$	$\alpha=0.975$ $n=141$	$\alpha=0.969$ $n=120$	$\alpha=0.978$ $n=138$	$\alpha=0.988$ $n=188$	$\alpha=0.978$ $n=141$	$\alpha=0.983$ $n=140$	$\alpha=0.982$ $n=113$
United States and Canada	$\alpha=0.983$ $n=248$	$\alpha=0.991$ $n=224$	$\alpha=0.986$ $n=257$	$\alpha=0.989$ $n=303$	$\alpha=0.977$ $n=246$	$\alpha=0.986$ $n=270$	$\alpha=0.979$ $n=239$	$\alpha=0.984$ $n=270$	$\alpha=0.984$ $n=269$	$\alpha=0.988$ $n=246$	$\alpha=0.984$ $n=263$	$\alpha=0.985$ $n=252$	$\alpha=0.987$ $n=226$
United Kingdom	$\alpha=0.879$ $n=16$	$\alpha=0.949$ $n=22$	$\alpha=0.936$ $n=34$	$\alpha=0.93$ $n=30$	$\alpha=0.886$ $n=34$	$\alpha=0.9$ $n=30$	$\alpha=0.911$ $n=34$	$\alpha=0.87$ $n=27$	$\alpha=0.892$ $n=37$	$\alpha=0.932$ $n=28$	$\alpha=0.92$ $n=27$	$\alpha=0.937$ $n=24$	$\alpha=0.899$ $n=18$
South America	$\alpha=0.948$ $n=97$	$\alpha=0.982$ $n=108$	$\alpha=0.944$ $n=112$	$\alpha=0.968$ $n=108$	$\alpha=0.957$ $n=121$	$\alpha=0.949$ $n=100$	$\alpha=0.938$ $n=110$	$\alpha=0.949$ $n=95$	$\alpha=0.937$ $n=117$	$\alpha=0.974$ $n=110$	$\alpha=0.952$ $n=107$	$\alpha=0.961$ $n=87$	$\alpha=0.973$ $n=116$
Scandinavia	$\alpha=0.95$ $n=48$	$\alpha=0.969$ $n=44$	$\alpha=0.949$ $n=46$	$\alpha=0.96$ $n=56$	$\alpha=0.941$ $n=49$	$\alpha=0.955$ $n=67$	$\alpha=0.958$ $n=54$	$\alpha=0.912$ $n=36$	$\alpha=0.915$ $n=37$	$\alpha=0.969$ $n=64$	$\alpha=0.949$ $n=58$	$\alpha=0.952$ $n=55$	$\alpha=0.952$ $n=39$
Middle East	$\alpha=0.912$ $n=32$	$\alpha=0.949$ $n=32$	$\alpha=0.934$ $n=42$	$\alpha=0.943$ $n=39$	$\alpha=0.9$ $n=35$	$\alpha=0.903$ $n=33$	$\alpha=0.896$ $n=48$	$\alpha=0.901$ $n=36$	$\alpha=0.87$ $n=34$	$\alpha=0.944$ $n=41$	$\alpha=0.895$ $n=42$	$\alpha=0.943$ $n=57$	$\alpha=0.896$ $n=32$
Eastern Europe	$\alpha=0.941$ $n=59$	$\alpha=0.971$ $n=58$	$\alpha=0.926$ $n=56$	$\alpha=0.946$ $n=60$	$\alpha=0.952$ $n=74$	$\alpha=0.923$ $n=56$	$\alpha=0.939$ $n=64$	$\alpha=0.937$ $n=68$	$\alpha=0.953$ $n=65$	$\alpha=0.955$ $n=68$	$\alpha=0.937$ $n=54$	$\alpha=0.964$ $n=74$	$\alpha=0.956$ $n=53$
Central America and Mexico	$\alpha=0.845$ $n=26$	$\alpha=0.93$ $n=25$	$\alpha=0.788$ $n=24$	$\alpha=0.89$ $n=32$	$\alpha=0.859$ $n=33$	$\alpha=0.835$ $n=23$	$\alpha=0.832$ $n=33$	$\alpha=0.817$ $n=23$	$\alpha=0.824$ $n=22$	$\alpha=0.882$ $n=28$	$\alpha=0.851$ $n=27$	$\alpha=0.771$ $n=27$	$\alpha=0.842$ $n=15$
Australia and New Zealand	$\alpha=0.956$ $n=77$	$\alpha=0.98$ $n=88$	$\alpha=0.964$ $n=90$	$\alpha=0.972$ $n=93$	$\alpha=0.936$ $n=66$	$\alpha=0.957$ $n=88$	$\alpha=0.951$ $n=81$	$\alpha=0.947$ $n=71$	$\alpha=0.937$ $n=68$	$\alpha=0.972$ $n=95$	$\alpha=0.953$ $n=72$	$\alpha=0.948$ $n=85$	$\alpha=0.962$ $n=70$
Asia	$\alpha=0.932$ $n=59$	$\alpha=0.957$ $n=52$	$\alpha=0.948$ $n=73$	$\alpha=0.959$ $n=72$	$\alpha=0.917$ $n=55$	$\alpha=0.908$ $n=55$	$\alpha=0.927$ $n=64$	$\alpha=0.909$ $n=51$	$\alpha=0.931$ $n=63$	$\alpha=0.952$ $n=65$	$\alpha=0.93$ $n=61$	$\alpha=0.937$ $n=61$	$\alpha=0.942$ $n=49$
Africa	$\alpha=0.808$ $n=45$	$\alpha=0.873$ $n=38$	$\alpha=0.865$ $n=44$	$\alpha=0.805$ $n=31$	$\alpha=0.79$ $n=38$	$\alpha=0.779$ $n=38$	$\alpha=0.756$ $n=37$	$\alpha=0.889$ $n=51$	$\alpha=0.811$ $n=36$	$\alpha=0.819$ $n=34$	$\alpha=0.867$ $n=49$	$\alpha=0.795$ $n=43$	$\alpha=0.889$ $n=37$

However, for all other world regions, we extracted more than two factors using parallel analysis. Full EFA loading matrices for each region and Oosterhof and Todorov's original data are shown in Fig. 2. The four-factor solution for the USA and Canada did not converge. We did not register a contingency for nonconvergence, but because parallel analysis can lead to over extraction, we reran the EFA with one fewer than the number of suggested factors. The model converged when estimating three factors.

In contrast with the PCA, the results of our robustness analyses showed less evidence that the valence–dominance model generalizes across world regions. For example, we extracted a different number of factors than the original solution for all world regions. A summary of the results for our replication criteria is given in Table 5.

Because the number of factors differed from the original solution in all world regions and the loading matrices were differentially rotated from the original solution, it is not valid to compare the differences in the loadings from the original solution with those observed in the world regions reported here, as we had initially planned. Loadings quantify the relationship of traits to a factor. To compare loadings across samples, we must first determine whether we extracted the same factor in each sample (that is, satisfied the assumption of configural invariance). Our registered analyses included the calculation of Tucker's coefficient of congruence, ϕ in order to compare the first factor from the original study with the first factor we extracted in a given world region, and to compare the second factor from the original study with the second factor extracted in a given world region. However, because we extracted a different number of factors from the original solution in all world regions, it is not valid to compare the loadings across these different factors, or to quantify their differences using ϕ.

The congruence coefficient is only appropriate to report when we can ensure that the factors are comparable across samples. That the number of factors extracted did not replicate the original pattern and that the EFAs were rotated differently across world regions negates the comparability of the loadings. Consistent with our registered analysis code, we reported ϕ for the relationship of the first factor from Oosterhof and Todorov to the factor with the most explained variance in a world region, and ϕ for the relationship of the second factor from Oosterhof and Todorov to the factor with the second most explained variance in a world region only in the Supplementary Information. However, we stress that these coefficients are quantifying loadings that link to different factors from different dimensional spaces and are not necessarily comparable.

In summary, the results of our EFA support neither prediction 1 (that the valence–dominance model will apply to all world regions) nor prediction 2 (that the valence–dominance model will apply to Western-world regions but not other world regions).

Discussion

Our primary analyses—PCAs identical to those reported by Oosterhof and Todorov—suggested that the valence–dominance model of social perception of faces generalizes well across world regions. Although most world regions showed a third component not discussed in the original work[12], this third component is actually similar to the third component in Oosterhof and Todorov's original study. In Oosterhof and Todorov's original study, they did not interpret the third component because its eigenvalue was below 1, whereas in our analyses the eigenvalues of the third components in most of the regions were just above 1. Nonetheless, the third component in each region had a factor congruence between 0.77 and 0.90 with the third component for Oosterhof and Todorov's data. However, we emphasize here that many of these dimensions accounted for a relatively small proportion of the variance explained and, thus, may be of limited theoretical importance.

In contrast with the results of our PCAs, an alternative analysis that addressed common criticisms of the type of analysis Oosterhof and Todorov employed showed much less generalization across world regions. We used modern extraction techniques and EFAs with correlated factor rotations. The correlated rotation methods aim to simplify the loading matrix with the goal of estimating

Fig. 1 | PCA loading matrices for each region. Positive loadings are shaded red and negative loadings are shaded blue. Darker colours correspond to stronger loadings. The proportion of variance (Prop.Var) explained by each component is included at the top of each table.

Table 3 | Replication criteria for the PCA for each region

Region	Component 1		Component 2		Replicated
	Trustworthy	Dominant	Dominant	Trustworthy	
Oosterhof and Todorov[12]	0.941	−0.244	0.929	−0.060	Yes
Africa	0.924	0.271	0.843	−0.065	Yes
Asia	0.922	0.370	0.863	−0.006	Yes
Australia and New Zealand	0.943	0.257	0.907	−0.076	Yes
Central America and Mexico	0.918	0.007	0.915	−0.050	Yes
Eastern Europe	0.938	0.599	0.755	−0.113	No
Middle East	0.831	0.490	0.810	−0.382	Yes
Scandinavia	0.953	0.392	0.881	−0.121	Yes
South America	0.898	0.309	0.905	−0.151	Yes
United Kingdom	0.944	0.331	0.851	−0.121	Yes
United States and Canada	0.966	0.406	0.841	−0.073	Yes
Western Europe	0.957	0.357	0.875	−0.166	Yes

Oosterhof and Todorov's valence–dominance model was judged to have been replicated in a given world region if the first component had a loading of >0.7 with trustworthiness and <0.5 with dominance, and if the second component had a loading of >0.7 with dominance and <0.5 with trustworthiness.

interpretable factors, and in our data revealed more regional variation. These results suggest that, if the dimensions of face perception are indeed correlated, using analytical techniques that force these dimensions to be uncorrelated may be obscuring important regional differences in the structure of face perceptions.

A necessary next step for moving forward in person perception research is to address which analysis model (PCA or EFA) best aligns with theory, so that models and theories can be revised and expanded appropriately in future research. Crucially, the two models make different assumptions about trait ratings of faces.

Table 4 | Factor congruence for each region's PCA

Region	Component 1		Component 2	
	Loading	Congruence	Loading	Congruence
Africa	0.980	Equal	0.947	Fairly similar
Asia	0.974	Equal	0.843	Not similar
Australia and New Zealand	0.982	Equal	0.959	Equal
Central America and Mexico	0.992	Equal	0.935	Fairly similar
Eastern Europe	0.953	Equal	0.948	Fairly similar
Middle East	0.952	Equal	0.859	Fairly similar
Scandinavia	0.973	Equal	0.960	Equal
South America	0.976	Equal	0.953	Equal
United Kingdom	0.976	Equal	0.938	Fairly similar
United States and Canada	0.972	Equal	0.952	Equal
Western Europe	0.975	Equal	0.936	Fairly similar

The PCA model does not assume that a latent factor causes the trait ratings of the faces. The component captures linear combinations of the original variables, maximized to explain variance. Furthermore, in the original valence–dominance model, those components were assumed to be orthogonal. In contrast, the theory underlying the EFA model is that a latent factor causes the trait ratings and any unexplained variance in that rating is measurement error. Additionally, our EFA models allowed for the factors to be correlated.

Theory can guide which model we use to analyse person perception data. A person perception theory that aligns with a PCA model would state that there are no underlying latent factors that cause a person to rate a face in a particular way. There are, instead, perceptual processes that vary across contexts, those doing the rating and those being rated, and the differential processes give rise to components that can be used to reduce the data. This theory of person perception would move forward with identifying the shared processes across contexts, raters and ratees to see whether there are predictable patterns in how the data are reduced.

A person perception theory that aligns with an EFA model makes different assumptions about the processes that give rise to face ratings. This theory would state that latent factors (for example, valence or dominance) cause the trait ratings and, once we account for the correct latent factors, any variability left in the ratings is measurement error. We suggest that more careful and explicit consideration of how theory connects to these approaches, and of which approach is best suited to different research questions, will benefit the field.

Our study is one of several recent studies that have begun to utilize different statistical models and to explore more dynamic theories of trait ratings[21,29,30] by exploring how the structures of trait ratings vary systematically. This growing body of work catalogues variations in trait ratings by target demographic[21,29,31], target status[32], target age[33], perceiver knowledge[34] and cultural factors[17,18]. Furthermore, this growing body of work proposes dynamic theories of person perception and more flexible statistical models for capturing them[21,29,30,35].

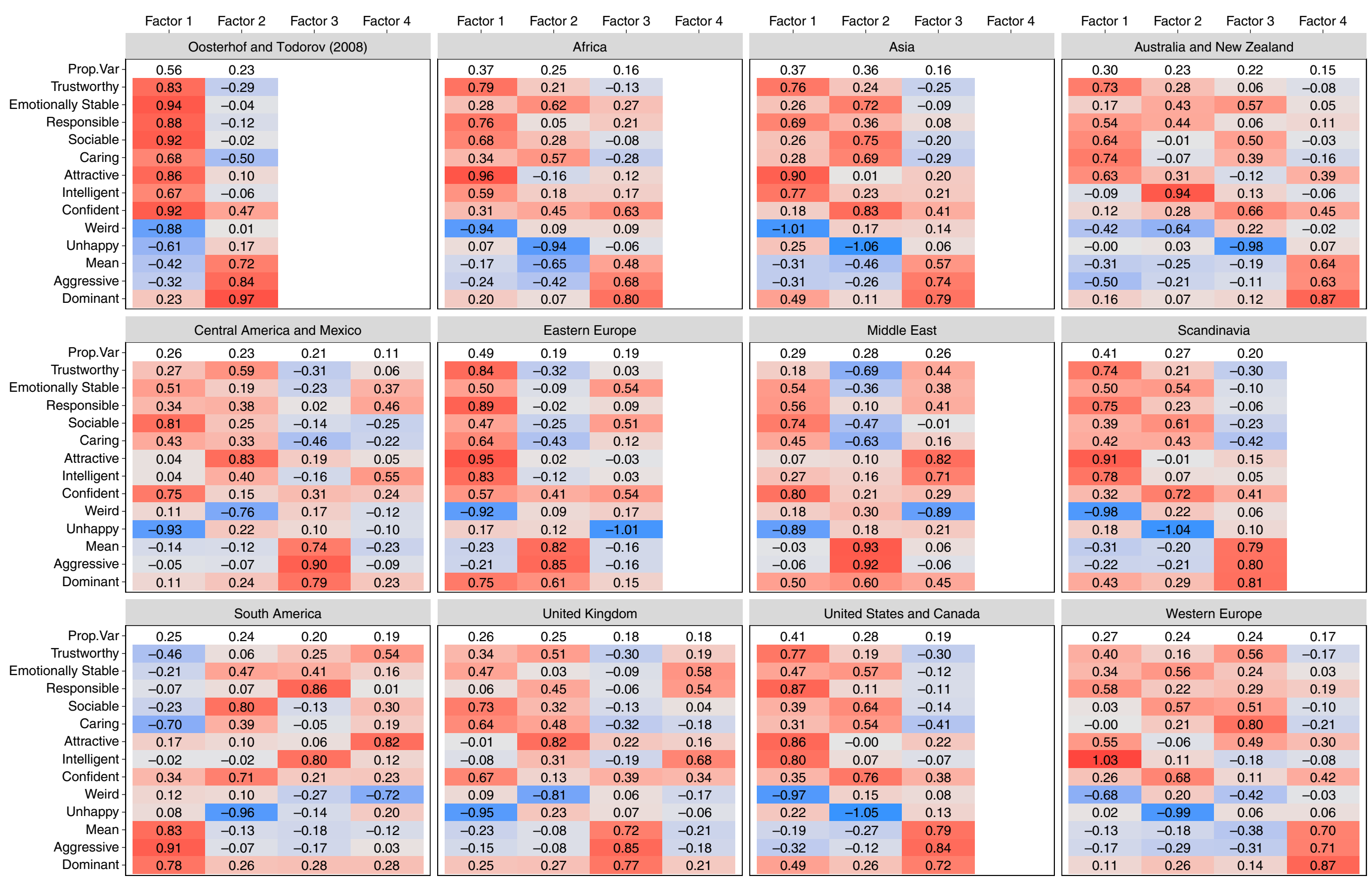

Fig. 2 | EFA loading matrices for each region. Positive loadings are shaded red and negative loadings are shaded blue. Darker colours correspond to stronger loadings. The proportion of variance explained by each factor is included at the top of each table.

Table 5 | Replication criteria for the EFA for each region

Region	Factor 1		Factor 2		Replicated
	Trustworthy	Dominant	Dominant	Trustworthy	
Oosterhof and Todorov[12]	0.826	0.228	0.970	−0.288	Yes
Africa	0.786	0.200	0.069	0.214	No
Asia	0.761	0.487	0.110	0.236	No
Australia and New Zealand	0.730	0.157	0.071	0.281	No
Central America and Mexico	0.268	0.108	0.241	0.591	No
Eastern Europe	0.843	0.750	0.609	−0.322	No
Middle East	0.177	0.502	0.600	−0.686	No
Scandinavia	0.744	0.428	0.293	0.211	No
South America	−0.458	0.778	0.261	0.058	No
United Kingdom	0.338	0.249	0.265	0.510	No
United States and Canada	0.768	0.491	0.264	0.189	No
Western Europe	0.398	0.111	0.256	0.164	No

Oosterhof and Todorov's valence–dominance model was judged to have been replicated in a given world region if the first factor had a loading >0.7 with trustworthiness and <0.5 with dominance and the second factor had a loading >0.7 with dominance and <0.5 with trustworthiness.

Our results are consistent with this recent work in that they do not provide strong evidence that there are a few generalizable latent factors that cause the trait ratings across world regions. However, they do suggest a dynamic process of person perception and elucidate the differential patterns of ratings across world regions. We can use these data, representing impressions formed on a global scale, to expand or refine our theories and to guide the selection of statistical models to represent those theories. Given the accumulating evidence for variation in trait ratings, it is important that the connection between the statistical models used to represent theories of person perception are explicit and can accommodate the complexities of the impression formation process.

Methods

Ethics. Each research group had approval from their local ethics committee or institutional review board to conduct the study, had explicitly indicated that their institution did not require approval for the researchers to conduct this type of face-rating task or had explicitly indicated that the current study was covered by a pre-existing approval. Although the specifics of the consent procedure differed across research groups, all participants provided informed consent. All data were stored centrally on University of Glasgow servers.

Procedure. Oosterhof and Todorov derived their valence–dominance model from a PCA of ratings (by US raters) of 66 faces for 13 different traits (aggressiveness, attractiveness, caringness, confidence, dominance, emotional stability, intelligence, meanness, responsibility, sociability, trustworthiness, unhappiness and weirdness)[12]. Using the criteria of the number of components with eigenvalues greater than 1.0, this analysis produced two principal components. The first component explained 63% of the variance in trait ratings, strongly correlated with rated trustworthiness ($r=0.94$) and weakly correlated with rated dominance ($r=-0.24$). The second component explained 18% of the variance in trait ratings, strongly correlated with rated dominance ($r=0.93$) and weakly correlated with rated trustworthiness ($r=-0.06$). We replicated Oosterhof and Todorov's method[12] and primary analysis in each world region we examined.

Stimuli in our study came from an open-access, full-colour face image set[36] consisting of images of the faces of 60 men and 60 women taken under standardized photographic conditions ($M_{age}=26.4$ years; s.d. = 3.6 years; range = 18–35 years). These 120 images consisted of 30 Black (15 male; 15 female), 30 White (15 male; 15 female), 30 Asian (15 male; 15 female) and 30 Latin faces (15 male; 15 female). As reported by Oosterhof and Todorov's study[12], the individuals photographed posed looking directly at the camera with a neutral expression, and the background, lighting and clothing (here, a grey t-shirt) were constant across images.

In our study, adult raters were randomly assigned to rate the 13 adjectives tested by Oosterhof and Todorov using scales ranging from 1 (not at all) to 9 (very) for all 120 faces in a fully randomized order at their own pace. Because all researchers collected data through an identical interface (except for differences in instruction language), data collection protocols were highly standardized across laboratories. Each participant completed the block of 120 face-rating trials twice so that we could report test–retest reliabilities of ratings; ratings from the first and second blocks were averaged for all analyses (see code 1.5.5 in the Supplementary Information).

Raters also completed a short questionnaire requesting demographic information (sex, age and ethnicity). These variables were not considered in Oosterhof and Todorov's analyses but were collected in our study so that other researchers could use them in secondary analyses of the published data. The data from this study comprise the largest and most comprehensive open-access set of face ratings with open stimuli from around the world, providing an invaluable resource for further research addressing the Western centrality assumption in person perception research.

Raters completed the task in a language appropriate for their country (see below). To mitigate potential problems with translating single-word labels, dictionary definitions for each of the 13 traits were provided. Twelve of these dictionary definitions had previously been used to test for effects of social impressions on the memorability of face photographs[37]. Dominance (not included in that study) was defined as strong and important.

Participants. Simulations determined that we should obtain at least 25 different raters for each of the 13 traits in every region (see https://osf.io/x7fus/ for code and data). We focused on ratings of attractiveness and intelligence for the simulations because they showed the highest and lowest agreement among the traits analysed by Oosterhof and Todorov, respectively. First, we sampled from a population of 2,513 raters, each of whom had rated the attractiveness of 102 faces; these simulations showed that more than 99% of 1,000 random samples of 25 raters produced good or excellent inter-rater reliability coefficients (Cronbach's α values > 0.80). We then repeated these simulations, sampling from a population of 37 raters, each of whom rated the intelligence of 100 faces, showing that 93% of 1,000 random samples of 25 raters produced good or excellent inter-rater reliability coefficients (Cronbach's α values > 0.80). Thus, averages of ratings from 25 or more raters will have produced reliable dependent variables in our analyses; we planned to test at least 9,000 raters in total.

In addition to rating the faces for the 13 traits examined by Oosterhof and Todorov, 25 participants in each region were randomly assigned to rate the targets' age in light of Sutherland et al.'s results showing that a youth/attractiveness dimension emerged from analyses of a sample of faces with a very diverse age range[38]. Age ratings were not included in analyses relating to replications of Oosterhof and Todorov's valence–dominance model. These age ratings were collected to allow for planned exploratory analyses including rated age, but we did not perform these analyses.

Analysis plan. The code used for our analyses is included in the Supplementary Information and publicly available from the Open Science Framework (https://osf.io/87rbg/). The specific sections of code are cited below.

Ratings from each world region were analysed separately and anonymous raw data have been published on the Open Science Framework. Our main analyses directly replicated the PCA reported by Oosterhof and Todorov to test their theoretical model in each region sampled (code 2.1). First, we calculated the average rating for each face separately for each of the 13 traits (code 2.1.2). We then subjected these mean ratings to PCA with orthogonal components and no rotation, as Oosterhof and Todorov did (code 2.1.3). Using the criteria they reported, we retained and interpreted components with eigenvalues greater than 1.0 (code 2.1.3.1).

Criteria for replicating Oosterhof and Todorov's valence–dominance model. We used multiple sources of evidence to judge whether Oosterhof and Todorov's valence–dominance model replicated in a given world region. First, we examined the solution from the PCA conducted in each region and determined whether Oosterhof and Todorov's primary pattern replicated according to three criteria: (1) the first two components had eigenvalues greater than 1.0; (2) the first component (that is, the one explaining more of the variance in ratings) correlated strongly with trustworthiness ($r > 0.7$) and weakly with dominance ($r < 0.5$); and (3) the second component (that is, the one explaining less of the variance in ratings) correlated strongly with dominance ($r > 0.7$) and weakly with trustworthiness ($r < 0.5$). If the solution in a world region met all three of these criteria, we concluded that the primary pattern of the model replicated in that region (code 2.1.3.3).

In addition to reporting whether the primary pattern was replicated in each region, we also reported Tucker's coefficient of congruence[39,40]. The congruence coefficient, ϕ, ranges from −1 to 1 and quantifies the similarity between two vectors of loadings[41]. It is:

$$\phi(x, y) = \frac{\sum x_i y_i}{\sqrt{\sum x_i^2 \sum y_i^2}}$$

where x_i and y_i are the loadings of variable i ($i = 1, \ldots, n$ number of indicators in the analysis) onto factors x and y, respectively. For the purposes of the current research, we compared the vector of loadings from the first component from Oosterhof and Todorov with the vector of loadings from the first component estimated from each world region. We repeated this analysis for the second component. This produced a standardized measure of component similarity for each component in each world region that was not sensitive to the mean size of the loadings[42]. Furthermore, this coefficient was fitting for the current study because it does not require an a priori specification of a factor structure for each group, as would be needed if we were to compare the factor structures in a multiple-group confirmatory factor analysis. Following previous guidelines[42], we concluded that the components reported by Oosterhof and Todorov were not similar to those estimated in a given world region if the coefficient was <0.85, were fairly similar if it was between 0.85 and 0.94 and were equal if it was >0.95 (code 2.1.4).

Thus, we reported whether the solution had the same primary pattern that Oosterhof and Todorov found and quantified the degree of similarity between each component and the corresponding component from Oosterhof and Todorov's work. This connects to our competing predictions.

Prediction 1 (the valence–dominance model applies to all world regions) was supported if the solution from the PCA conducted in each region satisfied all of the criteria described above. Specifically, the primary pattern was replicated and the components had at least a fair degree of similarity as quantified by a value of ϕ of 0.85 or greater.

Prediction 2 (the valence–dominance model applies in Western-world regions but not other world regions) was supported if the solutions from the PCA conducted in Australia and New Zealand, the United States and Canada, Scandinavia, the United Kingdom and Western Europe, but not Africa, Asia, Central America and Mexico, Eastern Europe, the Middle East or South America, satisfied the criteria described above.

Exclusions. Data from raters who failed to complete all 120 ratings in the first block of trials or who provided the same rating for 75% or more of the faces were excluded from the analyses (codes 1.5.1, 1.5.3 and 1.5.5).

Data quality checks. Following previous research testing the valence–dominance model[12–14], data quality was checked by separately calculating the inter-rater agreement (indicated by Cronbach's α and test–retest reliability) for each trait in every world region (code 2.1.1). A trait was only included in the analysis for that region if the coefficient exceeded 0.70. Cases in which the coefficient did not exceed 0.70 are reported and discussed. There were no cases in which the coefficient did not exceed 0.70. Test–retest reliability of traits was not used to exclude traits from analysis.

Power analysis. Simulations showed that we had more than 95% power to detect the key effect of interest (that is, two components meeting the criteria for replicating Oosterhof and Todorov's work, as described above). We used the open data from Morrison et al.'s replication[13] of Oosterhof and Todorov's research to generate a variance–covariance matrix representative of typical inter-relationships among the 13 traits tested in our study. We then generated 1,000 samples of 120 faces from these distributions and ran our planned PCA (which is identical to that reported by Oosterhof and Todorov) on each sample (see https://osf.io/87rbg/ for code and data). The results of >99% of these analyses matched our criteria for replicating Oosterhof and Todorov's findings. Thus, 120 faces gave us more than 95% power to replicate Oosterhof and Todorov's results.

Robustness analyses. Oosterhof and Todorov extracted and interpreted components with an eigenvalue greater than 1.0 using an unrotated PCA. As described above, we directly replicated their method in our main analyses but acknowledge that this type of analysis has been criticized.

First, it has been argued that EFA with rotation, rather than an unrotated PCA, is more appropriate when one intends to measure correlated latent factors, as was the case in the current study[43,44]. Second, the extraction rule of eigenvalues greater than 1.0 has been criticized for not indicating the optimal number of components, as well as for producing unreliable components[45,46].

To address these limitations, we repeated our main analyses using EFA with an oblimin rotation as the model and a parallel analysis to determine the number of factors to extract. We also recalculated the congruence coefficient described above for these EFA results (code 2.2.2).

We used parallel analysis to determine the number of factors to extract because it has been described as yielding the optimal number of components (or factors) across the largest array of scenarios[43,47,48] (code 2.2.1). In a parallel analysis, random data matrices are generated such that they have the same number of cases and variables as the real data. The mean eigenvalue from the components of the random data is compared with the eigenvalue for each component from the real data. Components are then retained if their eigenvalues exceed those from the randomly generated data[49].

The purpose of these additional analyses was twofold: (1) to address potential methodological limitations in the original study; and (2) to ensure that the results of our replication of Oosterhof and Todorov's study are robust to the implementation of those more rigorous analytical techniques. The same criteria for replicating Oosterhof and Todorov's model described above were applied to this analysis (code 2.2.1.3).

Reporting Summary. Further information on research design is available in the Nature Research Reporting Summary linked to this article.

Data availability
Full data are publicly available at https://osf.io/87rbg/.

Code availability
Full analysis code is publicly available at https://osf.io/87rbg/.

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☐	☒	The exact sample size (n) for each experimental group/condition, given as a discrete number and unit of measurement
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Our web collection on statistics for biologists contains articles on many of the points above.

Software and code

Policy information about availability of computer code

Data collection	DeBruine. L.M. (2019, April 9). Experimentum: Beta release 1 (Version v.0.1). Zenodo. http://doi.org/10.5281/zenodo.2634356
Data analysis	https://osf.io/87rbg/

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Behavioural & social sciences study design

All studies must disclose on these points even when the disclosure is negative.

Study description	Quantitative analysis of ratings data
Research sample	Student-type samples collected in eleven different world regions
Sampling strategy	Opportunistic sampling by individual research groups
Data collection	Rating of faces on one of thirteen randomly determined traits
Timing	Throughout 2019
Data exclusions	All data exclusions were described in the stage one protocol and in the analysis code
Non-participation	These data are given in the analysis code and output
Randomization	Participants were randonly allocated to rate one triat

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Materials & experimental systems

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☒	☐	ChIP-seq
☒	☐	Flow cytometry
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Human research participants

Policy information about studies involving human research participants

Population characteristics	Raters from a range of geographic regions and countries. Region and country information are reported.
Recruitment	Opportunistic recruitment by individual labs.
Ethics oversight	main ethics approval was from University of Glasgow, although some individual groups also obtained their own thicas approvals.

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