On the impact of the genocide on the intergroup empathy bias between former perpetrators, survivors and their offspring in Rwanda.

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ABSTRACT

Studying what factors influence the ability to resonate with the pain of others in the aftermath of a genocide and how this extends to the following generation is critical for understand better the perpetuation of conflicts. In the present study conducted in Rwanda, we recruited former genocide perpetrators, survivors and their respective offspring and investigated how their neural response to the pain of others is modulated when they visualized pictures of former perpetrators, survivors or their children. We further evaluated how the impact of the genocide and psychological factors associated with a trauma influenced the results. Results showed that the intergroup empathy bias, that is, a reduced neural response to the pain of the outgroup, is present for both individuals alive during the genocide and their offspring. We also observed that a higher number of stressors experienced during the genocide was associated with a higher reduction of the neural response to the pain of others, even towards the children of one's own ingroup. Finally, we observed that a deliberate and free decision to reconcile is associated with a higher neural response to the pain of others. The results may be central for encouraging reconciliation in peacebuilding programs and for fostering empathic repair after a trauma.

Keywords: Trauma; genocide; intergroup empathy bias; transmission

1 INTRODUCTION

2
3 Human societies must ensure peaceful relationships between groups in order to prevent
4 conflicts. A key neural process impacted by intergroup tensions and which is linked to prosocial
5 behaviors and to fostering forgiveness is empathy (Bruneau et al., 2017; Cehajic et al., 2008;
6 McCullough et al., 1997; Stephan & Finlay, 1999; Worthington et al., 2000). Empathy is a
7 fundamental process that allows us to understand and imagine what others feel by processing
8 their emotions and pain within our own neural system. In the case of empathy for pain, an
9 extensive literature has shown that seeing another individual in pain triggers an empathic
10 response in the brain of the observer, especially in the anterior cingulate cortex and the insula
11 (Decety, 2011; Keysers & Gazzola, 2014; Singer & Lamm, 2009; Timmers et al., 2018).
12 Critically, when the individual experiencing pain is perceived as an outgroup member, be it
13 based on ethnical, religious or political differences, the neural empathic response is attenuated
14 for the observer (Han, 2018; Hein et al., 2010). This so-called intergroup empathy bias (Cikara
15 et al., 2014) mediates reduced prosocial behaviors for outgroup members compared to ingroup
16 members (Bruneau et al., 2017; Hein et al., 2010), an effect thought to prevent reconciliation
17 in the case of group conflict (Shnabel & Nadler, 2008).

18
19 The intergroup empathy bias in itself is relatively well documented on western, healthy adults
20 (Amodio & Cikara, 2021). However, there are several gaps in the literature that prevent to fully
21 understand the implications of this bias on societies that experienced dramatic group conflicts
22 and suffered from severe trauma and mental health issues. Rwanda is a critical example of how
23 citizens of a divided society have nonetheless to preserve peaceful social interactions. Between
24 April 1994 and July 1994, about one million of Rwandese citizens, mostly Tutsis, were
25 mutilated and killed in a genocidal process. This dramatic event in the history of Rwanda seems
26 unforgivable. However, Rwandan citizens have to learn to live together: perpetrators of the
27 genocide were not invaders from another country; those who were killed died by the hands of
28 their neighbors. While the majority of people who experienced severe prejudices have the
29 possibility to avoid the group they were in conflict with in the past (McCullough, 2001),
30 Rwandan citizens have to be able to manage their emotions and behaviors towards their former
31 aggressors or victims. Can we expect individuals who have suffered such intense trauma, or
32 who are descendants of the victims, to be able to resonate with the suffering of others and to
33 develop empathy toward them, especially if those others were their former aggressors? And if
34 so, what factors prevent or support empathy towards the conflicting group? Answering these
35 questions is at the core of the present study and has the potential to understand better the
36 perpetuation of conflicts (Bruneau et al., 2017) and the factors that foster ‘empathic repair’
37 (Gobodo-Madikizela, 2008).

38
39 Surprisingly, there has been only little empirical research into the relationship between trauma
40 and empathy, and to the best of our knowledge, no systematic research on how a human-caused
41 trauma impacts empathy for the conflicting group and extend to their children. Past research,
42 mostly based on testimonies and self-report measurements, indicates quite divergent results.
43 Some previous work indeed indicated that past adversity and trauma can lead to an increased
44 compassion (Lim & DeSteno, 2016) and empathy (Greenberg et al., 2018) while other work
45 indicated that experiencing a trauma impairs empathic abilities (Nietlisbach et al., 2010) and
46 leads to a compassion deficit (Palgi et al., 2016). As these studies targeted populations with
47 diverse backgrounds and age and with different types of trauma, the reasons of such discordance
48 are unclear. Further, none of those studies manipulated the identity of the person supposedly in
49 pain to study empathy, thus precluding the possibility of knowing if the effect of trauma on
50 empathy and compassion is specific to a group or is a general consequence. Using fMRI, a

former study indicated that PTSD patients showed impairments in implicit and explicit emotional empathy towards other humans, but not in cognitive empathy (Mazza et al., 2015). However, as the trauma in this study was due to a natural disaster and not due to human beings, it is still unclear if a human-caused trauma impacts emotional empathy similarly. Further, an extensive amount of works has shown that the effects of social trauma do not end with the victims, but often impact their children and grandchildren (Sangalang & Vang, 2017; Weingarten, 2004). However, the extent to which children adapt to their parent's attitudes and beliefs towards the outgroup is less clear as former studies confirmed this adaptation (Degner & Dalege, 2013; Meeusen & Dhont, 2015), while other studies showed that survivors' and genocide perpetrators' attitudes towards the outgroup did not influence the attitudes of their children towards the outgroup (Kang et al., 2021). This could be of importance to understand how cycles of violence can be perpetrated by following generations (Bruneau et al., 2017).

In the present study conducted in Rwanda, we investigated how the neural empathic response varies between former perpetrators and victims of the genocide and their children when they visualized former perpetrators, victims or their offspring receiving painful or non-painful stimulations. Past qualitative work suggested that being a victim of collective violence often inhibits empathy toward others, especially their aggressors (Chaitin & Steinberg, 2008; Gobodo-Madikizela, 2008). We could thus expect a more attenuated empathic response from victims towards former perpetrators, an effect that could be accentuated by a more severe PTSD (Mazza et al., 2015), a lower resilience (Vinayak & Judge, 2018) and a lower capacity to regulate emotions (Lockwood et al., 2014). These effects could also be observed in the survivors' children as a consequence of the intergenerationality of the trauma (Sangalang & Vang, 2017). Finally, as empathy is a motivated phenomenon (Zaki, 2014), we also investigated how the willingness to reconcile influenced the results. We expected a stronger willingness to reconcile to be associated with an increased empathy.

METHOD

Participants. We recruited 108 families (N=216), which systematically included an individual who was either recognized as a genocide survivor or as a genocide perpetrator and one of their offspring (age 16-35). To determine the sample size, we conducted the calculations with a power of 95%. No previous studies examined the present research question, especially on non-western individuals. We thus used a standard small-to-medium effect size f of .12. The calculation was realized on GPower with 4 Groups and 3*2 within-subject factors. The estimated total sample size was N=164 (i.e., N=41/group). However, we recruited N=216 to prevent the loss of data due to the conditions in which the testing had to take place and because our inclusion criteria (see below) had to be flexible. For the group of individuals exposed to the genocide, N=53 were composed of genocide survivors and N=55 were composed of former genocide perpetrators released from prison. To identify survivors and former perpetrators, we recruited our participants through Prison Fellowship Rwanda (PFR), a local community-based organization, which works with former perpetrators and survivors in an attempt to promote reconciliation. By recruiting through PFR, we ensured that we recruited individuals officially recognized as genocide survivors or genocide perpetrators. To recruit participants, two volunteers working for PFR went door to door in rural villages of Rwanda to ask the families if they wanted to participate in our study. This process ensured that our participants would know about the study but also that they would trust us. This aspect was critical for them to accept answering our questionnaires, doing the computer task and wearing on their head a machine (i.e., the EEG) that they had never seen before.

1 We also included an additional between-subject factor in our experimental design, which was
2 not mentioned in the pre-registration (<https://osf.io/wrbz9>) of the present study as we could not
3 predict in advance, due to the Covid-19 pandemic, if we would be able to take it into account.
4 As part of the reconciliation process in Rwanda, several reconciliation villages, although in a
5 limited number (N=8) have been built across the country. Rwandese citizens officially
6 recognized as survivors or former perpetrators can decide to live in those villages and to
7 participate in socio-therapy activities. The aim of those villages is thought to improve
8 intergroup relation and to foster forgiveness between survivors and former perpetrators, as well
9 as their children. When we arrived in Rwanda during the Covid-19 pandemic in 2021, we could
10 not ensure that we would have access to those villages, as travelling between different districts
11 in Rwanda was forbidden. Fortunately, some restrictions were lifted, and we were thus able to
12 integrate this additional factor in our analyses.

13
14 We tested our volunteers directly in their villages, by conducting the experiment in buildings
15 that had at least two electrical plugs and a relative quietness. Half of our sample was recruited
16 and tested in the district of Kayonza and the other half in the district of Bugesera. For our
17 recruitment criteria, we had to be much more flexible than in classical neuroscience projects
18 conducted on the WEIRD (Western, Educated, Industrialized, Rich, Democratic). Here, half of
19 our sample could not read Kinyarwanda, never went to school, never saw or even used a
20 computer in their entire life. In addition to those aspects, a quarter of our sample spent years in
21 jail and were relatively old at the moment of the testing (i.e. the genocide perpetrators). We
22 tried to have a relatively good gender balance (82/216 females). However, obtaining a gender
23 balance was not possible for the group composed of former perpetrators. The first reason is that
24 there were much fewer female perpetrators than male perpetrators (Verwimp, 2005). The
25 second reason is that after the genocide, many men were put in jail but not women, which were
26 not directly considered as perpetrators. Many of the female perpetrators were judged and
27 sentenced to jail during the Gacaca Trials, which started in 2003. Most of those women were
28 thus still in jail at the moment of the testing. We found two female perpetrators released from
29 prisons, but one refused to participate in the study and the other one was mentally unstable. For
30 the group composed of genocide survivors, women were more frequent than men (33/53). Men
31 were indeed systematically killed during the genocide, while some women were left alive with
32 life-long body trauma or were raped by individuals knowingly having HIV to purposely let
33 them live with life-long sexual diseases. Our inclusion criteria were thus simply (1) being
34 officially recognized as a genocide survivor or perpetrator and (2) coming with one offspring
35 aged between 16 and 28. *A priori* exclusion criteria would involve not understanding the task
36 (N=3), having haircuts (i.e., braided hairs attached in a ponytail) that prevent to place the EEG
37 hat (N=2) and having a bad signal-to-noise ratio (N=26). As this population was never
38 approached by neuroscience projects before, we could not plan all the exclusion criteria *a*
39 *priori*. *A posteriori* exclusion criteria also included falling asleep during the task (N=2), being
40 drunk at the moment of the testing (N=3), not willing to separate from her baby during the
41 testing (N=1), being younger than 16 or older than 28 despite our recruitment criteria (N=8),
42 when a storm happened, which forced us to stop the testing (N=2) or when a low IQ was
43 suspected (N=1). The data of one participant was lost due to an issue in recording the EEG
44 triggers and the data of another participant was lost due to an alteration of the recorded file. In
45 the case of trauma revival during the experiment, we followed a procedure decided in
46 accordance with the Rwanda National Ethics Committee that involved a follow-up by a trained
47 clinical psychologist. Two survivors could not complete the task because of trauma revival and
48 were thus also excluded from the sample.

After exclusion criteria, our final sample was composed of 164 individuals. In the group of genocide survivors, 16/40 were males and the mean age was 50.85 (SD=9.76). 18/40 were living in a reconciliation village. In the group of former genocide perpetrators, 44/44 were males and the mean age was 58.95 (SD=8.12). 27/44 were living in a reconciliation village. In the group of children of genocide survivors, 24/41 were males and the mean age was 19.97 (SD=3.62). 16/41 were living in a reconciliation village. In the group of children of genocide perpetrators, 17/39 were males and the mean age was 19.79 (SD=3.67). 22/39 were living in a reconciliation village. The study has been approved by the Rwanda National Ethics Committee (Ref: 167/RNEC/2021) and pre-registered before data collection on OSF (<https://osf.io/wrbz9>).

Material & Method. Participants were invited to sit in front of a computer screen. To ensure a relative quietness, in several buildings there were no isolated rooms. We thus constructed isolation walls with planks of woods (see **FIGURE 1**) to reduce surrounding distractions (i.e., curious children, goats, etc.). We used a 64-channel EEG system in order to record their brain activity. Participants were told that they would witness pictures of six different individuals across four different experimental blocks, with three individuals alive during the genocide and three individuals not born yet when the genocide happened. Those six individuals included (1) a former perpetrator of the genocide, (2) the offspring of a former perpetrator of the genocide, (3) a genocide survivor, (4) the offspring of a genocide survivor, (5) an individual who was not present in Rwanda during the genocide and (6) the offspring of an individual who was not present in Rwanda during the genocide. The last two individuals were used as controls in order to understand if our effects on the neural response to the pain of others is group-specific (e.g., survivors towards former perpetrators only), or a general effect (e.g., survivors towards both former perpetrators and neutral individuals) after a social trauma. To control for gender, only males were displayed on those pictures as there was a higher percentage of male perpetrators during the genocide compared to female perpetrators (Verwimp, 2005).

FIGURE 1. Pictures of the set-up of the ‘experimental rooms’ in one of the testing locations in Rwanda.

To increase the ecology of the procedure, we told participants that the six individuals accepted to share their stories or the stories of their parents during the genocide for the sake of our study. Before starting an experimental block, participants were presented a picture of an individual and his story was presented in Kinyarwanda, both orally and written, see **FIGURE 2B** (see **Supplementary Material S1**). Oral audios were important for those who could not read, but also because Rwanda has a culture of oral transmission. The stories were created based on what really happened to some people during the genocide, such as hiding in the swamps to survive or having killed and being sentenced to prison during the *Gacaca Trials*. Each Rwandan citizen is, in a way or in another, linked to the genocide. To create the control story for a Rwandese

1 who would not have been present during the genocide and not have had his family killed or
2 involved in the genocide, we explained that this person left Rwanda with his entire family
3 before the genocide because of finding a job in Europe. To ensure that our participants really
4 paid attention to the stories and remembered them before starting an experimental block, we
5 presented after each story one out of four questions in which they had to rate how they felt
6 about that individual (e.g. '*I feel sad for what happened to this person*', see **Supplementary**
7 **Material S2**). Data were not analyzed due to a high difficulty for former perpetrators and
8 survivors to learn to read numbers on the keyboard.

10 We also told our participants that we had to preserve the anonymity of the six individuals who
11 had accepted to share their stories. As a consequence, pictures were centered on the hand of
12 those individuals, with their body and low part of the face being blurred. To avoid creating
13 physical distinctions between the different categories of individuals, which would not be
14 ethically acceptable in Rwanda as the genocide happened between two ethnicities that were
15 physically quite different, we ensured that the six individuals had a relatively similar skin color
16 and body shape. To ensure that our participants would associate the hands receiving the painful
17 or non-painful stimuli to a specific individual whose they read and heard the story about, we
18 ensured that the t-shirt and bottom part of the face were visible on the pictures, even if blurred
19 (e.g. a blue t-shirt for one individual, a kaki t-shirt and a bandana for another individual). For
20 each of the six individuals, we created 8 pictures, 4 with painful tools (e.g., a knife) and 4 with
21 non-painful tools (i.e., a feather), see **FIGURE 2A**. On the pictures, someone was holding the
22 tools in a way of intending to hurt the individual, but the skin color of that person was hidden
23 by gloves and a long shirt to avoid associating an ethnicity to the person holding the tools. Four
24 experimental blocks displayed randomly the 6 individuals and their stories, with 20 painful and
25 20 non-painful stimuli presented for each individual in a randomized order. The block design
26 was decided in order to limit visual habituation to the stimuli presented. In total, there were 20
27 trials per category of tools, thus resulting in 160 trials per individual (80 painful and 80 non-
28 painful) across the four experimental blocks. The number of trials was decided based on the
29 best ratio to obtain a good EEG signal-to-noise ratio but also avoiding too long computer task
30 for elderly participants. We also randomized the individuals and the stories. For instance, one
31 individual was a former perpetrator for some participants and a control for other participants.
32 Pictures were presented during 400 ms, with a jittered inter-trial interval (ITI) lasting between
33 1 and 1.4 seconds. A fixation cross located at the center of the screen was displayed during the
34 ITI.

FIGURE 2. A) Examples of painful and non-painful stimuli. B) Schematic representation of the task. The written and oral parts were in Kinyarwanda for our volunteer participants.

To ensure that participants were paying attention to the stimuli, on 12/160 trials per individual, we randomly displayed a question appearing on the screen where participants were asked to estimate the pain of the individual on a scale ranging from '0' (not painful at all) to '10' (very painful). Participants were told that they had to focus on how painful the presented tools could be for the individual in order to target emotional empathy (Decety et al., 2018). We also wanted to ensure that our participants would keep in mind who the individual on the picture they are actually seeing was. Therefore, we also mention the chosen name of the individual in the question (e.g., 'How was the intensity of the pain for Eric in the last trial?'). At the end of the experimental session, participants were asked to complete a series of questionnaires measuring: (1) the short version of PCL-C - DSM-4 scale to assess the persistence of PTSD symptoms (Fodor et al., 2015; Pham et al., 2004), (2) Resilience (Connor & Davidson, 2003), (3) a scale on the willingness to reconcile (see **Supplementary Information S3**), (4) a questionnaire on the impact of the genocide (Blanchette et al., n.d.), (5) the Bogardus Social Distance scale (adapted to our different groups), and (6) a short version of the emotion regulation questionnaire (Garnefski & Kraaij, 2006).

EEG recordings. Brain activity was recorded using a 64-channels electrode cap with the ActiveTwo system (BioSemi) and data were analyzed using Fieldtrip software (Oostenveld et al., 2011). The activities from left and right mastoids and from horizontal and vertical eye movements were also recorded. Amplified voltages were sampled at 2048 Hz. Data were referenced to the average signal of the mastoids and filtered (bandpass filter: 0.01-40 Hz). Baseline was taken from 250 ms to 50ms before the apparition of pictures. Artefacts due to eye movements were removed based on a visual inspection with the removal of epochs containing eye blinks or ocular saccades. Power line noise was strong as we tested in rural villages with

generally a single electrical circuit for the entire village. We thus also used Zapline (de Cheveigné, 2020) to first clean the data from the line noise and then used a spectral interpolation around 50Hz and its harmonics. All event-related potentials were analyzed across Cz, CPz, and Pz. Timing of the ERPs were decided based on visual inspection of the grand averages. The N1 and the N2 were measured as the most negative peaks within the 110-160 ms time-window and the 280-390 ms time-window after the picture, respectively. The P2 was measured as the most positive peaks within the 190-250 ms time-window and the 340-440 ms time-window after the tone, respectively. The P3, the early LPP and the late LPP were measured as the mean amplitude between the 390-510 ms time-window, the 520-770 ms time-window and the 790-1300 ms time-window after the picture, respectively. Source reconstruction was performed by first computing a filter with a covariance matrix taken between -400 ms to 1s with the Linearly Constrained Minimum Variance (LCMV) beamformer method to reconstruct the sources of ERPs components. A second covariance window was calculated on the period of interest for the pain response (390 ms to 1s, corresponding to the time windows of the P3, eLPP and ILPP combined) and the same LCMV beamformer method was applied based on the filter computed. The volume construction was based on standard head model and source model downloaded through Fieldtrip. Source localization was determined with the Brainnetome Atlas (Fan et al., 2016).

RESULTS

Results were systematically analyzed with both the frequentist and the Bayesian approach (see *Supplementary Information S4* for more information).

Electroencephalography. We first compared the amplitude of the P3, eLPP and ILPP when participants witnessed painful pictures vs non-painful pictures in order to confirm that these Event-Related Potentials (ERP) are sensitive to the visualization of pain, irrespective of the other independent variables. As expected, we observed very strong evidences in favor of H_1 for a higher amplitude for Pain trials vs No Pain trials for the P3 ($t_{(176)}=12.233$, $p < .001$, Cohen's $d=.919$, $BF_{10}=1.419e^{+22}$), the eLPP ($t_{(176)}=16.454$, $p < .001$, Cohen's $d=1.237$, $BF_{10}=1.331e^{+34}$) and the ILPP ($t_{(176)}=14.936$, $p < .001$, Cohen's $d=1.123$, $BF_{10}=7.091e^{+29}$). We subtracted the amplitude of the pain response during No Pain trials to Pain trials (i.e., Pain-No pain) and performed our statistical analyses on this new variable. For the sake of clarity of the results section, we computed a global pain response, which corresponded to the averaging of the P3, the eLPP and the ILPP. Results for each ERP are presented in *Supplementary Information S3* but they overall do not differ from the results on the global pain response (hereafter referred to as 'pain response'). We also reconstructed the sources of ERPs components in order to ensure that our computed pain response originated in empathy-related brain regions. Results showed a higher activation in the Inferior Parietal Lobule, in the precuneus, in the superior frontal gyrus and in the cingulate gyrus (see **FIGURE 3**).

FIGURE 3. Source reconstruction of the ERPs associated with the pain response. IPL=Inferior Parietal Lobule. SFG=Superior Frontal Gyrus.

The repeated-measures ANOVA was conducted with Generation (present during the genocide, offspring not present during the genocide) and Individual (neutral, perpetrator, survivor) as within-subject factors and Group (survivor of the genocide, former genocide perpetrator, child of a survivor of the genocide, child of a former genocide perpetrator) and living in a Reconciliation village (yes, no) as between-subject factors on the pain response. We found a strong evidence in favor of H_1 for a main effect of Group ($F_{(3,156)}=4.380$, $p=.005$, $\eta^2_p=.078$, $BF_{incl}=1.019e+10$). Independent sample t-tests revealed anecdotal to very strong evidence that the pain response was lower for the group of genocide survivors compared to the group of former genocide perpetrator ($t_{(82)}=-3.260$, $p=.002$, Cohen's $d=-.712$, $BF_{10}=19.974$), to the group of children of genocide survivor ($t_{(79)}=-3.671$, $p<.001$, Cohen's $d=-.816$, $BF_{10}=61.429$) and to the group of children of former perpetrators ($t_{(77)}=-2.289$, $p=.025$, Cohen's $d=-.515$, $BF_{10}=2.186$). The difference between the other groups were in favor of H_0 (all $ps \geq .3$, all $BF_{s10} \leq .354$).

We also observed a strong evidence in favor of H_1 for a main effect of Individual ($F_{(2,312)}=6.113$, $p=.002$, $\eta^2_p=.038$, $BF_{incl}=2.124e+10$) and an interaction Individual*Group ($F_{(6,312)}=12.564$, $p<.001$, $\eta^2_p=.195$, $BF_{incl}=4.898e+10$). The main effect of Generation was in favor of H_0 ($p>.3$, $BF_{10}=.019$) but the triple interaction Group*Individual*Generation was in favor of H_1 with the frequentist approach ($F_{(6,312)}=2.910$, $p=.009$, $\eta^2_p=.053$) but not with the Bayesian approach ($BF_{incl}=.040$). For investigating the intergroup empathy bias predicted in our hypotheses, we conducted paired comparisons between the pain response when visualizing the pictures of an individual representing one's own group and the amplitude of the pain response when visualizing the pictures of the other individuals (see **FIGURE 4**). For the sake of clarity, tables with full statistics are available in **Supplementary Information S5**. For the group of survivors, we observed moderate to strong evidences in favor of H_1 that their pain response was higher when they visualized the pictures of a survivor compared to all the other individuals (all $ps \leq .015$, all $BF_{s10} \geq 3.033$), except for the child of a neutral individual as this difference was inconclusive ($p=.047$, $BF_{10}=1.117$). For the group of children of survivors, we observed moderate to strong evidences in favor of H_1 that their pain response was higher when visualizing pictures of a child of a survivor compared to visualizing pictures of a former perpetrator and the pictures of the child of a former perpetrator (all $ps \geq .006$, all $BF_{s10} \leq 5.927$). Other comparisons were in favor of H_0 or inconclusive (all $ps \geq .025$, all $BF_{s10} \leq 1.86$ & $\geq .19$). For the group of former perpetrators, we observed strong to very strong evidences in favor of H_1 that their pain response was higher when they visualized the pictures of a former perpetrator compared to all the other individuals (all $ps \leq .003$, all $BF_{s10} \geq 13.063$), except for the child of a former perpetrator as this difference was inconclusive ($p=.061$, $BF_{10}=.875$). For the group of children of former perpetrator, the pattern of result was relatively similar to the one of their

parents. We observed strong to very strong evidences in favor of H_1 that their pain response was higher when they visualized the pictures of the child of former perpetrator compared to all the other individuals (all $p \leq .002$, all $BF_{S10} \geq 16.910$), except for the pictures of a perpetrator as this difference was inconclusive ($p = .05$, $BF_{10} = 1.088$). Overall, those results revealed an ingroup effect for one's own group and an outgroup effect for the group of individuals they were in conflict with during the genocide. Results also indicated that these effects extend to the subsequent generation, with similar ingroup and outgroup effects for their children. However, all the correlations between the pain response of survivors and the pain response of their direct offspring for each individual presented on the pictures were in favor of H_0 (all $p \geq .5$, all $BF_{S10} \leq .253$). For the group of former perpetrators and their direct offspring, the same correlations were either in favor of H_0 or inconclusive (all $p \geq .09$, all $BF_{S10} \leq .809$).

FIGURE 4. Graphical representation of the triple interaction Group*Individual*Generation. The four groups of participants are displayed on the horizontal axis. The vertical axis represents the amplitude of the pain response (Pain – No Pain). * represents a $p \geq .01$ & $\leq .05$. ** represents a $p \geq .001$ & $\leq .01$. *** represents a $p \leq .001$. All tests were two-tailed.

We also found evidence for a triple interaction Group*Generation*ReconciliationVillage with the frequentist approach ($F_{(3,156)} = 4.868$, $p = .003$, $\eta^2_p = .086$), but not with the Bayesian approach ($BF_{incl} = .034$), see **FIGURE 5**. For the group of survivors, we observed evidence for H_0 that living in a reconciliation village did not influence their pain response when they visualized pictures of individuals present during the genocide ($p > .2$, $BF_{10} = .525$) or their offspring ($p > .9$, $BF_{10} = .311$). For the group of children of survivors, living in a reconciliation village did not reliably influence their pain response when they visualized pictures of individuals present during the genocide ($p > .1$, $BF_{10} = .760$). However, when they visualized pictures of offspring of individuals present during the genocide, living in a reconciliation village reduced their pain response ($.92\mu V$, $SD = 1.70$) compared to not living in a reconciliation village ($2.58\mu V$, $SD = 1.52$, $t_{(39)} = 3.248$, $p = .002$, Cohen's $d = 1.040$, $BF_{10} = 15.245$). For the group of former perpetrators, living in a reconciliation village did not influence their pain response when they visualized pictures of individuals present during the genocide ($p > .8$, $BF_{10} = .308$). However, when they visualized pictures of offspring of individuals present during the genocide, living in a reconciliation village slightly increased their pain response ($1.81\mu V$, $SD = 1.57$) compared to not living in a reconciliation village ($.87\mu V$, $SD = 1.05$, $t_{(42)} = -2.183$, $p = .035$, Cohen's $d = -.676$, $BF_{10} = 1.940$). Finally, for the group composed of children of former perpetrators, living in a reconciliation village did not influence their pain response when they visualized pictures of individuals present during the genocide ($p > .5$, $BF_{10} = .353$). However, when they visualized pictures of offspring of individuals present during the genocide, living in a reconciliation village marginally increased their pain response ($2.47\mu V$, $SD = 1.81$) compared to not living in a

reconciliation village ($1.36\mu\text{V}$, $\text{SD}=1.66$, $t_{(37)}=1.986$, $p=.054$, Cohen's $d=.641$, $\text{BF}_{10}=1.432$). Results showed overall that living or not in a reconciliation village has an effect on the pain response when visualizing pictures of offspring of individuals present during the genocide, but not when visualizing the pictures of individuals present during the genocide. However, this effect differs between groups. Results indeed showed that living in a reconciliation village increased the pain response in the group of former perpetrators but decreased it for children of both survivors and former perpetrators. Results also revealed a significant triple interaction $\text{Generation}*\text{Individual}*\text{ReconciliationVillage}$ significant with the frequentist approach ($F_{(6,312)}=3.065$, $p=.048$, $\eta^2_p=.019$) but not with the Bayesian approach ($\text{BF}_{\text{incl}}=.014$) and a double interaction $\text{Individual}*\text{Reconciliation}$ significant with the frequentist approach ($F_{(2,312)}=4.043$, $p=.018$, $\eta^2_p=.025$) but not with the Bayesian approach ($\text{BF}_{\text{incl}}=.127$). However, as these interactions were not planned for answering our main research questions, there were not investigated further. Other main effects or interactions was in favor of H_0 or inconclusive (all $ps\geq.1$, all $\text{BF}_{s10}\leq.034$).

FIGURE 5. Graphical representation of the triple interaction $\text{Group}*\text{Generation}*\text{ReconciliationVillage}$. The four groups of participants are displayed on the horizontal axis. The vertical axis represents the amplitude of the pain response (Pain – No Pain). * represents a $p\geq.01\&\leq.05$. *** represents a $p\leq.001$. All tests were two-tailed.

We also run the same repeated-measures ANOVA with Gender (male, female) as an additional between-subject factors. The main effect of Gender was in favor of H_0 ($p>.8$, $\text{BF}_{10}<.040$) and the general pattern of results was unchanged.

Questionnaires. In order to try quantifying what our participants experienced during the genocide in 1994 and its psychological consequences, they had to fill in several questionnaires (see *Method* section). We systematically conducted Univariate ANOVAs with Group (survivor of the genocide, former genocide perpetrator, child of a survivor of the genocide, child of a former genocide perpetrator) and living in a Reconciliation village (yes, no) as fixed factors on the scores of each questionnaire. Full results when in favor of H_1 are displayed in. Overall, we observed evidence in favor of H_0 that the main effect of Group, the main effect of living in reconciliation village or their interaction did not influence scores on the willingness to reconcile (all $ps\geq.1$, all $\text{BF}_{s10}\leq.233$), on scores of post-traumatic stress disorder (all $ps\geq.1$, all $\text{BF}_{s10}<.248$), on scores on resilience (all $ps\geq.08$, all $\text{BF}_{s10}\leq.446$) and on emotion regulation (all $ps\geq.1$, all $\text{BF}_{s10}\leq.337$). We observed a very strong evidence that the impact of the genocide was higher for the group of survivors than for all the other groups (all $ps<.003$, all $\text{BF}_{s10}\leq.12$, see

Supplementary Information S6 for full results). Results also indicated that scores on social distance were higher towards former perpetrators, and, more moderately, towards children of former perpetrators, compared to the other group (see **Supplementary Information S7** for full results). We also observed that for survivors, former perpetrators and children of former perpetrators, living in a reconciliation village or not did not reliably influence the scores on social distance (all $p \geq .1$, all $BF_{10} \leq .9$). However, for the group of children of survivors, results revealed that when they were living in reconciliation villages, they scored higher on social distance towards former perpetrators and children of former perpetrator compared to those not living in reconciliation villages.

We also ran Pearson correlations between the different questionnaires. To correct for multiple comparisons with the frequentist statistics, we applied a False Discovery Rate (FDR) approach with the Benjamini and Hochberg method (Benjamini & Hochberg, 1995) to each p-value. We observed a positive correlation between the score on the PTSD scale and the number of stressors our participants endured during or after the genocide ($r = .260$, $p_{FDR} < .001$, $BF_{10} = 25.168$). We also observed positive correlations between the willingness to reconcile and scores on emotion regulation ($r = .232$, $p_{FDR} = .007$, $BF_{10} = 8.240$) and on resilience ($r = .262$, $p_{FD} < .001$, $BF_{10} = 28.666$). Scores on emotion regulation also positively correlated with resilience scores ($r = .214$, $p_{FDR} = .012$, $BF_{10} = 4.221$). Finally, we observed a positive correlation between scores on the PTSD scale and emotion regulation ($r = .261$, $p_{FDR} < .001$, $BF_{10} = 27.606$). Other correlations were in favor of H_0 (all $p_{SFDR} \geq .2$, all $BF_{S10} \leq .250$).

Effect of the trauma on the neural response to the pain of others.

To assess the impact of the genocide and the psychological profile in the aftermath of the genocide of our participants influence the pain response, a forced-entry regression method was used to fit a multiple linear regression model. We centered the overall score of all predictor variables (Impact of the genocide, PTSD symptoms, Resilience, Emotion Regulation, Willingness to reconcile) before building the model. We run a first model with the pain response as the dependent variable and scores on the different questionnaires as predictor variables, all participants combined. Results indicated that the best predictor variable of the pain response was the score regarding the number of stressors our participants endured during or after the genocide ($F_{(5,162)} = 3.020$, $p = .018$, $Beta = -.190$, $BF_{incl} = 2.760$), see **FIGURE 6**. The higher number of stressors our participants had to endure during or after the genocide, the more reduced their neural pain response was. We also observed an anecdotal evidence that the more participants indicated that they are willing to reconcile, the higher their neural pain response was ($F_{(5,162)} = 2.184$, $p = .030$, $Beta = .176$, $BF_{incl} = 1.303$). Further, the higher participants scored on the resilience subscale, the lower was their neural pain response ($F_{(5,162)} = -2.079$, $p = .039$, $Beta = -.167$, $BF_{incl} = 1.248$). Other predictor variables were slightly in favor of H_0 (all $p \geq .5$, all $BF_{S10} \leq .538$).

FIGURE 6. Graphical representation of the correlations between the pain response and the impact of the genocide (right), the willingness to reconcile (center), and resilience (left). All tests were two-tailed.

As we were specifically interested in the intergroup empathy bias and how a human-related trauma influences it, we conducted separate linear regressions on the different groups with respect to their relative outgroup and the other outgroup generation.

For the group of survivors, the best predictor variable of the pain response towards former perpetrator was the score regarding the number of stressors they endured during the genocide ($F_{(5,39)}=-2.732, p=.010, \text{Beta}=-.419, \text{BF}_{\text{incl}}=2.484$). The correlation indicated that the higher the number of stressors, the lower their pain response towards former perpetrator was. Other predictor variables were inconclusive (all $ps \geq .1$, all $\text{BF}_{s10} \leq .711$). None of the questionnaires influenced the pain response towards children of former perpetrators (all $ps \geq .3$, all $\text{BF}_{s10} \leq .238$). For the group of children of survivors, all predictor variables were in favor of H_0 or inconclusive regarding their pain response towards former perpetrators (all $ps \geq .1$, all $\text{BF}_{s10} \leq .399$) and towards children of former perpetrators (all $ps \geq .069$, all $\text{BF}_{s10} \leq .682$). For the group former perpetrators, all predictor variables were in favor of H_0 or inconclusive regarding their pain response towards survivors (all $ps \geq .079$, all $\text{BF}_{s10} \leq .433$) and towards children of survivors (all $ps \geq .5$, all $\text{BF}_{s10} \leq .177$). For the group of children of former perpetrators, all predictor variables were in favor of H_0 regarding their pain response towards survivors (all $ps \geq .6$, all $\text{BF}_{s10} \leq .180$). When visualizing pictures of a child of a survivor, we nonetheless observed evidence in favor of H_1 that a higher score on the PTSD scale ($F_{(5,38)}=-2.652, p=.012, \text{Beta}=-.410, \text{BF}_{\text{incl}}=3.220$) and a higher score on resilience ($F_{(5,38)}=-2.394, p=.023, \text{Beta}=-.410, \text{BF}_{\text{incl}}=3.603$) were associated with a more reduced pain response. Other predictor variables were inconclusive (all $ps \geq .3$, all $\text{BF}_{s10} \leq .737$).

DISCUSSION

In accordance with our hypothesis, we observed evidence for an association between the impact of the genocide and the neural response to the pain of others, with a higher number of stressors reported being associated with a lower pain response. This result is consistent with past literature showing that past traumatic or painful experiences impact the ability to resonate with the pain of others (Driscoll et al., 2012; Eidelman-Rothman et al., 2016; Mazza et al., 2015). Results further revealed that this association appeared to be stronger for the group of survivors compared to the other groups. Expectedly and similar to past studies (Blanchette et al., n.d.; Rieder & Elbert, 2013), survivors, as the primary targets of the atrocities that happened in 1994, were indeed the most impacted by the genocide compared to the other groups. Interestingly, we observed that the reduced pain response in the group of survivors was also present towards the pain of the child of a survivor. A first explanation is that a massive social trauma impacts so much empathy that even children of the ingroup are impacted, letting survivors with the unique possibility to empathize with the pain of those who experienced similar life events. Second, many women were raped during the genocide. The children born from those rapes face stigmatization (Mukangendo, 2007), and have been called “children of bad memories” (Goodwin, 1997) or even “devil’s children” (Nowrojee, 1996). In our story, the child of the survivor explicitly mentions the rape of her mother during the genocide, which could have resulted in an attenuated pain response.

Although to a lower level, genocide perpetrators also reported a high number of stressors, but those stressors were more frequently experienced after the genocide, during their prison time, similar to past studies (Rieder & Elbert, 2013; Schaal et al., 2012). However, unlike survivors, former perpetrators did not display an overall reduction of the pain response compared to the other group. It may thus suggest that the type and origin of stressors

1 experienced during a human conflict have different impact on the ability to resonate with the
2 suffering of others.

3 Our results also indicated that the impact of the genocide positively correlated with the
4 number of persisting PTSD symptoms, similar to previous results (Blanchette et al., n.d.).
5 Interestingly, although we found that a higher impact of the genocide was statistically
6 associated with a lower pain response, the number of persisting PTSD symptoms did not
7 statistically correlate with the pain response. This result may indicate that PTSD symptoms in
8 themselves are not what is associated with the reduction of the pain response. Rather, the type
9 and origin of stressors experienced are the factor that influences the ability to resonate with the
10 suffering of others.

11 We observed that children of survivors and children of former perpetrators both display
12 overall an intergroup empathy bias such as their parents, suggesting that the intergroup empathy
13 bias is transferred to the following generations. However, correlations between the pain
14 response of parents and their child were not significant. This result supports a previous study
15 conducted in Rwanda (Kang et al., 2021) showing that even if the intergroup empathy bias is
16 found on the following generation and towards the offspring of the outgroup, this transmission
17 is not direct and other factors, such as the number of voluntary interactions with the outgroup,
18 can influence it.

19 We observed a positive influence of living in a reconciliation village towards the pain
20 of the offspring for the group of former perpetrators. Past literature indicated that prejudice is
21 reduced with contacts with the outgroup (Beelmann & Heinemann, 2014; Cameron et al., 2011;
22 Crisp & Turner, 2009; Kang et al., 2021) and living in reconciliation villages involves more
23 contacts with the outgroup compared to not living in reconciliation villages, which could
24 explain this result. Yet, we observed that living in a reconciliation village compared to not had
25 a negative influence on the neural response to the pain of others for children of both former
26 perpetrators and survivors. Results also revealed that children of survivors living in
27 reconciliation villages scored higher on social distance towards former perpetrators and
28 children of former perpetrators compared to those not living in reconciliation villages. A
29 possible explanation relates to the freedom of the decision to live in a reconciliation village and
30 the personal willingness to reconcile. Past studies further indicated that one's own motivation
31 to engage in contacts with the outgroup is a critical determinant for reducing prejudice, beyond
32 simply being in contact with the outgroup (Cernat, 2011; Halperin et al., 2012; Lemm, 2006;
33 Ron et al., 2016). We indeed observed that a higher willingness to reconcile was associated
34 with a greater neural response overall. This result would be supported by current theoretical
35 views suggesting that empathy, despite being an inner process, is also a motivated phenomenon
36 (Zaki, 2014). Past studies showed that a free decision to forgive seems to be a key step in
37 reaching complete forgiveness, which has the potential to bring emotional and behavioral
38 changes (Worthington et al., 2000). While individuals alive during the genocide may have been
39 voluntarily chosen to live in a reconciliation village, their children generally do not have the
40 choice and live where they parents choose to live. Importantly, as this association rely on a
41 correlational approach, it is also possible that having a higher neural response to the pain of
42 others motivates the process of reconciliation.

43 We also observed that living in a reconciliation village had no effects on survivors, a
44 result which can be explained by the fact that even if the decision is relatively free, at least more
45 than for children, some other motivations could have underlined their decision. Indeed,
46 accepting to live in such villages frequently come with free housing charges and financial
47 benefits, which can be a critical incentive for individuals living in a low-income country. Some
48 survivors reported that they felt forced to reconcile, either because reconciliation is encouraged
49 by the government or because of religious ideology (Hatzfeld, 2007).

1 An interesting future line of research would be to understand the cross-culturality of
2 these effects. A previous fMRI study showed that cultural variation in preference for social
3 hierarchy modulates neural response underlying intergroup empathy, which a higher preference
4 for social hierarchy being associated with a higher intergroup empathy bias (Cheon et al., 2011).
5 The Rwandan culture involves a high deference to authority (Caspar et al., 2021; Prunier, 1998;
6 Staub, 1992), which is associated with the family honor (Green, 2020). It is thus possible that
7 the intergenerationality of the intergroup empathy bias observed in the present study would
8 differ in other cultures with less preference for social hierarchies, but the lack of previous
9 literature prevents to answer this question.

10 Past research found positive correlation between resilience and empathy (Grant &
11 Kinman, 2014; Smith & Hollinger-Smith, 2015). However, in the present study, we observed
12 that the higher our participants scored on the resilience scale, the lower their neural response to
13 the pain of others was. A first critical difference with past studies is that we used
14 electroencephalography instead of self-report measurements, which are more biased to social
15 desirability, especially for empathy (Neumann & Westbury, 2011). A second critical difference
16 may be cultural, as the majority of previous research was conducted on western individuals. A
17 former study conducted in Rwanda indicated that deliberately forgetting about the actions of
18 the other group, referred by the author to as ‘chosen amnesia’, is essential for peaceful local
19 coexistence (Buckley-Zistel, 2006) and to maintain harmony in the whole community. The
20 process of resilience to negative events could thus also involve a strategy of blocking any
21 emotions that could be felt in order to preserve peaceful contacts.

22 Several limitations should be considered in the present study. A first limitation concerns
23 the fact that we did not predict how complicated it would be for a high number of our
24 participants to learn to use a keyboard precluded to investigate if our neural results would
25 correlate with subjective report of pain on the pictures. One possibility in future studies could
26 be to use pictorial material instead of digital numbers, which may be more difficult to learn.
27 Another limitation is that although we observed a reduction of the pain response for survivors
28 compared to the other groups, we do not know if the pain response for the other groups is also
29 reduced compared to neutral controls, or not. As the other groups also reported stressors during
30 the genocide and PTSD symptoms, it is possible that their neural pain response is also somehow
31 attenuated. However, finding neutral controls with our Rwandese participants is almost
32 impossible as each Rwandan citizen is, in a way or in another, linked to the genocide.

33 By recruiting the Rwandan population in a cross-sectional study which involved actual
34 survivors, former perpetrators and their children, this study offers a first critical investigation
35 of how a human-caused trauma impacts empathy for the conflicting group and their children.
36 We observed that suffering from PTSD symptoms is not the best predictor variable of a reduced
37 pain response. Rather, it seems that the type and origins of stressors experienced during the
38 genocide is the best predictive factor associated with the reduced pain response. Second, we
39 observed that a deliberate and free decision to reconcile is associated with a higher pain
40 response. This may be critical for encouraging reconciliation in peacebuilding programs and
41 for fostering empathic repair after a trauma.

42
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45
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47 helpful comments from D.G. and C.K. E.A.C. and G.P. conducted the experiment and analyzed the results. E.A.C.
48 drafted the first draft of the manuscript and G.P., D.G. and C.K. provided comments. All the authors agree on the
49 final version of the manuscript.

50
51 **Data availability.** Data are made available on OSF (doi: DOI 10.17605/OSF.IO/MD97V).

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