The local perceptual bias of a non-remote and educated population

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Abstract (155 words)

In 1977, Navon argued that perception is biased towards the processing of global as opposed to local ~~perceptual processing of~~ visual information (or the forest before the trees) and implicitly assumed this to be true across places and cultures. Previous work with normally developing participants has supported this assumption except in one extremely remote African population. Here we explore local-global perceptual bias in normally developing African participants living much less remotely than the African population tested previously. These participants had access to modern artefacts and education but presented with a local bias on a similarity matching Navon task, contrary to Navon's assumptions. Nevertheless, the urban and more educated amongst these participants showed a weaker local bias than the rural and less educated participants, suggesting an effect of urbanicity and education in driving differences in perceptual bias. Our findings confirm the impact of experience on perceptual bias~~processes~~ and suggest that differences in the impact of education and urbanicity on lifestyles around the world can result in profound differences in perceptual style. In addition, they suggest that local bias is more common than previously thought; a global bias might not be universal after all.

Key words: Perceptual bias, Cross-cultural differences, Navon, Local-Global, Urbanicity, Education.

The local perceptual bias of a non-remote and educated population

The landmark study of Navon (1977)[1] examined whether humans process~~the perceptual system integrates~~ visual scenes in a feature-by-feature manner, prioritising the processing of local elements, or in a Gestalt-like manner, prioritising the processing of global characteristics. Using hierarchical figures – global shapes made up of local elements (see Figure 1) – Navon showed that participants were faster at detecting global than local information, and were more distracted by to-be-ignored global than local information. On the basis of these findings, he concluded that there exists a perceptual bias~~perception is biased~~ towards global processing, with the associated advantages of overlooking irrelevant details and saving processing resources (Navon, 1977). In his conclusions, however, Navon made no reference to the sample from which his global-bias model was derived (i.e., undergraduate students from the University of California, San Diego) and implicitly suggested that global bias is a universal norm.

Inspired by Navon's work in 1977, the general view has persisted until the present that there exists a universal global bias (e.g., De Lillo, Spinozzi, Truppa, & Naylor, 2005; Lachmann, Schmitt, Braet, & van Leeuwen, 2014; Poirel, Mellet, Houdé, & Pineau, 2008), with an abundant number of studies reporting a global bias in normally developing Western and Asian participants (e.g., Caparos, Fortier-St-Pierre, Gosselin, Blanchette, & Brisson, 2015; Lachmann et al., 2014; Mahoney, Brunyé, Giles, Lieberman, & Taylor, 2011; McKone, Davies, Fernando, Aalders, Leung, Wickramariyaratne, & Platow, 2010; Poirel et al., 2008). Recent data have however shown that the Himba of Northern Namibia (Southern Africa), a normally developing non-western population living a traditional lifestyle in remote rural settlements, show a strong local perceptual bias (Bremner, Doherty, Caparos, De Fockert, Linnell, & Davidoff, 2016; Caparos, Ahmed, Bremner, De Fockert, Linnell, & Davidoff, 2012; Davidoff, Fonteneau, & Fagot, 2008; De Fockert, Davidoff, Fagot, Parron, & Goldstein, 2007).

[1] As of 2018, the study was cited more than 3000 times.

The local bias of Himba observers has been measured using two tasks. In a first task (Davidoff et al., 2008), hierarchical figures such as those introduced by Navon (1977) were used. Participants made subjective judgements of similarity: they chose which of two 'comparison' hierarchical figures most resembled a 'target' hierarchical figure (Kimchi & Palmer, 1982; see Figure 1). One of the comparison figures matched the target figure on the global level (i.e., the two figures shared the same global shape), while the other comparison figure matched the target figure on the local level (i.e., the two figures shared the same local elements). While British participants chose the comparison figure matching on the *global* level about 80% of the time, Himba participants chose the figure matching on the *local* level about 85% of the time. The second task used to measure bias in the Himba (De Fockert et al., 2007) is based on a size contrast phenomenon, the Ebbinghaus illusion (or Titchener's circles). Participants compared the size of two circle targets surrounded by irrelevant circle 'inducers'. As expected, the size perception of British participants was strongly influenced by the irrelevant inducers, showing a marked sensitivity to the illusion. In contrast, the perception of Himba participants was much less affected by the irrelevant inducers. Thus, the Himba appear to be more inclined to extract local information than to extract contextual, or global, information.

While the local processing bias displayed by the Himba shows that global perceptual bias is not universal, global bias may nevertheless be the norm in most of the human populations in today's world. Indeed, the Himba are uneducated and illiterate, and live extremely remotely and according to ancestral traditions, in a society completely devoid of modern artefacts. As of today, few populations live a life as remote and traditional as that of the Himba. In this study, we used the similarity-matching Navon task previously used with the Himba (see Figure 1; Caparos et al., 2012; Davidoff et al., 2008) to explore whether a global bias is always the norm in populations that live less remotely. To this end, we studied a Rwandan population which, unlike the Himba, is educated, literate, and not isolated from modern artefacts (e.g., modern architecture, transport, and many other facilities and technological artefacts also found in the Western world). Rwanda (in Central

Africa) is a low income country on the path to becoming a middle income country.[2] Given that as of 2018 a majority of humans live in low or middle income countries (6.1 billion inhabitants, out of 7.4 billion in total, according to the World Bank; http://data.worldbank.org/income-level/low-and-middle-income), the Rwandan sample used in this study is arguably more representative of the human beings in today's world than the Western samples used in the majority of prior studies of perceptual bias, as well as being more representative than the remote Himba samples.

The Rwandan volunteers who participated in this study were living in and tested in (1) rural villages, (2) small towns, and (3) the capital city (Kigali, with a population of 1.1 million inhabitants; www.populationdata.net), with a view to extending previous demonstrations of the impact of urban exposure on bias (Bremner et al., 2016; Caparos et al., 2012; Linnell, Bremner, Caparos, Davidoff, & de Fockert, 2018). Previous demonstrations have shown that urbanised Himba living in a small town (Opuwo, Northern Namibia, with about 12,000 inhabitants in 2012 when demonstrations were run) expressed a local bias that was less strong than that of their traditional Himba counterparts; importantly, however, they still did not express a global bias. The urbanised Himba tested were, however, a special case because of having received a traditional upbringing, and being illiterate and without any formal education. Thus, their local bias could have been due to their traditional upbringing, their lack of education, and/or their illiteracy. The Rwandan population studied here allowed us to test for effects of urbanicity, education, and literacy.

Recent research has suggested that there is an effect of education on perceptual bias (Spray, 2018). ~~and, while there is no research showing an effect of literacy on perceptual bias per se,~~ In addition, several studies have shown that, in Western children, global perception develops in parallel with the first years of schooling, and learning to read is a key aspect of early schooling (e.g., Dukette & Stiles, 2001; Poirel et al., 2008). Literacy could be an important explanatory factor for cross-cultural

[2] According to the African Bank of Development, Rwanda's real GDP grew by an average of 8% annually during the period 2000 to 2013, which is among the highest average growth rates in Africa (see "Rwanda - 2014 - Country Profile - African Development Bank"; www.afdb.org). According to the World Bank, Rwanda might become a middle income country by 2020 (www.worldbank.org/en/country/rwanda/overview).

differences in perceptual bias given that learning to read has been linked to reorganisation of the hemispheric specialisation of the brain (e. g., Dehaene et al, 2015) and there is some lateralization of local-global processing (e.g., Heinze, Hinrichs, Scholz, Burchert, & Mangun, 1998; Robertson & Lamb, 1991). In addition, previous work has demonstrated a link between learning to write and local/global processing (Tso, Au, & Hsiao, 2014), suggesting that sensorimotor experience may affect bias, albeit in this case to make it less global. Also of potential relevance here is the proposal that cognitive style can affect perceptual bias (Nisbett, Peng, Choi, & Norenzayan, 2001). While studies such as those of Klauer and Singmann (2015) and Firestone and Scholl (2016) question the possibility that cognitive processes can penetrate perceptual ones, perceptual bias is a complex construct potentially involving several levels of information processing, from information sampling (e.g., Nisbett & Miyamoto, 2005) and attentional processes (e.g., Van der Helm, 2012) even up to metacontrol processes (Hommel & Colzato, 2017). All the Rwandans tested in this study were literate and educated to at least primary school level, although levels of reading proficiency and education varied within the sample, making it possible to evaluate the effect of these variables.

In this study, we also tested the effect of other cultural-demographic factors which may conceivably influence perceptual bias: religiosity, wealth, and family size. African societies (the Himba society included) differ from Western societies in that they are typically more religious, have lower family income and larger family units. Important cultural-demographic variables such as wealth and religiosity have not previously been examined in African-Western cross-cultural studies (e.g., Caparos et al., 2012; Davidoff et al., 2008), ~~Yet, just like education, they may strongly affect cognitive style, and cognitive style has been proposed – albeit not without controversy – to affect perception (e.g., see suggested links between religiosity and analytical reasoning; Pennycook, Cheyne, Koehler, & Fugelsang, 2013; and between cognitive style and perception; Nisbett, Peng, Choi, & Norenzayan, 2001) and so we also tested for the effect of these variables.~~ yet religiosity at least has been suggested to impact cognitive style and may therefore affect bias (Pennycook, Cheyne, Koehler, & Fugelsang, 2013). Finally, because Rwanda was exposed to wide-scale violence in 1994, with the

genocide of the Tutsi causing an estimated 800 000 deaths, we controlled for the effect on perceptual bias of genocide impact and any psychopathology, namely posttraumatic stress disorder (PTSD) and depression. Years after the genocide, the latter two pathologies remain more prevalent in Rwanda than in Western societies (Caparos, Giroux, Rutembesa, Habimana, & Blanchette, 2018; Munyandamutsa, Nkubamugisha, Gex-Fabry, & Eytan, 2012), though still present only in a minority of our sample. While PTSD may increase global processing (Vasterling, Duke, Tomlin, Lowery, & Kaplan, 2004), depression may decrease it (De Fockert & Cooper, 2014). Because the two pathologies usually co-occur (depression is a comorbidity of PTSD; Brounéus, 2010; Munyandamutsa et al., 2012), we made no prediction regarding the direction of any effect on bias of psychopathology in our sample.

Aims

By testing perceptual bias in Rwandan populations, we had three main aims:

(1) The first aim was to test the purported generality of global perceptual bias in a non-remote population. As mentioned above, Rwanda is a low- to middle-income country arguably more representative of the human populations in today's world than the samples reported in previous studies so if Rwandans express a global bias this would reinforce the idea that global bias is a widespread norm in human beings. If, however, Rwandans express a local bias, this would suggest that global bias is much less of a norm than initially envisaged.

(2) The second aim of this study was to test the effect of a number of factors on local-global bias, most notable among them urbanicity, education, and literacy. There are reasons to believe that these three factors are important drivers of cross cultural differences in local-global bias, and they were thus given priority in the analyses.

(3) The last aim of this study was to test whether the conclusions reached from (1) and (2) based on the Rwandan participants tested here are borne out by comparisons between these Rwandan participants and the Himba/British participants tested in a previous study (Caparos et al.,

2012). If perceptual bias is a universal norm, Rwandans may present a global bias similar to that of British participants (Caparos et al., 2012; Davidoff et al., 2008), irrespective for example of their level of education and urbanicity. If, however, global bias is not a universal norm and is sensitive to lifestyle changes linked to urbanicity, education, and/or literacy, then Rwandans may present a bias somewhere in between that of Himba and British participants, depending on the extent of these lifestyle changes.

Method

Participants

Rwandan participants

We recruited 286 Rwandan participants with the help of local research assistants and through word of mouth. The number of participants was not pre-determined. Data collection took place during three 3-week visits to Rwanda, in August 2014, February 2015 and July 2015. During each visit, we recruited as many participants as possible during the 3-week testing window. All participants could speak and read Kinyarwanda, the native language of Rwanda. They were compensated 8,000 Rwandan Francs (€9) for their time.

Nine participants did not complete the experiment. In addition, 16 participants made more than one mistake on the catch trials of the perceptual task (see "Stimuli and procedure" section above) and their data were not analysed on the assumption that they did not fully understand the task. We thus report the data of 261 Rwandan participants (133 females, mean age 37 yr, SD = 7.6, range 27-64 yr). We tested 121 participants in Kigali, the capital city of Rwanda (which has a population of about 1.1 million inhabitants; www.populationdata.net), 52 participants in Butare, Gizenyi, and Nyanza, which can be considered 'small towns' (each with about 100 000 inhabitants; www.populationdata.net) and 88 participants in rural villages (Kibirizi, Mututu, Muymbu, Ntarabana, and Nyabihu) referred to as 'rural villages' (i.e., settlements in the countryside with an exact population size that is unknown but estimated to be lower than 1000).

Rural villages in Rwanda are much less remote than the Himba rural settlements in which previous studies on perceptual bias have been conducted (e.g., Caparos et al., 2012), in the sense that homes in Rwandan rural settlements are usually equipped with some modern supplies and services: electricity, running water, mobile phones, radio, and basic furniture (e.g., beds, sofas, chairs, tables, cutlery). In addition, while most people in rural Rwandan villages do not use cars, they use bicycles extensively. They also have access to reliable and affordable public transport (in the form of a frequent bus service) which allows for convenient travel to the whole of the country. Finally, they have easy access to public services (e.g., school, health centre, town hall) and private services (e.g., food stores, pharmacies, banks, computing and Internet shops). The urban settlements (small towns and capital city) in which data were collected offer the same services as rural villages but are more populous and more modern, and they allow easier and wider access to modern artefacts (i.e., most roads are tarmacked; smart-phones are more widely used; houses are larger and sometimes offer the same level of comfort as that found in Western countries; motorcycles, taxis and buses are used to travel within the city).

The socio-demographic and psychological-health data of the Rwandan participants tested in this study (see Stimuli and procedure below, for details about the method of data collection) are broken down in Tables 1 and 2 below, by testing location and by level of education respectively. For each socio-demographic and psychological-health variable, we used t-tests to compare the mean values between capital city and small towns, between small towns and rural villages, and between primary and secondary levels of education. Significant differences (p value < .05) are indicated in bold.

Table 1. Sample characteristics broken down by testing location.

	Capital city (Kigali) *Mean (SD)*	Small towns *Mean (SD)*	Rural villages *Mean (SD)*
Gender (proportion females)	.52 (0.5)	.46 (0.5)	.52 (0.5)
Age (years)	35 (6.8)	**37 (6.9)***	**39 (8.5)***
Education (proportion attending secondary)	.66 (0.5)	**.67 (0.5)***	**.47 (0.5)***
Reading proficiency (min=0, max=9)	7.1 (1.9)	7.6 (1.6)	7.3 (1.5)
Religiosity (min=0, max=3)	2.4 (0.7)	2.3 (0.8)	2.3 (0.8)

Nuclear family size (min=1, max=7)	2.1 (1.9)	2.8 (2.3)	3.5 (2.3)
Wealth (min=1, max=7)	2.9 (1.2)	**3.0 (1.2)***	**2.5 (1.1)***
Genocide impact (min=0, max=9)	4.3 (2.0)	4.4 (2.0)	4.8 (2.2)
PTSD symptoms (min=17, max=85)	39.5 (14.3)	38.0 (12.7)	42.9 (15.4)
Depression symptoms (min=0, max=30)	7.4 (6.5)	7.6 (6.4)	8.1 (6.9)

** Significant difference ($p < .05$)*

Table 2. Sample characteristics broken down by level of education.

	Primary education *Mean (SD)*	Secondary education *Mean (SD)*
Gender (proportion females)	.56 (0.5)	.49 (0.5)
Age (years)	**38 (7.9)***	**36 (7.2)***
Reading proficiency (min=0, max=9)	**6.4 (1.9)***	**7.8 (1.4)***
Religiosity (min=0, max=3)	2.3 (0.8)	2.3 (0.7)
Nuclear family size (min=1, max=7)	**3.6 (2.2)***	**2.1 (2.0)***
Wealth (min=1, max=7)	**2.5 (1.2)***	**3.0 (1.1)***
Genocide impact (min=0, max=9)	4.6 (2.1)	4.4 (2.1)
PTSD symptoms (min=17, max=85)	42.3 (15.2)	39.2 (13.9)
Depression symptoms (min=0, max=30)	**8.8 (6.8)***	**7.1 (6.4)***

* Significant difference ($p < .05$)

It is possible to compare the psychological-health data of the Rwandan sample to previously published epidemiological data about levels of clinical PTSD and depression in other parts of the world. We estimated the percentage of Rwandan participants reaching clinical levels of depression using the Diagnostic and Statistical Manual of Mental Disorders criteria (American Psychiatric Association) applied to the Hopkins Depression Symptom Checklist (HDSCL) with the algorithm described by Bolton and Ndogoni (2000, Table 14). In our sample, 12% of the participants reached a level of clinical depression, which is significantly higher than the prevalence of around 4.5% observed in the UK and in Namibia in 2017 (World Health Organisation; http://www.who.int/mental_health/management/depression/prevalence_global_health_estimates/en/). We also estimated the percentage of Rwandan participants reaching clinical levels of PTSD using a cut-off score of 50 on the PCL-C scale (Blanchard, Jones-Alexander, Buckley, & Forneris, 1996). In the Rwandan sample, 24% of the participants scored above the threshold for a possible clinical diagnosis of PTSD, which is

significantly higher than the prevalence of around 3 to 8% observed in Western countries (Andrews, Slade, & Peters, 1999; Kessler, Sonnega, Bromet, Hughes, & Nelson, 1995).

British and Namibian participants from a previously published study (Caparos et al., 2012)

We compared the Rwandan data collected in this study to an age-matched subsample of previously reported data (Caparos et al., 2012), consisting of 23 British participants from London (6 females, mean age 33 yr, SD = 3.2, range 30-40 yr), and 106 Namibian participants (47 females, mean age 37 yr, SD = 5.6, range 30-48 yr); in the Namibian sample, 23 participants lived in the small town of Opuwo, Northern Namibia (with about 12 000 inhabitants in 2012), and 83 participants lived in rural settlements located 15 to 60 kilometres away from Opuwo (and consisting of 20 to 40 inhabitants each). In the British sample, all participants were literate and had completed secondary school and started at university. In the Himba sample, no participant had been to school and none could read. Other socio-demographic and psychological-health data are not collected.

Stimuli and procedure

The data reported in this paper were collected as part of a larger investigation of the cognitive and health profile of the Rwandan population two decades after the Rwandan genocide. Participants completed (1) a series of computer-based cognitive tests and (2) a computer-presented questionnaire, in counterbalanced order. The similarity-matching Navon task reported in this paper was always performed last in the series of cognitive tests. Cognitive tests and the questionnaire were presented using E-Prime (Schneider, Eschman, & Zuccolotto, 2002). The first and last author of the current paper and two Rwandan research assistants (trained clinical psychologists) were present during all testing sessions in order to offer guidance, assistance and support. Research assistants supported participants who were unfamiliar with computers to complete the questionnaires autonomously.

Similarity-matching Navon task

The task was similar to the one previously reported by Davidoff et al. (2008) and Caparos et al. (2012). Each display consisted of three figures (see Figure 1): one target figure, presented at the top of the display, and two comparison figures, presented at the bottom of the display. The three figures were displayed at equal distance from each other (and were centred 4.2° away from the centre of the screen). Each figure was a hierarchical Navon-like figure (Navon, 1977), in which small circles, squares or crosses (subtending 0.6°) – the local elements – were spaced equally apart from each other and were arranged to create a larger square, circle, or cross (subtending, respectively, 2.4°, 3.1°, and 3.5°) – the global shape.

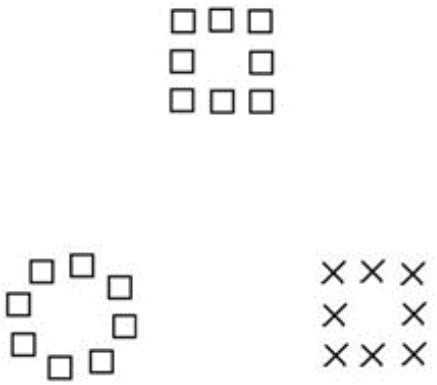

Figure 1. *The figure represents one of the test displays used in the similarity-matching Navon task, containing one target figure (top figure) and two comparison figures (bottom figures). The left comparison figure shares local similarity with the target and the right comparison figure shares global similarity with the target.*

Participants were asked to indicate which of the two comparison figures, on the left or on the right, "looks most like" the target figure. They provided their answers by pressing the 'x' or 'c' key on the laptop keyboard, to choose the left or right figure respectively. On three 'catch' displays, there was a correct response: one comparison figure shared both global and local levels with the target (i.e., it was identical to the target) while the other figure shared neither level with the target. Thirteen participants made more than one mistake on these catch displays and their data are not reported. On six test displays, there was no objectively correct response: one comparison figure shared the same global shape as the target (randomly presented to the left or right) and the other

comparison figure shared the same local elements as the target. When participants chose the comparison figure matching the global shape, they were said to have made a 'global match'; when they chose the other comparison figure, they were said to have made a 'local match'. Each display was presented until a response was given. Catch and test displays were presented in an intermixed and random order.

The six test displays used in the present study were a subset of the 36 test displays used in Caparos et al. (2012). In new analyses of the 2012 data (i.e., data from traditional Himba, urban Himba and British observers), we compared percentages of global matches calculated from all 36 test displays and from the subset of 6 test displays used in the present study. There was no significant difference, either for traditional Himba (M=14.7% for all 36 test trials and M=15.1% for the subset of 6 test trials), $t(218) = 0.87$, $p = .39$, or for urban Himba (M=32.8% for all 36 test trials and M=32.6% for the subset of 6 test trials), $t(67) = 0.18$, $p = .85$, or for British observers (M=77.8% for all 36 test trials and M=76.2% for the subset of 6 test trials), $t(55) = 1.09$, $p = .28$. The 6-test display version used in the present study is thus deemed equivalent to the 36-test-display version used in Caparos et al. (2012).

Questionnaires

The questionnaire used to acquire demographic data was first written in French and then translated and back translated from French to Kinyarwanda, the native language of Rwanda, by two translators, operating independently of each other. Differences and errors were discussed with the lead researchers, and appropriate rewording was decided on. Each question was presented at the top half of the screen and a set of proposed answers was presented at the bottom half. Each proposed answer was identified by a unique digit (from 0 to 8; there were never more than 9 proposed answers for a given question). Participants gave their answer to each question by pressing the digit key corresponding to their chosen answer (0 to 8) on the laptop keyboard. For each

question, participants had the possibility not to respond by pressing the '9' key (for "(9) I prefer not to respond"). Questions were presented in a fixed order, which was the same for all participants.

Socio-demographics. In the questionnaire, participants answered socio-demographic questions about (a) nuclear family size (scored from '1', for no partner and no children, to '8', for a partner and six or more children), (b) wealth (scored from '1', "I consider that I am very poor", to '7', "I consider that I am very rich"), (c) religiosity (scored from '0', "God plays no role in my daily life", to '3', "God plays a very important role in my daily life"), and (d) education (scored '0', "highest level achieved is primary school", or '1', "highest level achieved is secondary school or higher").

Genocide impact. Participants were asked whether they had been exposed to a number of potentially traumatic events linked to the genocide, namely, (1) damaged, stolen or lost belongings, (2) fleeing, (3) being seriously ill, (4) being injured, (5) having experienced sexual assault, (6) being handicapped, (7) having a close parent who was killed during the genocide, (8) having a close parent who became seriously ill because of the genocide, and (9) having a close parent who became handicapped because of the genocide. Participants answered "yes" (scored '1') or "no" (scored '0') to each item and obtained a genocide-impact score that ranged from zero (no impact of the genocide) to nine (maximal impact of the genocide). Note that the severity of experiences was not ranked, and each experience was given an equal weighting of one.

Psychological health. Participants completed a Kinyarwanda-translated version of the Posttraumatic Stress Disorder Checklist – Civilian (PCL-C; Blanchard, et al., 1996). This questionnaire indexed the incidence of posttraumatic stress symptoms related to the Rwandan genocide. Participants gave an answer from '1' (not at all) to '5' (extremely) to each item. Items addressed symptoms associated with the three clusters of posttraumatic stress disorder symptoms, namely, (1) intrusion (i.e., persistently remembering or reliving the genocide through intrusive flashbacks, vivid memories, and/or recurring dreams), (2) avoidance/numbing (i.e., efforts to avoid any circumstance resembling or associated with the genocide; feelings of detachment and emotional numbness), and

(3) hyperarousal (difficulty in falling or staying asleep, irritability or outbursts of anger, difficulty in concentrating, hypervigilance, exaggerated startle response). Participants also filled in a Kinyarwanda-translated version of the 10-item Hopkins Depression Symptom Checklist (HDSCL; Derogatis et al., 1974). Participants gave an answer from '0' (not at all) to '3' (extremely) regarding the incidence of a set of depression symptoms, namely, worry, sadness, melancholy, suicidal thoughts, loneliness, feelings of guilt, loss of appetite, loss of sexual interest, loss of interest in daily activities, and loss of hope. The PCL-C and the HDSCL are both well-known and widely used measures. They have good psychometric properties, are easily administered by laypeople, and they use simple language. Both measures have been previously used in Rwandan samples (Blanchard et al. 1996; Bolton & Ndogoni, 2000; Brounéus, 2010; Weathers et al. 1993; Veijola et al. 2003).

Reading proficiency

Participants read out loud to one of the research assistants a short (one-paragraph) newspaper article written in Kinyarwanda (see Table 3 in Supplemental Material). The article was obtained from a local newspaper and described the recent opening of a shared mobile-phone network (MTN) across Rwanda, Uganda and Tanzania. The research assistant evaluated the participant's reading proficiency from '0' (the participant cannot read) to '9' (the participant has excellent reading proficiency).

Ethics

This study was approved by the Ethics Committee of Université du Québec à Trois-Rivières in Canada (ethical approval number CER-14-206-08-02.09). In Rwanda, the research project was ethically and methodologically reviewed and approved by the National Ethics Committee of Rwanda (ethical approval number 042/RNEC/2014), the National Unity and Reconciliation Commission, and the National Commission for the Fight against Genocide, the three authorities from which permission was required for research in Rwanda.

Results

We first computed the percentages of global matches made by our Rwandan participants on the similarity-matching task. Overall, participants made few global matches (*M*=26%, *SD*=34; see Figures 2, 3 and 4). The level of global matches was significantly lower than 50%, suggesting the presence of a *local* perceptual bias, at least on the task used in this study, $t(246) = 11.8$, $p < .001$, d = 1.07.

Then, we used a linear hierarchical regression analysis to test for the effect on percentages of global matches of the different variables tested in this study. In the first step of the analysis, we entered the three variables postulated to play an important role in driving cross-cultural differences in perceptual bias, namely, Urbanicity (1, 2 or 3; for rural village, small town, and capital city abode respectively), Education (1 or 2; for "no more than primary schooling" and "at least secondary schooling", respectively), and Reading proficiency (1 to 9; from low to high). The model significantly predicted global matches, $F(3,232) = 5.0$, $p = .002$, $r^2 = .061$. The analysis showed a significant effect of Urbanicity, $\beta = .15$, $p = .024$, and a non-significant trend for an effect of Education, $\beta = .13$, $p = .065$. The effect of Reading proficiency was not significant, $\beta = .09$, $p = .210$.

In what follows, we describe the effects of urbanicity and education. Participants living in rural villages made fewer global matches (*M*=15%, *SD*=26) than those living in small towns (*M*=34%, *SD*=36, $p = .004$, Bonferroni corrected) and in the capital city Kigali (*M*=29%, *SD*=36, $p = .010$, Bonferroni corrected; see Figure 2); the difference in percentages of global matches made by participants living in small towns and Kigali was not significant ($p = 1.0$). In addition, participants who had attended secondary school or a university (6 years of education and more) made more global matches (*M*=30%, *SD*=36) than participants who had completed only primary school or less (*M*=16%, *SD*=26, $p = .002$).

In the second step of the hierarchical regression analysis, we added the remaining variables tested in this study, namely, Nuclear family size (1 to 8; for the number of people in the family),

Wealth (1 to 7; from low to high respectively), Religiosity (0 to 3; from "God plays no role in my life" to "God is extremely important in my life" respectively), Age (27 to 58), Genocide impact (0 to 9; from low to high respectively), PTSD symptoms (17 to 85; from low to high respectively), and Depression symptoms (0 to 30; from low to high respectively). The model still significantly predicted global matches, $F(10,225) = 1.9$, $p = .048$, $r^2 = .077$. However, the increase in explained variance was not significant, $\Delta R^2 = .017$, $p = .775$, and none of the added variables had a significant effect (Nuclear family size: β = -.07; Wealth: β = -.06; Religiosity: β = -.05; Gender: β = -.08; Age: β = .09; Genocide impact: β = -.05; PTSD symptoms: β = .01; Depression symptoms: β = -.09; all p values > .30; see Figures 5 and 6 in the supplemental materials for illustrations of the lack of relationships). These results show that the variables added in the second step of the analysis did not play a significant role in determining perceptual bias. In addition, in this second model, the effect sizes of Urbanicity and Education (respectively, β = .15, and β = .12) remained similar to those observed in the first model, suggesting that the effects of Urbanicity and Education were not confounded with those of socio-demographics or psychological health.

In order to assess whether the effects of Urbanicity and Education were independent, we ran an analysis of variance on percentage of global matches, using Urbanicity and Education as between-participant independent variables (for this additional analysis, an analysis of variance was preferred to a regression analysis given that both independent variables were categorical). While the main effects of both Urbanicity and Education were significant, respectively, $F(2,250) = 5.12$, $p = .007$, $\eta_p^2 = .039$, and, $F(1,250) = 5.72$, $p = .018$, $\eta_p^2 = .022$, the interaction between the two variables was not, $F(2,250) = 0.92$, $p = .399$, $\eta_p^2 = .007$, suggesting that the effects were independent (see Figure 2).

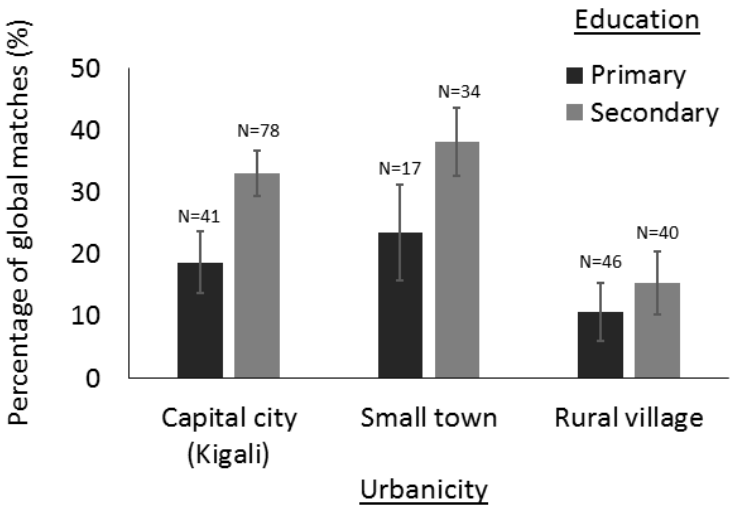

Figure 2. *The figure shows percentages of global matches made by Rwandan participants on the Similarity-matching Navon task, as a function of their Urbanicity (Capital city, Small town, or Rural village) and Education (Primary or Secondary). 'N' indicates the number of participants in each group. Error bars represent +/- one standard error of the mean (SEM).*

In a further set of analyses, we contrasted the Rwandan data collected in this study to age-matched Namibian (Himba) and British (London) data collected in a previous study (Caparos et al., 2012). Data from the 2012 study were reanalysed to calculate the percentages of global matches from the subset of 6 test stimuli used in the present study (see Method).[3] These data included data for rural and urban Himba, and urban British participants. Himba participants, whether rural or urban, were uneducated and illiterate.

We performed two analyses to contrast the different groups, using analyses of variance. In the first analysis, we contrasted Rwandan and Namibian participants using Population (two levels: Namibian vs. Rwandan) and Urbanicity (two levels: Rural vs. Urban) as between-subject independent variables (note that, for the Rwandan sample, we included participants from the small towns only, on the basis that the latter were more similar to the town from which the Himba sample came). Education was not used as an independent variable in this analysis as none of the Himba participants

[3] This reanalysis left the data largely unchanged because the 6 stimuli used in this study were purposefully selected to be representative of performance on the full version of the test.

were educated. The analysis showed a significant main effect of Population, $F(1,367) = 3.9$, $p = .047$, $\eta_p^2 = .011$, with Namibians being more local than Rwandans (see Figure 3), and a significant main effect of Urbanicity, $F(1,367) = 6.5$, $p = .011$, $\eta_p^2 = .017$, with rural participants being more local than urban participants (see Figure 3). The interaction between the two independent variables was not significant, $F(1,367) = 1.2$, $p = .266$.

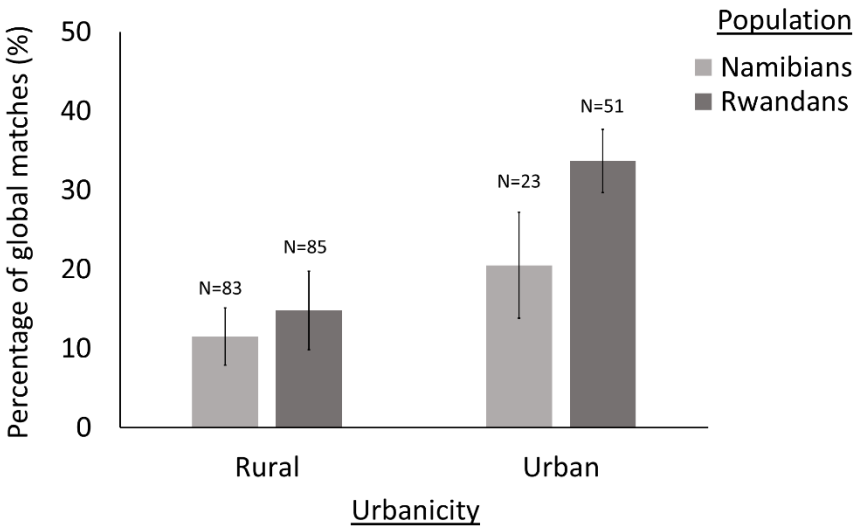

Figure 3. *The figure shows percentages of global matches made by Namibian and Rwandan participants on the Similarity-matching Navon task, as a function of Population (Namibian vs. Rwandan) and Urbanicity (Rural vs. Urban participants). The Namibian data are a reanalysis of a subset of the data collected in a previous study (Caparos et al., 2012) for comparison purposes. 'N' indicates the number of participants in each group. Error bars represent +/- one standard error of the mean (SEM).*

In the second analysis, we compared urban Rwandans from Kigali to urban British from London using an independent-sample t-test. These two samples were compared on the basis that they both came from large capital cities (with more than 1 million inhabitants). The first group was significantly more local (M= 30%, SD=37) than the second (M=75%, SD=29), $t(72) = 4.9$, $p < .001$, $d = 1.35$.

In a final analysis, we examined the possibility that the difference between Rwandans and British participants was founded on profound low-level differences between the groups, given the

lack of global bias in Rwandans from Kigali with urban exposure and education. Therefore, we tested to see whether or not similar patterns were found in participants from Kigali and London in the matching behaviour with the six different displays in the set of test stimuli. We ran an analysis of variance using Population (2 levels: London vs. Kigali) as a between-subject independent variable, and Display (6 levels, corresponding to the six different displays in the set of test stimuli) as a within-subject independent variable. The main effect of Display was significant, $F(5,660) = 10.7$, $p < .001$, $\eta_p^2 = .075$, showing that some displays yielded larger global biases than others (see Figure 4). The interaction between Display and Population was also significant, $F(5,660) = 2.3$, $p = .044$, $\eta_p^2 = .017$. In order to investigate the origin of the interaction, we tested the effect of Display in each population, using one-way analyses of variance. The effect of Display was significant and followed a linear trend for both populations (all p values < .05), with the same displays yielding the lowest/highest global bias in each group; however, the effect of Display appeared to be steeper in Londoners than in Kigalians.

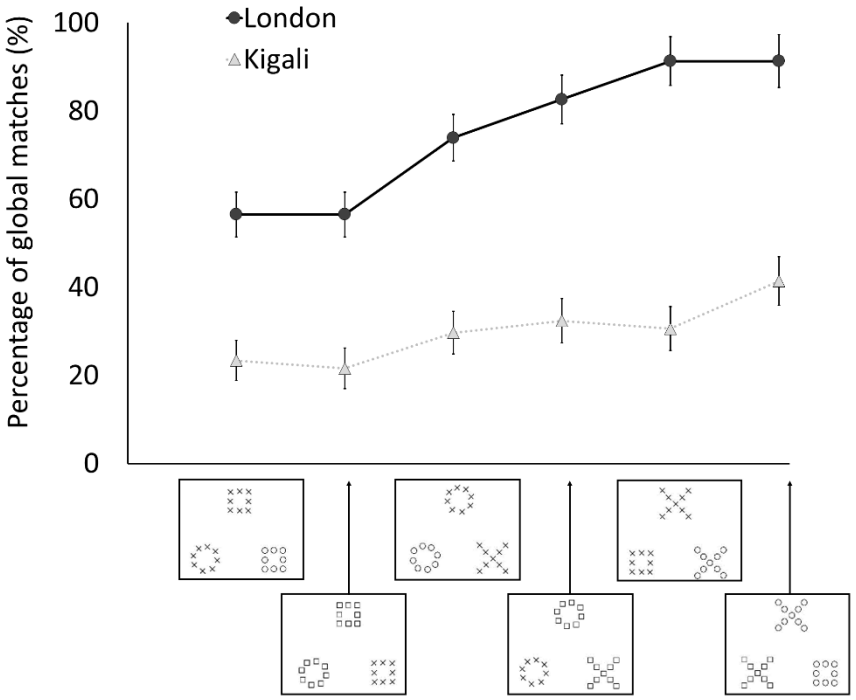

Figure 4. *The figure shows percentages of global matches on the Similarity-matching Navon task, as a function of Figure (the six test displays used in the task) and Population (London vs. Kigali). We present here a reanalysis of British data collected in a previous study (Caparos et al., 2012) for comparison purposes. Error bars represent +/- one standard error of the mean (SEM).*

Discussion

In this study, we examined the generality of the global perceptual bias (Navon, 1977) in a Rwandan sample, and the influence of a number of factors which may drive cross-cultural differences in perceptual bias, foremost among them urbanicity, education, and literacy, (e.g., Caparos et al., 2012; Spray, 2018).

Prior to this work, numerous studies have reported a global bias in normally developing adults in both Western and Asian cultures (e.g., Caparos et al., 2015; De Lillo et al., 2005; Lachmann et al., 2014; McKone et al., 2010) and just a handful of studies have reported a local bias in one population of normally developing adults (Bremner et al., 2016; Caparos et al., 2012; Davidoff et al., 2008; de Fockert et al., 2007). The latter population is remote, uneducated and illiterate, namely, the Himba of Northern Namibia (Southern Africa). In the present study, we tested another African population, from Rwanda (Central Africa). Compared to the Namibian participants tested previously, the Rwandan participants tested here shared more in common with Westerners: they had been to school, they could read, and they used modern artefacts. Yet, the local bias previously observed in the Himba with the similarity-matching Navon task (Caparos et al., 2012; Davidoff et al., 2008) was also observed using the same paradigm in Rwandan participants.

In Rwandan participants, we also replicated the ~~previously observed~~ effect of urbanicity on perceptual bias previously observed with the Himba (Bremner et al., 2016; Caparos et al., 2012; Linnell et al., 2018)~~. In the current study,~~ Rwandan participants who lived in a rural setting made about twice as many local matches on the similarity matching Navon task as participants who lived in small towns or in the capital city of Rwanda, Kigali (see Figure 2). In addition, we replicated the previously observed effect of education on perceptual bias (Spray, 2018): less educated Rwandan

participants tended to make more local matches than more educated Rwandan participants. None of the other factors tested in the present study accounted for a significant amount of variance in perceptual bias (i.e., reading proficiency, wealth, religiosity, nuclear family size, genocide impact, PTSD symptoms, or depression symptoms).

It remains to be seen whether or not these findings extend to other tasks also invoked to measure perceptual bias. Recent studies have highlighted discrepancies between tasks (e.g., Chamberlain, Van der Hallen, Huygelier, Van de Cruys, & Wagemans, 2017; Dale & Arnell, 2013), suggesting that different tasks measure only partially overlapping facets of the complex construct that is perceptual bias. As suggested in the introduction, perceptual bias likely involves several levels of information processes, including information sampling (e.g., Nisbett & Miyamoto, 2005) and attentional processes (e.g., Van der Helm, 2012) and even metacontrol processes (Hommel & Colzato, 2017). Future work will need to determine which of these processes are sensitive to crosscultural differences.

For now, we can only speculate about the underlying factors mediating effects of education and urbanicity on our measure of perceptual bias. The effect of education was not driven by reading proficiency, given that the latter factor was not related to bias. It is possible that education promotes a different way of processing information, for instance by supporting more flexible and/or abstract thinking, and this could affect perceptual style by influencing the way ambiguous information is interpreted: extracting global structures is arguably like extracting a general mathematical rule from examples, in requiring abstract thinking (e.g., Beer, 1989; Caparos et al., 2015). With regards to what factors might mediate the effect of urbanicity, it is possible that - as for education - flexible/abstract thinking plays a role. The literature would also suggest a role for the physical environment, specifically visual clutter (Miyamoto, Nisbett, & Masuda, 2006) or exposure to modern artefacts more generally. It is possible that a local bias is observed even in Kigali, a capital city, because the latter may be less visually cluttered than Western cities. After all, Kigali - like other Rwandan cities - is

subdivided into regions termed 'cells', each comprising several 'villages' (http://www.minaloc.gov.rw/). These 'villages' are akin to local communities where everyone knows each other. This strong sense of community that is part of the Rwandan urban lifestyle may also provide another reason why living in Kigali does not increase perceptual bias to the same extent as living in Western cities of comparable size, if stress and the felt 'pace of life' can impact bias. The stress and pace of life of many urban environments may augment arousal (Lederbogen et al., 2011; Linnell, Caparos, de Fockert, & Davidoff, 2013; Linnell, Davidoff, & Caparos, 2014) which, in turn, may increase global bias (Giles, Mahoney, Brunyé, Taylor, & Kanarek, 2013; Mahoney et al., 2011).

A role for urbanicity and education in explaining cross-cultural differences in perceptual bias is at first sight hard to reconcile with comparisons between the findings reported here – in Rwandan participants – and earlier findings with Himba and British participants. The Rwandans expressed a bias more similar to that of the Himba than to that of British participants and yet – unlike Himba participants – were educated (Davidoff et al., 2008; Caparos et al., 2012) and, many of them, lived in towns or cities with between 100 000 to 1 million inhabitants, many more than the 12 000 inhabitants living in the town where even the urban Himba that were tested lived (Caparos et al., 2012). The higher levels of depression, PTSD, and/or trauma exposure in our Rwandan sample compared to the British population do not appear to explain the difference between Rwandan and British participants given that the Rwandans in our sample who had little to no genocide impact, and no PTSD/depression symptoms, also displayed a local bias (N=23, mean global matches = 25%; see Figure 6a, 6b and 6c in Supplemental Material). The difference between Rwandan and British participants can however be explained by postulating that compared to the British (who were university undergraduates living in London) the Rwandans were much less educated (only half of them had completed secondary school, and even though some participants had completed a university degree, being university-educated in Rwanda may not exert as much impact on for example abstract thinking as being university-educated in the UK; for a similar argument, see Spray, 2018). Rwandan participants were also most probably much less urban (in the Western sense, for

example, in terms of felt 'pace of life'). In sum, it is possible that, although the Rwandan participants in our sample were educated and lived in a modern setting, the gap in terms of the impact of education and urbanicity on lifestyles is higher between Rwandans and British than it is between Rwandans and Namibians. This being the case, differences in the *impact* of education and urbanicity on lifestyles around the world may exert more profound effects on perceptual bias than simple statistics like the number of years of education or the extent of population size.

An important consideration raised by the results of this study concerns the generalisability of research results in psychology. There is a widespread tendency for psychology researchers to make general statements about human psychological functioning based on patterns of results obtained entirely with Western populations, and then mostly with psychology students (Henrich et al., 2010). According to Arnett (2008), 96% of all psychology-study samples as of 2008 came from countries with only 12% of the world's population. The generalisation of a given model by psychology researchers is often implicit, indicated by usage of the terms 'humans' or 'people', and by omission of any mention of the specific population from which data were obtained. This habit of implicitly generalising a model to all humanity is observed in all areas of psychology~~, and notable amongst them perception~~. The present work shows that, contrary to what Navon implicitly suggested in 1977, global perceptual bias – at least when measured using a standard version of the similarity-matching Navon task – is not necessarily the universal norm. In fact, the participants tested in this study are likely to be more representative of the human populations living today on earth than the western and highly educated participants studied in the majority of psychological studies (Henrich et al., 2010). Our findings thus suggest that local perceptual bias might be more common in normally developing adults than usually assumed, and reinforce previous suggestions that psychology researchers need to be particularly wary of neglecting important cross-cultural differences in basic psychological functioning (Wang, 2016).

In conclusion, a sample of non-remote Rwandan participants, arguably more representative of today's human populations than previously tested samples, presented a local perceptual bias. Variations in education and urbanicity modulated the strength of this bias; these factors are thus candidates to drive cross-cultural differences in perceptual bias, especially when their impact on wider lifestyle changes is considered. The findings of this study confirm the plasticity of perceptual bias to experience-related factors and show that local bias is more common than previously thought. Global perceptual bias might not be a universal norm after all, even in literate and educated samples exposed to modern-day artefacts and urban environments.

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Compliance with Ethical Standards

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Conflict of Interest: Serge Caparos declares that he has no conflict of interest. Karina J Linnell declares that she has no conflict of interest. Isabelle Blanchette declares that she has no conflict of interest.

Ethical approval: All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Informed consent: Informed consent was obtained from all individual participants included in the study.

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Supplemental material

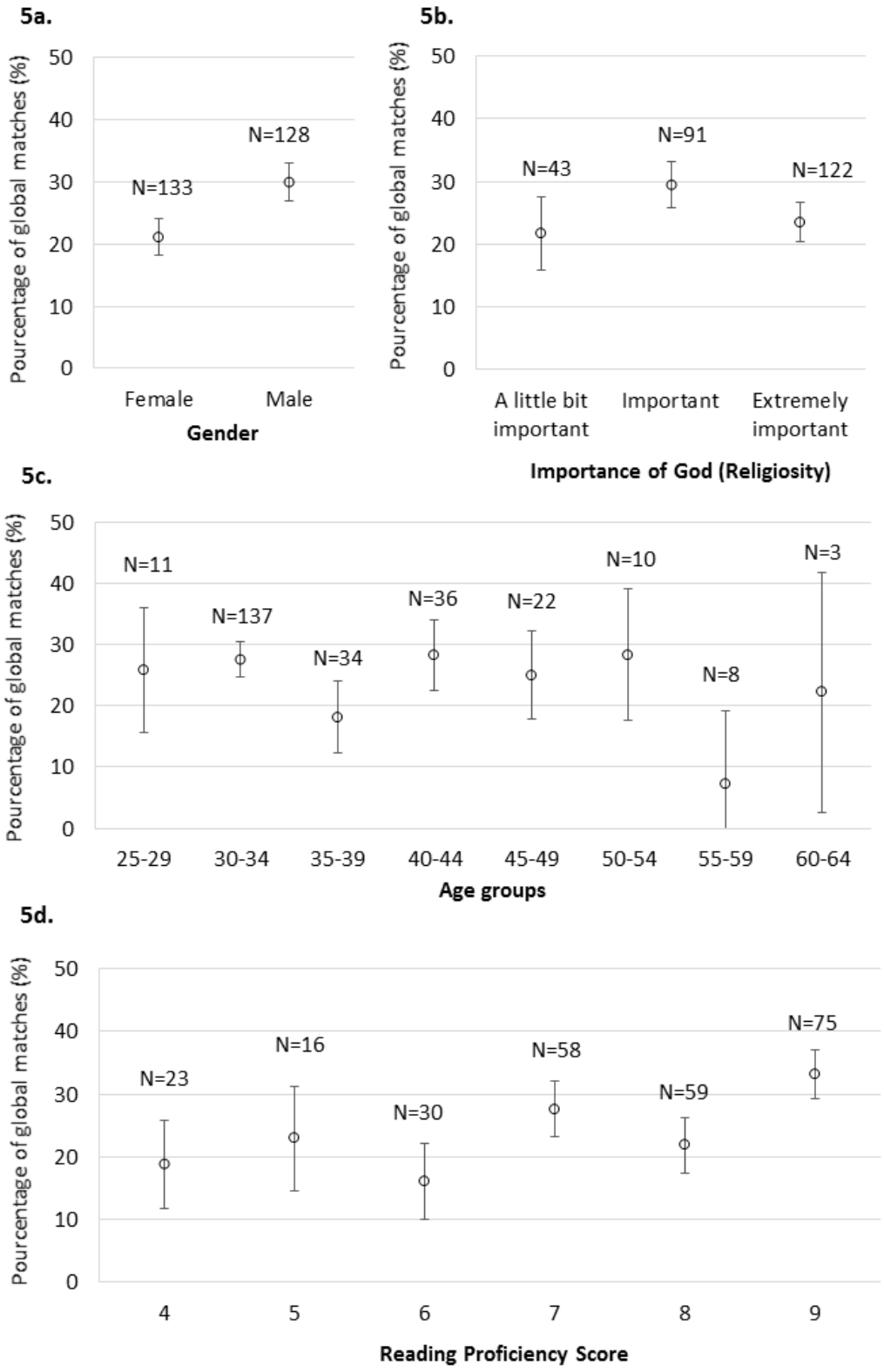
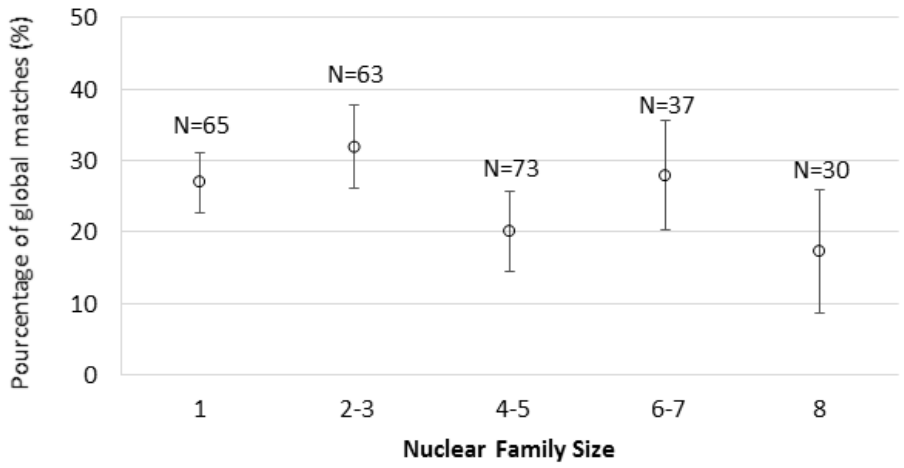


Figure 5. *The figure shows percentages of global matches on the Similarity-matching Navon task, as a function of gender (5a), religiosity (5b), age (5c) and reading proficiency (5d). Error bars represent +/- one standard error of the mean (SEM).*

6a.



6b.

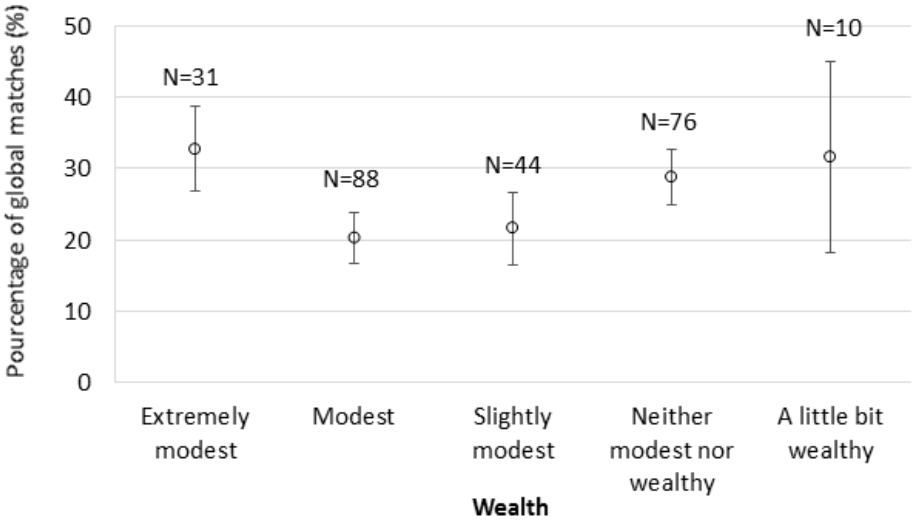


Figure 6. *The figure shows percentages of global matches on the Similarity-matching Navon task, as a function of nuclear family size (6a) and wealth (6b). Error bars represent +/- one standard error of the mean (SEM).*

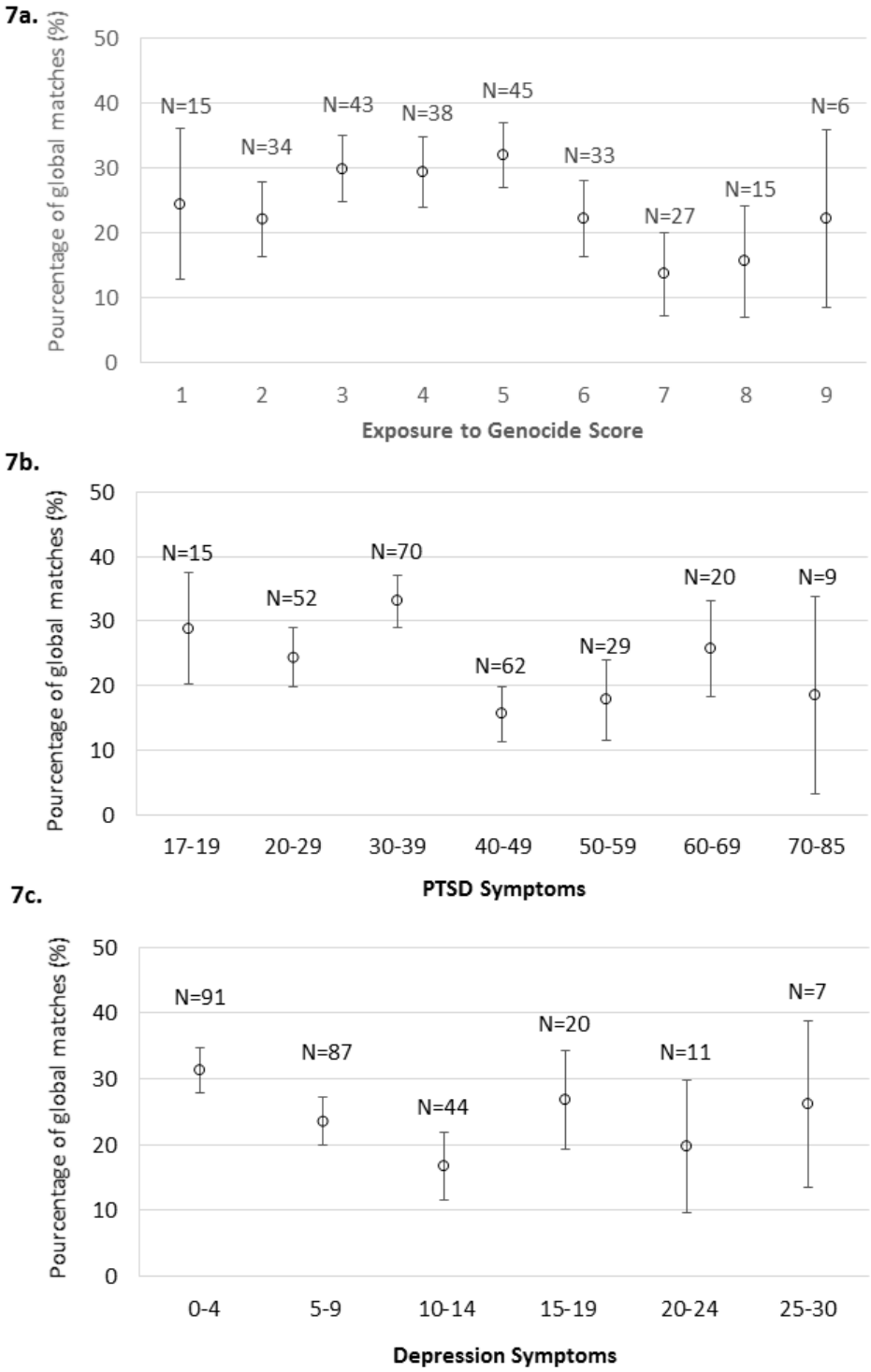


Figure 7. *The figure shows percentages of global matches on the Similarity-matching Navon task, as a function of genocide impact (where a score of 0 means no impact and a score of 9 means very high impact; 7a), PTSD symptoms (where a score of 17 means no symptoms and a score of 85 means maximum level of symptoms; 7b), and depression symptoms (where a score of 0 means no symptoms and a score of 30 means maximum level of symptoms; 7c) Error bars represent +/- one standard error of the mean (SEM).*

Table 3. Text used to assess reading proficiency. Participants read the text (written in Kinyarwanda) out loud to a research assistant, who then awarded a reading proficiency score to the participant (from 0, "the participant cannot read", to 9, "the participant has excellent reading proficiency").

Version used in this study (Kinyarwanda)	Translated version (English)
"Uhereye ku itariki ya mbere z'ukwezi kwa cyenda, igihugu cy'Urwanda n'icya Uganda bigiye gukuraho imipaka mu buryo bwo guhamagaza telefoni. Guhamagara muri ibyo bihugu bizajya byishyurwa hakurikijwe ibiciro by'aho mutuye. Uwo mwanzuro uzatuma habaho igabanuka ryìbiciro byo guhamagara mu bihugu bizashyiraho umukono kuri icyo cyemezo."	"From the 1st of September, Rwanda and Uganda will remove their tariff barriers on phone calls. The calls across the two countries will thus be charged at local prices. Eventually, this will allow a reduction in the price of phone calls for all the countries that will ratify this agreement."