INTRODUCTION

The idea that inequality negatively impacts population health is not a new one; it is a key concern of epidemiological research (Wilkinson & Pickett, 2018). Undeniably, rich Western countries have healthier populations compared with poorer developing nations (Gwatkin, 2002; Hansen & Postmes, 2013). However, prosperity has not delivered health equally across society in developed countries. In fact, it would seem some egalitarian countries have better overall population health even compared with more affluent countries (Scheepers & Ellemers, 2018; Wilkinson & Pickett, 2010).

In this paper, we examine the possibility that this phenomenon is a consequence of income inequality being a cause of stress for rich and poor alike.

Here, we conceptualize stress response using cardiovascular reactivity. Perturbation of cardiovascular activity in response to acute psychological challenge is consistent with the reactivity hypothesis (Obrist et al., 1986) and is routinely used as a measure of stress in the health research literature (Blascovich & Tomaka, 1996; Kim et al., 2017). Berntson and Cacioppo (2004) show that stressors of any intensity, from a lab-based stressor to everyday “hassles,” influence cardiovascular responses. Heart rate (HR) is also

Physiological stress responses to inequality across income groups in a virtual society

Megan Ryan1,2 | Orla T. Muldoon1 | Stephen Gallagher1,2 | Jolanda Jetten3

1Department of Psychology, Centre for Social Issues Research, University of Limerick, Limerick, Ireland
2Department of Psychology, Centre for Social Issues Research, Study of Anxiety, Stress and Health Laboratory, University of Limerick, Limerick, Ireland
3School of Psychology, University of Queensland, Brisbane, QLD, Australia

Abstract

A growing body of research suggests that inequality can be stressful for all within a society. We consider this assertion by exploring whether there is evidence of physiological stress responses to different income and inequality conditions in a hypothetical society. The combined effect of inequality for different income groups on cardiovascular reactivity was assessed while participants engaged in purchasing decisions. The study included 102 participants, 84 of which had full data for analyses (42 male, 41 female, 1 unspecified). The average age was 23 years. A 3 × 2 design manipulated both inequality (stable, increasing, and decreasing) and income (high and low). Cardiovascular reactivity was operationalized as change in heart rate (HR) and blood pressure (BP; diastolic and systolic) responses at the end of the purchasing task compared with baseline. Although there was no direct association between income, inequality, and BP, results indicated that low-income participants had the higher HR reactivity to stable inequality compared with increasing inequality. These findings indicate that inequality has the hallmarks of a stressor; this is contingent on the type of inequality. This suggests that inequality itself may be detrimental to future health via the stress pathway. These findings highlight that the nature of inequality, increasing, decreasing, or stable is relevant to its impact and that these impacts of inequality may extend to the biological.
a good indicator of stress (Kim et al., 2017). We and others have shown that these metrics are sensitive to stress-induced manipulations (Gallagher et al., 2014; Segerstrom & Miller, 2004). Increased blood pressure (BP) or HR responses in response to a presented stressor and its emotional correlates as well as being a good indicator of stress is associated with future cardiovascular disease risk (Obrist et al., 1986; Pickering & Gerin, 1990). In fact, a large body of literature has found that cardiovascular reactivity is indicative of, and a proxy for, future cardiovascular health and disease (Black et al., 2017; Carroll et al., 2012; Chida & Steptoe, 2008). Several prospective studies have found that individuals who display exaggerated responses to acute psychological challenges are at a greater risk of future hypertension, atherosclerosis, and cardiovascular mortality (Carroll et al., 2012; Gerin et al., 2000; Kamarck et al., 1997).

The aim of this paper is to explore the possibility that inequality can act as a stressor in an experimental setting. Here, inequality is presented in a virtual society and as such is controlled and manipulated. In reality, societal inequality is pervasive in many aspects of our everyday lives. Some of the prevalences of heart disease in our society stem from how stress impacts along social gradients and inequalities (Chida & Steptoe, 2008; Heslop et al., 2001). The precise mechanisms behind this are still not fully known, although they have been thoroughly examined. In fact, although conventional risk factors (e.g., lifestyle, genetics, gender, hypertension) account for some of the risk in explaining the social inequality-coronary heart disease risk, they do not explain it all (Lynch et al., 2006; Ramsey et al., 2009). As such the psychological impact of perceived inequality may be important. As such, if inequality is in and of itself a stressor, or a stressor of different proportions for different income groups, this may be linked to the variable risk of cardiovascular disease across social gradients and income groups.

Much research has shown that the experiences of low-income individuals is very different to those of a higher income. Chronic stress associated with having a lower income has long been connected to poorer health outcomes (Baum et al., 2006). Baum et al. (2006) highlight how this stress can result from more frequent stressful life events, which are associated with being from a lower socioeconomic status (SES) or lower income. Ferraro and Shippee (2009) discuss how this accumulated stress compounds in later life and can increase the aging process, resulting in poor health outcomes, and these stressful life events have been demonstrated even in children as young as nine in a study by Bradshaw et al. (2020). In this study, which looked at the impact of parental incarceration, children of these parents were found to report more anxiety and report more life stressors. These children were also found to be of a SES compared with their cohorts of the same age who had not experienced parental incarceration. As such, this is an issue for individuals regardless of age and according to work by Ferrie et al. (2002) and Elovainio et al. (2011), using the Whitehall II study, it is a problem that is only growing.

Inequality is implicated in population health and is linked to health indicators such as increased mortality (Kawachi & Kennedy, 1997; Kawachi et al., 1997), decreased happiness (Oishi & Kesebir, 2015), and negative well-being (Schneider, 2012). Although there are many possible pathways that link inequality to health (Wilkinson & Pickett, 2017), in the social psychological literature, there is a particular emphasis on the way inequality enhances status competition and anxiety and lowers cohesion (Scheepers et al., 2009; Wilkinson & Pickett, 2010)—processes that all manifest in an enhanced stress response. Here, we focus on measuring this stress response by experimentally manipulating the level of inequality using a virtual society paradigm (Jetten et al., 2015), which randomly allocated participants to inequality conditions. We also explore how the effect of inequality is moderated by income group.

Even though they are both complex and connected, income and inequality are not synonymous and thus need to be considered as separate concepts. Wilkinson and Pickett (2010) acknowledge the similarity of these concepts when they examine the health implications of poverty and inequality. Poverty, which is related to an individual’s income group, explains some ill health, but it does not explain all of it. Research suggests that inequality explains an additional proportion of the variance in population health. To put it more broadly, income relates to individual material conditions and access to resources (Wilkinson & Pickett, 2010), whereas inequality relates to the wider, social conditions that make up the social context that an individual’s income group exists within (Subramanian & Kawachi, 2004). Therefore, although income delineates individuals access to social, cultural, and economic resources, income inequality determines the larger social context within which income groups experience these everyday conditions.

This is important because Wilkinson and Pickett (2010) have found that to improve health and well-being at a societal level, the focus needs to move away from individual material conditions. Rather, the negative effects of inequality on population health needs to be considered. This is particularly the case for outcomes such as cardiovascular health (Chida & Steptoe, 2008; Phillips et al., 2013) and increased mortality from cardiovascular disease (Kim et al., 2008).

Inequality, however, is a complex concept and is difficult to capture in its totality. Its effects can be examined in different ways. Wilkinson and Pickett’s (2010) seminal work, for example, compares countries that differ in the extent with the gap in income between the poorest and wealthiest individual (as assessed by the Gini coefficient) affects particular societal outcomes such as stress and health. This work has prompted others to study patterns of inequality, which can be characterized within countries as stable, decreasing, or increasing across time (Smeeding, 2000). Although we know that inequality can change within a society, as yet it is unclear what impact this has on stress. This study will add to this literature. Rather than comparing inequalities across societies, our focus is on the effects of different patterns of inequality, increasing, decreasing, or stable inequality. We use a virtual society to study the effects of these patterns for two different income groups; a poorer group versus a wealthier group. This allows us to examine the effect of changing inequality within a society for more and less affluent income groups.

Indeed, to examine only inequality would neglect the well-established impact income has on health. And so, although it is argued that inequality affects all of the population in a society, its effect appears to be contingent on income group membership. We know from prior work that lower income is negatively related to
health. Borders et al. (2007) found that lower income negatively impacted birth weight due to chronic maternal stress. Ell et al. (2007) found that lower income led to worse recovery for cancer patients. And overall, the research suggests that the health consequences of inequality are greatest for the poor (Allen et al., 2011) as inequality heightens the negative experiences associated with low SES (Pickett & Wilkinson, 2015). Ahern and Galea (2006) found that income groups and income inequality interacted to affect levels of depression, with low-income groups in particular reporting higher levels of depression in unequal neighborhoods. Thus, it is necessary to examine both inequality and income group to understand their potential as interacting stressors in everyday life.

1.1 The present study

Jetten et al. (2015) suggest that the effect of inequality is contingent on income group. Specifically, they found that the wealthy and less wealthy both fear inequality but for different reasons. Although we know that inequality in society can be typified as stable, increasing, or decreasing, little to no other research has sought to identify whether different degrees of income inequality are demonstrably stressful for different income groups. As such, this study aims to examine how inequality and income group affect cardiovascular stress responses, defined as changes in systolic blood pressure (SBP), diastolic blood pressure (DBP), and HR. Specifically, this paper hypothesizes that income and inequality will have main effects on stress responses. In addition, we also hypothesize that inequality will moderate income’s effect on our cardiovascular indicators SBP, DBP, and HR. The direction of these relationships is not hypothesized due to the contradictory nature of the research in this area.

The paradigm, created by Jetten et al. (2015), was originally used to investigate the impact of differing types of inequality and income group on opposition to immigration. Their study showed that, compared those with moderate wealth levels, opposition to immigration was higher in those with low wealth levels and those with high wealth levels. Building on this, their study also found that when inequality was increasing in their virtual society, all wealth groups had higher opposition to immigration. The authors also found that fear of future wealth mediated this relationship. This work highlights the complex nature of the relationship between income and inequality and how different factors may influence this. As well as this, the use of an experimental paradigm allows for some causal inferences to be made.

This paradigm has since been adapted and used in other work such as Sánchez-Rodríguez et al. (2019) in which only inequality was manipulated. This demonstrates that the paradigm can be used in different ways and in relation to many different factors. The fact that it allows for the operationalization/manipulation of both inequality and income, it provides the perfect basis for the current study. By manipulating them in a controlled lab setting, the present study adds to the existing literature by considering how both income and inequality impact on physiological indices of stress, something which to the best of our knowledge has not yet been explored.

2 METHOD

2.1 Design

The independent variables in the current study were inequality at three levels: increasing, decreasing and stable, and income group, at two levels: high and low. DirectRT was used to randomly allocate participants to inequality and income conditions. The dependent variables were SBP, DBP, and HR. These were measured at baseline and final purchase point. Final purchase point refers to the time point where participants completed the last of four purchasing tasks that are a central part of the paradigm. This point was chosen as participants at this point in the experiment had just made all their purchasing decisions. Participants advanced at varying paces dependent on their reading speed. As such CV indices at this point in the paradigm rather than a set time point meant that participants had equivalent information and experience of the virtual environment at this time point. Readings from the Finometer Pro used mean scores at both the baseline time point and final purchase point to facilitate comparability of participant BP and HR. Baseline levels were included in analysis as a control measure. Gallagher et al. (2018) highlight how including baseline measures as covariates controls for any variance that already exists in BP/HR before the tasks begins. BMI was also included as a covariate as research has shown this can be a confounding factor when looking at HR and BP (Staessen et al., 1988).

2.2 Participants

Participants were recruited via email and were all students from our local university. All participants were required to be more than 18. Participants were asked if they were taking any BP medication as this would render them unable to take part in the study. Given that prior research has demonstrated the confounding effects of alcohol, smoking, and caffeine on BP (Gallagher et al., 2018), no alcohol was to be ingested 12 hr prior to the study, and strenuous/vigorous exercise was to be avoided. No caffeine or nicotine could be ingested for 2 hr prior to taking part in the study. A breakdown of participant numbers in each income and inequality group can be seen in Table 1. A total of 102 participants took part in the current study. A manipulation check was included in the paradigm where participants were asked how much they agreed with the statements “my group are rich” and “my group are poor” on a scale of 1 to 7. If a participant failed the check by stating they strongly agreed or

| Table 1 Number of participants per group |
|-----------------------------------------|
|            | Increasing | Decreasing | Stable | Total |
| Low        | 16         | 15          | 18     | 49    |
| High       | 12         | 10          | 13     | 35    |
| Total      | 28         | 25          | 31     | 84    |
strongly disagreed to both statements, their data were excluded from analysis. Eighteen participants did not pass the manipulation check and because they cannot be assumed to have understood the manipulation, they were excluded from the analysis. Full data on 84 participants was available for analyses, with a baseline HR range of 53.27 to 125.03 (M = 82.50, SD = 14.12). 41 self-identified as women, 42 self-identified as men, and a single participant identified as nonbinary. The age of participants ranged from 18 to 59 years, with a mean age of 23 years (SD = 5.83). Height ranged from 152 to 197 cm, with a mean height of 170.91, SD = 9.36. Weight ranged from 45.60 to 123.20 with a mean weight of 73.72, SD = 15.84. BMI was calculated using weight and height. Mean BMI was 25.18, SD = 4.80. Sensitivity analysis using G*Power indicated that based on our sample size, an alpha value of .05 and 80% power indicated sensitivity to detect medium effects (f = 0.085).

2.3 | Apparatus

DirectRT (v2014) was used to present the virtual society paradigm. DirectRT is a software program that allows for the presentation of visual stimuli in the form of both images and text, which was needed for the paradigm used in this study. This program was also used for its user-friendly interface, which would make it straightforward for participants to navigate.

2.4 | Cardiovascular monitoring

A Finometer Pro (v2.10) was used to take beat to beat noninvasive cardiovascular responses: SBP, DBP, and HR. It is considered highly accurate due to the height correction system, which accounts for the distance from finger to heart, as well as the use of both a finger and wrist cuff. As such, it is considered a validated measure for cardiovascular reactivity by the British Hypertension Society protocol (McMahon et al., 2020, Schutte et al., 2004). It has also been shown to fit the criteria set forward by the Association for the Advancement of Medical Instrumentation as the standard deviation was under 8 mm Hg (Schutte et al., 2004).

Analyses were also carried out to examine any significant differences between income groups and inequality groups during baseline. This was to ensure that any differences between the groups could be attributed to the task rather than pre-existing differences in responses present at baseline.

2.5 | Procedure

Participants were welcomed into the lab by a researcher, where they were given information and consent forms. This study was approved by the appropriate ethics committee, and participants gave their informed consent before taking part in the study. This study is in accordance with the ethical standards laid down in the 1964 Declaration of Helsinki. Once consent was obtained, height, weight, and age of each participant were gathered. Participants were then seated at a laptop with DirectRT and allocated randomly to their condition. Once the Finometer was calibrated and baseline had elapsed (approximately 2 min), the researcher started the DirectRT program on the laptop, which explained the hypothetical society. Participants were instructed to follow the instructions and requests via DirectRT and were also assured that they could ask questions or stop at any time.

Within the paradigm, participants were told that they had moved to a virtual society, “Ballyboola”, and had to start a new life. They were informed of the wealth distribution in the new society. They were then told how much each of the five income groups earns in Ballyboolean dollars. This information was accompanied by a table with their breakdown. As per Jetten et al. (2015), to avoid extreme positions, participants were shown five income groups but only assigned to one of the two income groups. Participants were, therefore, led to believe that they were members of the second lowest income group in “Ballyboola”, a group hereafter referred to as low income, or the second highest income group in “Ballyboola”, the condition hereafter referred to as high income.

Both income groups were then shown the same information regarding the wealth history of “Ballyboolean” society. Participants were assigned to one of the three inequality conditions: increasing, decreasing, or stable. For each inequality condition, a brief text explanation was given as well as a graph to demonstrate the changes that had occurred in the last 20 years in “Ballyboola.” The wealth of the income group the participant was assigned to did not change over this time period, and this was reflected in the displayed graph. Replicating the original paradigm, participants were then asked to make four spending choices (Jetten et al., 2015). Based on photos of houses, phones, cars, and holidays, participants were asked to choose what they would purchase in their new life. There were five possible car, phone, housing, and holiday options (see Table 2). Three pictures of car, phone, holiday, and housing were offered to each of the five income groups. So, for each purchase made, 15 options were visible to all participants. Participants could only purchase items within the price range as per their income group membership. So, income group 2, for example, could see all 15 cars available to purchase but only those that were in the price bracket for income group 1 and 2 could be purchased. Income group 4, the high-income group, could see all the purchasing options and those in income group 5 were not available to them.

3 | RESULTS

3.1 | Approach to analysis

To explore the effect of inequality and income on the physiological-dependent variables, a multivariate analysis of covariance (MANCOVA) was conducted using SBP, DBP, and HR at final purchase point. As the literature has so strongly suggested that a
contingent relationship was also conducted to look at the possibility of different income groups moderating the potential effects of inequality on cardiovascular responses. Three moderation analyses using PROCESS macro, model 1, for SPSS, were conducted with 5,000 bootstrapping resamples to test this hypothesis for the three physiological variables, HR, DBP, and SBP, separately. Inequality group (1 = increasing, 2 = decreasing, 3 = stable) was entered as a predictor, and income group (1 = low income, 2 = high income) was entered as a moderator. To control for baseline SBP, DBP, and HR, each was included as a covariate in each respective analysis.

3.2 | Correlations and descriptive statistics

Correlations and descriptive statistics can be found in Tables 3 and 4.

3.3 | Income groups, inequality conditions, and cardiovascular reactivity

A one-way analysis of variance was conducted to examine if baseline HR differed between income groups. This revealed no significant difference between high- and low-income group HRs at baseline. The same was also true for inequality, with no significant differences in baseline HR between the three inequality conditions (increasing, decreasing, stable). A MANCOVA was conducted to examine the effect of inequality and income on all physiological measures using change scores. The test revealed no significant main effect for income, $F(3, 73) = 0.25, p = .864$, or inequality, $F(6, 148) = 1.14, p = .343$. There was also no significant interaction effect of income and inequality, $F(6, 148) = 2.04, p = .063$.

3.4 | Moderation analysis

Our moderation analysis revealed that the overall model predicting SBP during final purchase point was not significant $F(4, 79) = 1.20, p = .32$. The same was also true for DBP, $F(4, 79) = 0.81, p = .521$. Thus, there was no direct or indirect association between income, inequality, and either SBP or DBP.

The overall model predicting HR at final purchase point was significant, $R^2 = .94, F(7, 76) = 173.43, p < .001$. Using the PROCESS multivariate function, dummy codes were created for the three inequality conditions using increasing inequality as a reference category. This moderation analysis suggests that income and inequality interact to affect the HR. The indirect effect was significant for low-income group participants. Income group moderated the effects of inequality on HR at the final purchase point for stable inequality using increasing inequality as a reference category, $b = -4.67, SE = 1.91, p = .017, 95\% CI [-8.48, -0.85]$. Looking at the mean HR change for each of the three groups separately (see Table 5) indicates that in the low-income group those experiencing stable inequality had the highest HR in response to the purchasing task.

Inequality had a main effect on HR (decreasing with increasing as reference, $b = 5.91, SE = 2.92, p = .046, 95\% CI [1.11, 17.3])$ (stable with increasing as reference, $b = 8.37, SE = 2.87, p = .005, 95\% CI [2.65, 14.08]$). Income group did have a main effect on HR, $b = 2.16, SE = 1.34, p = .112, 95\% CI [-0.51, 4.83]$. These findings are qualified by the above interaction effects. There was no significant difference in the high-income group. Means in the decreasing inequality condition did not differ significantly by income group.

4 | DISCUSSION

This paper explores the interactive effect of inequality and income on physiological stress responses. We showed that in a hypothetical virtual society, inequality has an effect on physiological responses, which is moderated by income group. Effects of inequality on stress responses were conditional on income. Stable inequality caused physiological responses, characteristic of increased stress in our low-income group, when using increasing inequality as a reference group. This reflects previous epidemiological research that highlighted the negative effect of inequality on low-income groups (Bjorntskov et al., 2013; Mani et al., 2013; Ryan et al., 2018).

### Table 2: Criteria for photo selection

| Income group 1 | Income group 2 | Income group 3 | Income group 4 | Income group 5 |
|----------------|---------------|---------------|---------------|---------------|
| House          | Cramped bed set | Spacious studio apartment | Apartment with more than one room | Bungalow |
| Car            | €200–€499     | €500–€999     | €1,000–€1,999 | Up to €5,000 |
| Phone          | Small screen with buttons | Flip top | Small touch screen, unknown brands | Small touch screen, popular brand |
| Holiday        | Caravan in Ireland | Irish cottages | Self-catering apartments | Villa |
|                |               |               |               | 5 star + hotel |

### Table 3: Correlation table

|                | 1 | 2   | 3   | 4   |
|----------------|---|-----|-----|-----|
| 1. Income      | – | –   | –   | –   |
| 2. Inequality  | –0.007 | –   | –   | –   |
| 3. Baseline heart rate | 0.04 | –0.006 | –   | –   |
| 4. Heart rate at final purchase | 0.03 | 0.05 | 0.96*** | –   |

***p < .001.
These findings support prior research that suggests negative health effects are apparent in contexts where there is limited or no potential for economic growth (i.e., stagnation) (Paskov et al., 2013; Storper, 2000). Although increasing inequality is objectively more related to stagnation in economic growth (Wisman, 2013), subjective beliefs have been shown to be more important for stress (Solomon et al., 1987). Research by Wang et al. (2020) looked at this in relation to high-income group individuals and found evidence for the idea of a “having more wanting more” mentality. When thinking about this in relation to our study, it may be that for low-income individuals they are unable to foresee improvements in their current economic situation if they felt there was no potential for economic growth or that society was economically stagnant. That is, inequality remaining unchanged may have elicited a stress response due to feelings of not having enough combined with an economic situation that is not changing and, therefore, is not improving. As we did not ask individuals how much room for economic growth they believed their virtual society allowed them, we cannot say for certain this is what elicited this response.

Although research comparing inequality across countries was crucial in developing the understanding of the adverse impact of inequality on health, this work highlights that inequality is a complex and contingent on a variety of factors. Key factors would also appear to be whether inequality is rising, falling, or stagnant.

Even though the paradigm, created by Jetten et al. (2015), has been used in other research exploring other outcomes such as belief in an individualistic society (Sánchez-Rodríguez et al., 2019), this study is among the first to combine this manipulation with physiological data collection. As the study manipulates inequality, this allows for some inferences to begin to be made about how inequality itself may elicit physiological stress responses. This then lends itself to the suggestion that inequality itself can be a stressor for individuals directly and not just indirectly through other factors it influences such as status anxiety and feelings of competition.

The current study is not the first to link inequality to physiological stress. Prior work such as that by Scheepers et al. (2009) has examined physiological stress related to inequality and status. Our research is novel in that it focuses on income specifically, rather than a related concept that income may influence. As mentioned above, this allows for some inferences to be made about how income itself and its interaction with inequality is eliciting a stress response.

Both a limitation of the current study and an area of possible future research is examining the extent to which individuals identified with their assigned income group. Scheepers et al. (2009) argue that we need to account for the effect of identifying with a group when looking at inequality, which is something this paper did not examine but is certainly worth future attention. Equally, Gallagher et al. (2014) demonstrate that identification can ameliorate the impact of stress on physiological responses. Future research could usefully investigate the role of identification with groups as a

| TABLE 4 | Mean HR during the final purchase point |
|-----------------|-----------------|-----------------|-----------------|-----------------|
|                | Increasing       | Decreasing      | Stable          |                |
|                | M    | SD   | M    | SD   | M    | SD   |
| Low income     |      |      |      |      |      |      |
| SBP            | 128.76 | 10.77 | 128.15 | 10.43 | 130.71 | 15.80 |
| DBP            | 78.77  | 8.47  | 76.87  | 9.97  | 80.38  | 11.30 |
| HR             | 80.07  | 9.22  | 83.70  | 14.89 | 75.29  | 13.76 |
| High income    |      |      |      |      |      |      |
| SBP            | 124.19 | 13.36 | 127.98 | 14.43 | 129.27 | 19.28 |
| DBP            | 73.78  | 8.54  | 78.46  | 13.51 | 80.77  | 11.78 |
| HR             | 74.12  | 16.33 | 81.65  | 12.93 | 84.81  | 12.49 |

Note: For model.
HR final purchase $R^2 = 94.11, F(7, 76) = 173.43, p < .001.
$p < .05; **p < .01; ***p < .001.$

| TABLE 5 | Model exploring the moderating role of income in the relationship between inequality and heart rate (HR) |
|-----------------|-----------------|-----------------|-----------------|-----------------|
|                | CI 95% for b     | Lower          | Upper          | t    | r    | sr^2 |
| HR final purchase |      |      |      |      |      |      |
| Income         | 2.16 | -0.51 | 4.83 | 1.61 |      |      |
| Decreasing (ref. increasing) | 5.91 | 1 | 11.73 | 2.03 |      |      |
| Stable (ref. increasing) | 8.37 | 2.65 | 14.08 | 2.92 |      |      |
| Decreasing × income | -2.31 | -6.22 | 1.61 | -1.17 |      |      |
| Stable × income | -4.67 | -8.48 | -0.85 | -2.44 |      |      |
potential mediator of the impact of inequality on physiological stress response.

Although our results only demonstrated an effect on HR and not SBP or DBP, this is not uncommon. Trapp et al. (2014) state that the type of stress influences cardiovascular reactions, and it depends on the nature of stress whether a response is elicited in both HR and BP or only one. For example, Trapp et al. (2014) found that combined mental and physical stress caused a reaction in SBP. However, no such effect was found for mental stress alone. They also highlight the key role that psychological processes play in this. Thus, the type of stress can cause different cardiovascular reactions, and this can be due to psychological processes such as coping mechanisms. This reasoning is also supported by Bernstson and Cacioppo (2004), who also demonstrate that different types of stressors will elicit different responses in SBP, DBP, and HR. As such, it may be that the type of stress or coping mechanism being used in the current study is one that elicits an HR response rather than a BP response. Although this study cannot comment on the type of stress or coping mechanism individuals may have been engaging in as this was not measured, it is a consideration to keep in mind, and this may explain the fact that an effect on HR was found but no effect on BP. Similar to Gallagher et al. (2020), although we did not find an association for BP, the effect was in the same direction, possibly because our study was not sufficiently powered to demonstrate the impact on HR. Thus, it is not so much the case that HR and BP differed in the type of response but rather that they differed in the strength of their response. In addition, an effect on HR alone is still an important one to consider as HR has been connected to cardiovascular disease, cardiovascular events in general, and all-cause mortality (Black et al., 2017; Chen et al., 2019; Phillips et al., 2013). The above research also shows that a response in HR alone is not a shortcoming of the present study and thus is still worth considering.

The sample size for this study is modest. This could increase the chance of both type 1 and type 2 errors (Christley, 2010; Vadillo et al., 2016). This may account for our lack of findings for high-income individuals and for decreasing inequality, both of which had a smaller sample. As such, these results should be taken with some caution, and we are being conservative with inferences which can be drawn from this study. In saying that, these results still suggest the possibility of inequality as a type of stress and suggest further research with larger samples could extend and develop this useful paradigm.

Although the sample size of the current paper is small, to our knowledge, this is the first of its kind to combine income, inequality, and cardiovascular reactivity using this paradigm. As such, we believe it is still a worthwhile study with findings that are important to consider. In addition, although a student sample is used in this study, this is still a worthwhile sample to examine and gather findings with. Inequality and disadvantage impacts individuals of any age, and research has shown that early adversity influences future health (Sigfusdottir et al., 2017). Thus, examining cardiovascular reactivity, which is considered a proxy for future heart health and disease (Black et al., 2017; Carroll et al., 2012), is a worthwhile endeavor and should not be dismissed.

Going forward, it is also worth considering how the ecological validity of our findings could be increased beyond purchasing tasks in assigned inequality and income conditions. The current study used a paradigm in which both inequality and income are operationalized in a simple way that is not fully reflective of their multifaceted nature. Income and inequality are both methodologically complex concepts. Baum et al. (2006) suggest that SES is a key consideration when examining public health and that income is not a complete or fully appropriate replacement. Importantly, however, our work demonstrates that even when stripped back, inequality and income do appear to cause a physiological response. This is important, as these physiological responses have been shown to be indicative of detrimental cardiovascular health in later life.

5 | CONCLUSION

The current study explored how income together with inequality impacted on physiological stress responses. We showed that stable inequality when using increasing inequality as a reference group elicited the strongest stress responses for low-income group members in a virtual society. Although both income and inequality have been linked to health previously, our study is the first to show that stress may be the pathway linking these two factors. In addition, although the relationship is complex and contingent on the type of inequality, our study nonetheless highlights that inequality is a stressful context likely to have important health consequences.

CONFLICT OF INTEREST

The authors state that they have no competing interests.

ETHICS STATEMENT

Ethical approval for this study was granted by the University of Limerick’s Research Ethics Committee. Approval code: 2017_11_06_EHS.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are openly available on the Open Science Framework at https://doi.org/10.17605/OSF.IO/THNB7.

ORCID

Megan Ryan https://orcid.org/0000-0002-3621-2633
Orla T. Muldoon https://orcid.org/0000-0001-9082-2443
Stephen Gallagher https://orcid.org/0000-0002-5471-7774
Jolanda Jetten https://orcid.org/0000-0002-7588-5355

REFERENCES

Ahern, J., & Galea, S. (2006). Social context and depression after a disaster: The role of income inequality. Journal of Epidemiology
McMahon, G., Creaven, A. M., & Gallagher, S. (2020). Perceived social support mediates the association between attachment and cardiovascular reactivity in young adults. *Psychophysiology, 57*(3), e13496. https://doi.org/10.1111/psyp.13496

Obrist, P. A., Light, K. C., Sherwood, A., Allen, M. T., Langer, A. W., & Koepeke, J. P. (1986). Some working hypotheses on the significance of behaviorally evoked cardiovascular reactivity to pathophysiology. In T. H. Schmidt, T. M. Dembroski, & G. Blümchen (Eds.), *Biological and psychological factors in cardiovascular disease* (pp. 406–417). Springer. https://doi.org/10.1007/978-3-642-31234-0_25

Oishi, S., & Kesebir, S. (2015). Income inequality explains why economic growth does not always translate to an increase in happiness. *Psychological Science, 26*(10), 1630–1638. https://doi.org/10.1177/0956797615596713

Paskov, M., Gërçxhani, K., & van de Werfhorst, H. G. (2013). Income inequality and status anxiety. *Growing Inequality Impacts: The inner level: How more equal makes societies stronger*. Bloomsbury Press.

Pickering, T. G., & Gerin, W. (1990). Cardiovascular reactivity in the laboratory and the role of behavioral factors in hypertension: A critical review. *Annals of Behavioral Medicine, 12*(1), 3–16. https://doi.org/10.1207/s15324796abm1201_1

Pickett, K. E., & Wilkinson, R. G. (2015). Income inequality and health: A causal review. *Social Science & Medicine, 128*, 316–326. https://doi.org/10.1016/j.socscimed.2014.12.031

Ramsay, S. E., Morris, R. W., Whincup, P. H., Papacosta, O., Rumley, A., Lennon, L., Lowe, G., & Wannamethee, S. G. (2009). Socioeconomic inequalities in coronary heart disease risk in older age: Contribution of established and novel coronary risk factors. *Journal of Thrombosis and Haemostasis, 7*(11), 1779–1786. https://doi.org/10.1111/j.1538-7836.2009.03602.x

Ryan, D. A., Singh, M. R., Hentschke, E. A., & Bullock, H. E. (2018). “Minding the gap”: Social psychological insights for strengthening interclass relations and advancing economic justice. *Translational Issues in Psychological Science, 4*(2), 187–197. https://doi.org/10.1037/tps0000158

Sánchez-Rodríguez, Á., Willis, G. B., Jetten, J., & Rodríguez-Bailón, R. (2019). Economic inequality enhances inferences that the normative climate is individualistic and competitive. *European Journal of Social Psychology, 49*(6), 1114–1127. https://doi.org/10.1002/ejsp.2557

Scheepers, D., & Ellemers, N. (2018). Stress and the stability of social systems: A review of neurophysiological research. *European Review of Social Psychology, 29*(1), 340–376. https://doi.org/10.1080/10463283.2018.1543149

Scheepers, D., Ellemers, N., & Sintemaartensdijk, N. (2009). Suffering from the possibility of status loss: Physiological responses to social identity threat in high status groups. *European Journal of Social Psychology, 39*(6), 1075–1092. https://doi.org/10.1002/ejsp.609

Schneider, S. M. (2012). Income inequality and its consequences for life satisfaction: What role do social cognitions play? *Social Indicators Research, 106*(3), 419–438. https://doi.org/10.1007/s11205-011-9816-7

Schutte, A. E., Huisman, H. W., Van Rooyen, J. M., Malan, N. T., & Schutte, R. (2004). Validation of the Finometer device for measurement of blood pressure in black women. *Journal of Human Hypertension, 18*(2), 79–84. https://doi.org/10.1038/sj.jhh.1001639

Segerstrom, S. C., &Miller, G. E. (2004). Psychological stress and the human immune system: A meta-analytic study of 30 years of inquiry. *Psychological Bulletin, 130*(4), 601–630. https://doi.org/10.1037/003-2909.130.4.601

Sifgusdottir, I. D., Kristjansson, A. L., Thorlindsson, T., & Allegrante, J. P. (2017). Stress and adolescent well-being: The need for an interdisciplinary framework. *Health Promotion International, 32*(6), 1081–1090. https://doi.org/10.1093/heapro/daw038

Smeeding, T. M. (2000). *Changing income inequality in OECD countries: Updated results from the Luxembourg Income Study* (LIS Working Paper Series, No. 252). Luxembourg Income Study (LIS).

Solomon, Z., Mikulincer, M., & Hobfoll, S. E. (1987). Objective versus subjective measurement of stress and social support: Combat-related reactions. *Journal of Consulting and Clinical Psychology, 55*(4), 577–583. https://doi.org/10.1037/0022-006X.55.4.577

Staessen, J., Fagard, R., & Amery, A. (1998). The relationship between body weight and blood pressure. *Journal of Human Hypertension*, 2(4), 207–217.

Storper, M. (2000). Lived effects of the contemporary economy: Globalization, inequality, and consumer society. *Public Culture, 12*(2), 375–409. https://doi.org/10.1215/08992363-12-2-375

Subramaniam, S. V., & Kawachi, I. (2004). Income inequality and health: What have we learned so far? *Epidemiologic Reviews, 26*(1), 78–91. https://doi.org/10.1093/epirev/mxh003

Trapp, M., Trapp, E. M., Egger, J. W., Domej, W., Schillaci, G., Avian, A., Rohrer, P. M., Hörlesberger, N., Magometschnigg, D., Cervar-Zivkovic, M., Komervick, P., Velk, R., & Baumlmann, J. (2014). Impact of mental and physical stress on blood pressure and pulse pressure under normobaric versus hypoxic conditions. *PLoS One, 9*(5), e89005. https://doi.org/10.1371/journal.pone.0089005

Vadillo, M. A., Konstantinidis, E., & Shanks, D. R. (2016). Underpowered samples, false negatives, and unconscious learning. *Psychonomic Bulletin & Review, 23*(1), 87–102. https://doi.org/10.3758/s13423-015-0892-6

Wang, Z., Jetten, J., & Steffens, N. K. (2020). The more you have, the more you want? Higher social class predicts a greater desire for wealth and status. *European Journal of Social Psychology, 50*(2), 360–375. https://doi.org/10.1002/ejsp.2620

Wilkinson, R., & Pickett, K. (2010). *The spirit level: Why greater equality makes societies stronger*. Bloomsbury Press.

Wilkinson, R. G., & Pickett, K. E. (2017). The enemy between us: The psychological and social costs of inequality. *European Journal of Social Psychology, 47*(1), 11–24. https://doi.org/10.1002/ejsp.2275

Wilkinson, R. G., & Pickett, K. E. (2018). The inner level: How more equal societies reduce stress, restore sanity and improve everyone’s well-being. Penguin Press.

Wisman, J. D. (2013). Wage stagnation, rising inequality and the financial crisis of 2008. *Cambridge Journal of Economics, 37*(4), 921–945. https://doi.org/10.1093/cje/bes085

How to cite this article: Ryan, M., Muldoon, O. T., Gallagher, S., & Jetten, J. (2021). Physiological stress responses to inequality across income groups in a virtual society. *Journal of Applied Social Psychology, 00*, 1–11. https://doi.org/10.1111/jasp.12807
APPENDIX A
Introduction to direct RT program
In this study you will become a citizen of Ballyboola. You will start a new life there and become a member of Ballyboolean society. Ballyboola is just like any other society. In terms of wealth distribution, income levels take the shape of the following picture.

|   |   |
|---|---|
| 5 | • > 250,000 BD |
| 4 | • 125,000 - 250,000 BD |
| 3 | • 75,000 - 125,000 BD |
| 2 | • 25,000 - 75,000 BD |
| 1 | • < 25,000 BD |

APPENDIX B
Table with relevant income group highlighted (high-income group)

|   |   |
|---|---|
| 5 | • > 250,000 BD |
| 4 | • 125,000 - 250,000 BD |
| 3 | • 75,000 - 125,000 BD |
| 2 | • 25,000 - 75,000 BD |
| 1 | • < 25,000 BD |

APPENDIX C
Table with relevant income group highlighted (low-income group)

|   |   |
|---|---|
| 5 | • > 250,000 BD |
| 4 | • 125,000 - 250,000 BD |
| 3 | • 75,000 - 125,000 BD |
| 2 | • 25,000 - 75,000 BD |
| 1 | • < 25,000 BD |

APPENDIX D
Text and graph for increasing inequality group
In the past 20 years, Ballyboola was affected by a change in economy. As a result, the wealth gap in Ballyboolean society increased. Status differences increased: the poor became poorer. The moderately wealthy earned about the same. The rich gained more wealth and became richer. Please keep this in mind.

APPENDIX E
Text and graph for decreasing inequality
In the past 20 years, Ballyboola was affected by a change in economy. As a result, the wealth gap in Ballyboolean society decreased. Status differences decreased: the poor became richer. The moderately wealthy earned about the same. The rich lost some of the wealth and became poorer. Please keep this in mind.

APPENDIX F
Text for stable inequality
In the past 20 years, Ballyboola was not affected by a change in economy. As a result, the wealth gap in Ballyboolean society has remained the same. Status differences have not changed: the poor are still poor. The moderately wealthy earned about the same. The rich remain rich. Please keep this in mind.

APPENDIX G
Explanation of purchasing task
To begin your new life in Ballyboola, the daily essentials must be purchased. The following questions will ask you to select items that you
require. However, only items that you can afford are able to be selected. This is governed by your group’s annual income.

APPENDIX H
House purchase information
Next, you will see a number of houses with corresponding letters.
Important: You can only choose between those houses that your income group can afford. The items are labelled by income group, so you know what you can afford. For example, if you are in income group 3, you can afford houses A to I but not houses J to O. Please press the corresponding letter of the house you wish to purchase.

APPENDIX J
Phone purchase information
Next, you will see a number of phones with corresponding letters.
Important: You can only choose between those phones that your income group can afford. The items are labelled by income group, so you know what you can afford. For example, if you are in income group 3, you can afford phones A to I but not phones J to O. Please press the corresponding letter of the phone you wish to purchase.

APPENDIX I
Car purchase information
Next, you will see a number of cars with corresponding letters.
Important: You can only choose between those cars that your income group can afford. The items are labelled by income group, so you know what you can afford. For example, if you are in income group 3, you can afford cars A to I but not cars J to O. Please press the corresponding letter of the car you wish to purchase.

APPENDIX K
Holiday purchase information
Next, you will see a number of holidays with corresponding letters.
Important: You can only choose between those holidays that your income group can afford. The items are labelled by income group, so you know what you can afford. For example, if you are in income group 3, you can afford holidays A to I but not houses J to O. Please press the corresponding letter of the holiday you wish to purchase.