Lista de Autores (en orden):

- Ismael Palacios-García^{1,#}
- Nicolas Duarte^{1,2,#}
- Marie Geraldine Herrmann-Lunecke³
- Aitana Grasso-Cladera^{1,4}
- Francisco J. Parada^{1,*}

Lista de Afiliaciones:

- ¹ Laboratorio de Neurociencia Cognitiva y Social, Facultad de Psicología, Universidad Diego Portales. Santiago, Chile
- ² Programa de Magíster en Neurociencia Social, Facultad de Psicología, Universidad Diego Portales. Santiago, Chile
- ³ Escuela de Arquitectura, Facultad de Arquitectura, Arte y Diseño, Universidad Diego Portales, Santiago, Chile
- ⁴ Programa de Pregrado en Psicología, Facultad de Psicología, Universidad Diego Portales. Santiago, Chile

Autor para correspondencia:

Francisco J. Parada, Ph.D.

Laboratorio de Neurociencia Cognitiva y Social, Facultad de Psicología, Universidad Diego Portales.

Vergara 275, Santiago, Chile

Teléfono: +56 22 676 2578

Correo electrónico: francisco.parada@udp.cl

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English title:

Environmental noise is differently associated with negative and positive urban experience: an exploratory first-person pedestrian mobile study in Santiago de Chile

Ismael Palacios-García^{1,#}, Nicolas Luarte^{1,2,#}, Marie Geraldine Hermann-Lunecke³, Aitana Grasso-Cladera^{1,4} & Francisco J. Parada^{1,*}

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¹ Laboratorio de Neurociencia Cognitiva y Social, Facultad de Psicología, Universidad Diego Portales, Santiago, Chile

² Programa de Magíster en Neurociencia Social, Facultad de Psicología, Universidad Diego Portales, Santiago, Chile

³ Escuela de Arquitectura, Facultad de Arquitectura, Arte y Diseño, Universidad Diego Portales, Santiago, Chile

⁴ Programa de Pregrado en Psicología, Facultad de Psicología, Universidad Diego Portales, Santiago, Chile

Both authors contributed equally

*Corresponding author:

Francisco J. Parada, Ph.D.

Laboratorio de Neurociencia Cognitiva y Social, Facultad de Psicología, Universidad Diego Portales, Vergara 275, Postal code: 8370076, Santiago, Chile

E-mail: francisco.parada@udp.cl

Phone: +56 22 676 2578

65 **Abstract** (174 words)

66 Urban environments are increasing worldwide, providing access to public facilities. Nevertheless,
67 specific city features such as environmental noise have been related to health detriments. Deleterious effects
68 of noise in health might depend on socioeconomic and demographic factors. The present mixed-method
69 exploratory study examines the relationship between first-person experience while walking through
70 neighborhoods in Santiago, Chile. Geo-referenced mobile eye-tracking measured first-person audio-visual
71 perceptual experience while interviewed. Logistic regression was used to study the relationship between
72 environmental noise, socioeconomic status, and specific ‘positive’ and ‘negative’ self-reported experiences
73 during walking.

74 Our results suggest that reporting negative experiences depends on environmental noise levels for
75 higher and middle-income neighborhoods. However, in lower-income neighborhoods, higher
76 environmental noise was associated with positive experiences, while lower noise was reported as negative.
77 We interpret these results considering that access to public facilities (e.g. supermarkets, banks) is usually
78 concentrated along main, noisy streets and, in lower-income neighborhoods, this meant benefits of
79 urbanicity (i.e. access to services and facilities, green areas). Furthermore, our results suggest an impact of
80 urban planning and development on socio-economic inequality.

81 **Introduction**

82 Cities are the main environment for most human beings and the global tendency for urbanization
83 is still increasing. The 2018 Revision of the World Urbanization Prospects, published by the United Nations
84 (UN) Population Division (United Nations, Department of Economic and Social Affairs, Population
85 Division, 2019), reports that 55% of the world's human population lives in urban areas. Moreover, an
86 increment of up to 68% is expected by 2050. In Latin America particularly, the actual number is much
87 higher reaching 80%, with two cities classified as megacities, Sao Paulo and Mexico City (United Nations,
88 Department of Economic and Social Affairs, Population Division, 2019). There is no doubt that cities offer
89 a huge variety of facilities for modern life: from hospitals to restaurants to public transportation means.
90 Furthermore, cities also cover basic human needs like drinking water and electricity. However, for many
91 different reasons, urban lifestyle has been related to mental health problems, such as schizophrenia
92 (Gruebner et al., 2017) and diverse psychological distress (Gong, Palmer, Gallacher, Marsden, & Fone,
93 2016). Specific city features related to the etiology of stress include neighborhood quality, the amount of
94 greenspace, industrial activity, and traffic volume (Gong et al., 2016). Hence, evidence supports the UN's
95 call for sustainable urban planning and public services worldwide (United Nations, Department of
96 Economic and Social Affairs, Population Division, 2019).

97 A relevant and measurable stressor emerging from cities is environmental noise or sonic pollution
98 (Pedersen, 2015). The World Health Organization (WHO) states that noise harms human health, affecting
99 work, school, and even leisure activities, causing psychological effects, reduced performance and changes
100 in social behavior (Organization & Others, 2011; Schwela, 2001). Thereby, environmental noise has been
101 considered one of the major public health problems (Geravandi, Takdastan, Zallaghi, & Niri, 2015;
102 Passchier-Vermeer & Passchier, 2000), the obvious one is hearing loss (Kryter, 1994; Nandi & Dhatrik,
103 2008). However, noise pollution has less-obvious system-wide effects including sleep disturbances,
104 increased nor-adrenaline and cortisol levels, perceived stress augmentation, and higher cardiovascular risk,
105 among others (Barbaresco et al., 2019; Münzel et al., 2018; Stansfeld & Matheson, 2003; Tonne et al.,

2016). Altogether, the effects of long term traffic noise exposure are reflected in increased levels of mortality by conditions like myocardial infarction along with type II diabetes (Barceló et al., 2016). In addition to health issues, it has been shown that higher noise levels induce cognitive disruptions over attention and memory in both adults (Zeydabadi et al., 2019) and children (Foraster et al., 2019). Interestingly, pregnant mothers exposed to noise leads to postnatal increase of anxiety and cortisol, impaired spatial memory and affected hippocampal plasticity in both mother and child (Barzegar, Sajjadi, Talaei, Hamidi, & Salami, 2015). Hence, evidence suggests that noise impacts health and cognition through activation of the stress system.

Stress is highly associated with urban environments. Even though neurophysiological mechanisms are yet unknown, evidence suggests that socio-demographic factors mediate as risk and protection variables (El-Gilany, Amr, & Hammad, 2008; Klein & Forehand, 2000; Lederbogen et al., 2011; Lindencrona, Ekblad, & Hauff, 2008; Reynolds, O’Koon, Papademetriou, Szczygiel, & Grant, 2001). Hence, the effects of noise -as a health risk factor- might be modulated by socioeconomic and topographic factors. Factors such as crowding (i.e. large amount of people or cars in the streets) have been associated with decreased psychological health (Galea, Ahern, Rudenstine, Wallace, & Vlahov, 2005); (Hotwani & Tripathi, 2017); (Matheson et al., 2006). However, the effect of socioeconomic and topographic factors might be highly context-dependent. For example, being surrounded by other people in a large crowd can be a protective factor in the context of social gatherings (Fischer et al., 2014; Páez, Rimé, Basabe, Włodarczyk, & Zumeta, 2015). In contrast, overcrowding is also a long-known risk factor for many species, from rodents to human and non-human primates (Calhoun, 1950; Hall, 1966). Furthermore, in humans, heart rate, blood pressure, salivary cortisol levels, and activity in emotion and stress-related brain structures are all modulated by urban living (Lederbogen et al., 2011). Within urban populations, there are differences in stress levels considering socioeconomic, sociodemographic and topographical factors (Matheson et al., 2006). Hence, urbanicity alone is not a direct predictor of environmental noise as a health risk factor. Factors such as socioeconomic, regional, ethnic, or even specific neighborhood qualities of the built environment are directly related to a

country's social equality (Ravallion, 2014). Addressing these differences is a necessary challenge for the field of psychology and the cognitive sciences (Parada & Rossi, 2018).

Chile, in particular, leads the ranking of most unequal countries in the World and of the Organisation for Economic Co-operation and Development (OECD). Even though Chile has an economy in expansion -sharing similar growth rates as developed countries like Finland and Germany- inequality is a widespread phenomenon. Its effects are far-reaching and can be seen from education (Otero, Carranza, & Contreras, 2017), health (Rocha et al., 2013) through social behaviors (e.g. domestic violence, Kim, Grogan-Kaylor, Han, Maurizi, & Delva, 2013). Recently, inequality has led to massive protests with society-wide implications (e.g. Rodríguez Mega, 2019). For example, stressors like transport crowding have greater effects on lower-income people in contrast to higher-income ones (Ureta, 2007).

Even though environmental noise levels in Santiago de Chile have already been assessed (Suárez & Barros, 2014), the impact of inequality or socioeconomic/demographic factors in stress and mental health remains unknown. The present work explores the relationship between the first-person experience of the urban environment of pedestrians in the presence of environmental noise in six different pericentral neighborhoods of Santiago de Chile with 3 different socioeconomic distributions. In order to do this, we used geo-referenced mobile eye-tracking to measure the first-person audio-visual perceptual experience during natural walking behavior.

Materials and Methods

Neighborhood and Participant Selection

Neighborhoods were representative of three socioeconomic levels (low, middle and high), and located in pericentral areas next to subway stations (low=San Alberto Hurtado, Ecuador; middle=Santa Ana, Cumming; high= Colón, Bilbao). Each socioeconomic level was represented by two neighborhoods. Six people (three females, three males), residents of each neighborhood (N=36, Mean age= 38) were

recruited through public announcements placed in stores and streets to complete a predetermined 600-meter guided walk (in-situ interview) from a pre-established starting point towards the closest subway station. Potential participants had to be residents and live within a radius of two kilometers from the walk's starting point for at least one year. All participants were native Spanish speakers, had normal or corrected vision, and reported no psychiatric conditions. Experimental protocol was approved by Universidad Diego Portales Institutional Review Board following requirements established by the Comisión Nacional de Investigación Científica y Tecnológica (CONICYT, Chile).

Data acquisition procedures

After each subject gave written consent equipment setup proceeded. Data acquisition equipment consisted of (1) a small backpack containing the recording computer, (2) Tobii glasses 2 eye-tracking system, (3) a global positioning system (GPS) camera, and (4) ENOBIO 8 electroencephalograph (EEG). EEG impedances were adjusted and the eye-tracker was calibrated following standardized manufacturer's instructions. Eye-tracker calibration consists of staring at a calibration card held in front of the participant until the calibration was successful. The present work uses data that are not calibration-dependent. After a successful equipment setup, synchronized data recording started (Figure 1).

During each guided walk, participants were instructed to make a continuous report of their experience, describing which specific aspects of the street affected their mood (Dubé, Schinke, Strasser, & Lightfoot, 2014). The report could be associated with very particular features of the streets like the sidewalk width (i.e. "The sidewalk is too narrow and makes me feel unsafe") but also with more complex feelings related with the environment (i.e. "That church reminds me of my childhood and makes me feel happy"). In order to better inquire in a participant's experience, the in-situ interview was accompanied, in some cases with open questions from the experimenter. It is worth mentioning that these questions were not intended to drive the participant's report but to trigger descriptions during silent moments.

(Insert Figure 1)

Even though our experimental setup recorded many data streams, the present work focuses on environmental noise. Hence, processing and analysis procedures are described for the data streams that were used to answer our research question.

Data processing and analysis

In-situ interview

The complete recorded interview was transcribed and analyzed by a researcher in order to identify geo-referenced periods where participants reported positive and/or negative experiences using the Atlas.ti software (Frieze, 2019).

Environmental noise

Environmental sounds were recorded during each guided walk using the built-in microphone of the Tobii glasses 2 eye-tracker system. This microphone was used given its position, close to each participants' ears, effectively measuring a "first-person" environmental sound. Audio files recorded by Tobii glasses 2 were extracted using custom Matlab functions.

Data integration

Using the associated GPS data, we obtained the precise geolocation of each participant as the in-situ interview took place. Thus, from the first-person experiential reports obtained from the in-situ interviews, a list of different 'positive' or 'negative' geo-referenced temporal events were obtained using custom MATLAB functions (The MathWorks, Natick, MA). Each reported experience had an associated positive/negative valence, temporal duration, and geographic position. Furthermore, audio files extracted from the eye-tracker microphones, were parsed using each 'positive' and 'negative' geo-referenced event. Once the audio files were integrated into the geolocation and in-situ interview data, these were parsed into correspondent 'positive' and 'negative' events. Audio waves corresponding to every event was averaged to obtain a single value for each event. This procedure was performed for all events obtained for all neighborhoods. Finally, the single obtained value was used in order to normalize all audio files (-1/1) with a resolution of 44000 Hz. These normalized, georeferenced environmental noise events were used for statistical analysis. The procedure is described in the following section.

Data Analysis

A nested logistic regression model was implemented considering environmental noise levels and socioeconomic factors. Level 1 was a single predictor model, using noise levels as covariate and experience valence as dependent variable. Model 2 incorporated socioeconomic factors to the noise predictor. This was done in order to test the hypothesis that noise levels negatively affect participants' report of

positive/negative experiences and that this effect is dependent on the interaction of the socioeconomic level. The logistic regression analysis was carried out in R programming language (R Core Team, 2017). The essence of this model is that it transforms the binary dependent variable into a logit (equation 1), which corresponds to the natural logarithm of the odds. This is the logarithmic probability of the binary variable having the outcome of interest against the probability of not having such value, given a specific value of the independent variable (equation 2). Finally, intercept α and coefficients βs are estimated using maximum likelihood method. This fitted model allows for interpreting the behavior of the log odds of the dependent variable (this can be turned into simple probabilities) given a 1 unit increase in the independent variable. For a more detailed overview of logistic regression models and issues concerning validation and reporting see (Peng, Lee, & Ingersoll, 2002).

$$\text{Equation 1: } \text{logit}(\text{dependent variable}) = \text{natural log(odds)} = \ln\left(\frac{\pi}{1-\pi}\right) = \alpha + \beta_1\chi_1 + \beta_2\chi_2 +$$

...

$$\text{Equation 2: } \pi = \text{Pr}(\text{dependent variable} = \text{outcome of interest} \mid \chi = x)$$

Results

First-person environmental noise from the residential areas towards main streets increases

Residents from different neighborhoods and socio-economic status walked from a residential area near their homes to the closest subway station located on a main street, while an in-situ interview was carried out. Qualitatively, at the beginning of the walk, environmental noise is low in the residential area. It increases as the walker approaches the main street, where the subway station is located. This can be seen throughout neighborhoods since subway stations are located on main roads, with higher flows of motorized traffic (Figure 2a). This observation was particularly evident for high-income neighborhoods and less marked for lower- and middle-income ones. Increased environmental noise in all neighborhoods

was accompanied by an increased number of self-reported bad experiences, mostly grouped near the end of the defined route towards the main streets and subway station. These results suggest that as an overall effect, the amount of positive self-reported experiences decreased as the participants' approached the main streets, where higher noise levels were present (Figure 2b).

(Insert Figure 2)

Environmental noise levels are associated with valence of reported experience

Logistic regression results suggest that increased environmental noise increases the likelihood of reporting a negative experience during the urban in-situ interview. In contrast, reduced environmental noise predicts an increase in the likelihood of reporting a positive experience (Figure 2, 3, and Table 1, Estimate = -26,215). The first model was statistically significant (Table 1, Wald $\chi^2=21.921$, $p<.001$).

242 Considering the performance metrics, the percent rate of correct classification for positive self-reported
243 events was 59% (Table 1, Sensitivity = 0.59) and 61% for negative self-reported events (Table 1, Specificity
244 = 0.61). As a whole, the model had 60% accuracy (Table 1, Accuracy = 0.6). In order to account for the
245 imbalance of our data regarding ‘positive’ and ‘negative’ self-reported experiences, Cohen’s kappa was
246 calculated. Results suggest a higher than expected (if only data distribution is considered) agreement
247 between ground truth and our model (Table 1, $K = 0.21$).

Table 1

Model 1: Noise prediction of Mood

	Estimate	Standard Error	Wald Chi-Squared Value	p-value (dF)
(Intercept)	0.232	0.137	2.852	0.091 (1)
Noise	-26.215	5.599	21.921	<0.001 (1)

Performance Metrics

Threshold	0.56
Sensitivity	0.59
Specificity	0.61
Accuracy	0.60

Figure. 1:

K	0.20
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(Insert Figure 3)

Valence of reported experience depends on socio-economic status

The second model added socio-economic status as predictor. This variable was statistically significant (likelihood-ratio test, $\chi^2(df = 4) = 73.94$, $p < 0.001$). Results show that inhabitants of high-income neighborhoods have a higher probability of reporting a positive experience while walking their neighborhood (probability = 0.54, $p > 0.05$). In contrast, inhabitants walking through both low- and

middle-income neighborhood presented lower probability of reporting positive experiences (low-income probability = 0.22, $p < 0.001$; middle-income probability = 0.46, $p > 0.05$).

Furthermore, environmental noise levels were associated with an increased likelihood of reporting a negative experience in high (Figure 4a. Table 2, Estimate = -53.9, Wald $\chi^2(1)=16.896$, $p<.001$) and middle-income neighborhood (Figure 4b. Table 2, Estimate = -44.9, Wald $\chi^2(1)=14.975$, $p<.001$). In contrast, in low-income neighborhoods, environmental noise was associated with an increased likelihood of reporting a positive experience instead of negative (Figure 4c. Table 2, Estimate = 22, Wald $\chi^2(1)=7.168$, $p<.001$). These results support our hypothesis that variables other than noise levels are also relevant when experiencing urbanicity. This second model predicted 70% of the reported positive events and 57% of the negative ones (Cohen's kappa coefficient = 26%; Table 2). Altogether, the more complex model (i.e. environmental noise levels + socio-economic status) better predicts perceived urban experience.

(Insert Figure 4)

probability of experiencing a positive mood also increases. Additionally, is to be noted that in low-income neighborhoods the highest probability of experiencing a positive mood is significantly lower than both middle- and high-income neighborhoods

268

Table 2
Model II: Noise prediction of Mood by Socioeconomic Status

	Estimate	Standard Error	Wald Chi-Squared Value	p-value (dF)	Likelihood-ratio test
High	-53.9	13.1	16.896	<0.001 (1)	p < 0.001
Middle	-44.9	11.6	14.975	<0.001 (1)	
Low	22	8.2	7.168	0.007(1)	

Performance Metrics

Threshold	0.57
Sensitivity	0.596
Specificity	0.6972
Accuracy	0.638

K

0.28max

Discussion

In this exploratory study, we measured first-person environmental noise levels recorded in a first-person fashion. Furthermore, we estimated the valence of personal experience by using an in-situ interview during natural walking behavior in different neighborhoods of Santiago de Chile. Our results show that increasing levels of environmental noise are associated with a higher likelihood of reporting negative experiences in neighborhoods of high and middle socioeconomic status (Figure 4b-c). In contrast, in low-income neighborhoods, environmental noise was associated with an increased likelihood of reporting a positive urban experience (Figure 4a). It is important to remark that lower socioeconomic status was associated with a decreased likelihood of reporting positive experiences regardless of noise levels, whereas both high- and middle-income neighborhoods were more likely to report positive urban experiences in general (Figure 2b). Therefore, the effects of noise over experiential report valence were different in high- and low-income neighborhoods. We interpret these results as a product of income inequality in Chile and the socio-geographical/environmental segregation/inequality it produces. Hence, in order to further interpret our results, we have to take into account the qualitative characteristics of the urban environment provided by Santiago de Chile.

Increased environmental noise is associated with the benefits of urbanicity for lower-income Santiago neighborhoods

In Santiago de Chile, increased environmental noise in lower-income neighborhoods is related to more accessibility to urban infrastructure such as hospitals, banks, supermarkets, retail and overall better urban benefits. In the six studied neighborhoods, areas near the subway station presented higher vehicular flows along with urban infrastructure/commerce. It has been shown that rural communities are more likely to develop depressive symptoms than urban ones. These effects are attributable to isolation,

poor health care and quality of life that those communities are exposed (Probst et al., 2006). Additionally, inhabitants of poorer built environments are also associated with greater likelihood of depression, diabetes, and other mental health issues (Belle & Doucet, 2003; Mendenhall, Kohrt, Norris, Ndeti, & Prabhakaran, 2017). Therefore, it is probable that areas with increased noise in lower-income neighborhoods were related to higher quality of built environment/urbanicity features and/or better access to basic needs.

Furthermore, increased environmental noise in lower-income neighborhoods could be associated with the feeling of safety. Hence “noisy” main streets with commerce and many pedestrians could be perceived as safer places due to passive surveillance.

Finally, increased environmental noise levels in lower-income neighborhoods could be associated with cleaner/appropriately sized sidewalks and more greenspace. Sidewalks close to the subway stations and along the main streets tend to be wider and better maintained. It has been shown that contact with greenspace/parks in deprived communities is related to a decrease in stress markers and increase in wellbeing (Ward Thompson et al., 2012). Interestingly, the positive effects of those greenspace areas are dependent on their existence within walking distance from the participant’s home (Bertram & Rehdanz, 2015; Wood, Hooper, Foster, & Bull, 2017).

In contrast to lower-income neighborhoods, Santiago’s higher- and middle-income neighborhoods are characterized by having large greenspace areas and cleaner/appropriately sized sidewalks in the residential areas where noise is relatively low. Our results show that in all six neighborhoods as the walking route comes to an end, participants get closer to the subway station where environmental noise increases (Figure 1). However, in high-/middle-income neighborhoods, environmental noise is accompanied by reduced greenspace and crowded sidewalks. Given the socio-economic differences, these factors are not associated with any benefits of urbanicity. Hence, inhabitants of these higher- and middle-income neighborhoods reported more negative urban experiences in these

urban contexts. Considering our results, we can infer that built environment and urban planning decision differences based on socioeconomic status directly impact the phenomenological meaning of environmental noise, explaining the difference in self-reported urban experience. This is, unequal urban planning creates socio-geographical/environmental segregation influencing inhabitants' urban experience.

There are some differences between the likelihood of reporting positive or negative urban experiences during in-situ interviews in different neighborhoods (Figure 1 and 4). However, self-reported experience is a multi-level outcome that might depend, as discussed, not only on noise levels but also on other environmental features, such as the presence and quality of urban infrastructure, appropriately sized sidewalks, maintenance of public spaces, green areas and accessibility. Furthermore, the relationship between urban experience/urban planning has direct and indirect impact on inhabitants' health and behavior. In the next section we will briefly talk about these possible effects.

Possible impact of socio-geographic/environmental inequality on health and behavior

It is important to discuss the impact of environmental noise on health, since it is a risk factor for several issues (Basner et al., 2014; Stansfeld & Matheson, 2003). It has been shown that noise exposure induces increased blood pressure in preschool children (Belojevic, Jakovljevic, Stojanov, Paunovic, & Ilic, 2008), leading to increased risk of cardiovascular disease in adulthood (Juonala et al., 2015). Additionally, in animal models, noise exposure induces increased levels of glycogen and triglyceride in the liver, affecting glucose metabolism via changes in microbiota-defendant inflammatory response and promoting diabetes like phenotypes (Cui, Gai, She, Wang, & Xi, 2016). Accordingly, traffic noise in Barcelona city was related with the mortality levels of myocardial infarction together with type II diabetes mellitus (Barceló et al., 2016). This evidence is relevant since the prevalence of both cardiovascular disease and diabetes are in Chile are among the highest in the region. It was recently shown that 10% of Chilean population have Diabetes Mellitus 2 (Bertoglia et al., 2017; Sapunar Z., 2016). Among other factors, socioeconomic

status emerge as one of the main variable explaining the prevalence of those conditions. Poverty explains the incidence of stroke mortality on one side, while diabetes is higher in children growing up in more developed socioeconomic backgrounds (Lavados et al., 2011; Torres-Avilés, Carrasco, Icaza, & Pérez-Bravo, 2010). Our results showed that sensitivity to environmental noise depends on socioeconomic status (Figure 4). Even though our project did not include epidemiological data, future research should investigate a possible relationship between environmental noise, socioeconomic status and disease incidence. Thus, including demographic and epidemiological data would increase our understanding of how environmental stressors may influence the incidence of chronic diseases.

Finally, it has been shown that exposure to noise has been related with cognitive impairment including effects over attention, verbal and nonverbal learning, anxiety and memory (Tzivian et al., 2015; Zeydabadi et al., 2019). It is possible that effects of noise over cognitive processes were mediated by the activation of two neural systems, i) stress-mediated hippocampal function (Barzegar et al., 2015) and ii) stress-defendant hypothalamic-pituitary-adrenal axis (Jafari, Mehla, Kolb, & Mohajerani, 2017). Therefore, growing evidence indicates environmental noise levels effectively activate stress responses, thus affecting cognition, behavior, and mental health (Barbaresco et al., 2019; Evans, Lercher, Meis, Ising, & Kofler, 2001). It is probable that this relationship is not simple, acting over long periods of time and, as seen in our data, affecting populations differently (Clark & Paunovic, 2018). Longitudinal studies including larger populations are needed in order to further understand the impact of socio-geographic/environmental variables in health.

Methodological considerations

The measure used in the current study was of environmental sound intensity, which was assumed to generate changes in subjective state of each participant. However, this assumption can present at least two problems: (1) It is known that while sound intensity is directly proportional to loudness (subjective perception of sound pressure), the function relating both, is probably not linear and could be better

approximated by a power function (Stevens, 1957). Hence, the effect of environmental sound intensity in subjective state is mediated by some function relating noise to loudness. (2) This measure assumes that subjective states will be affected by direct exposure to sound intensity. Such exposure has to be further mediated by, at least, ear physical properties. Therefore, normalizing sound intensity, does not control for these very particular circumstances. These considerations could be addressed by using a loudness estimation function (Maisonneuve, Stevens, Niessen, & Steels, 2009; Nilsson, 2007), which takes into consideration the composition of sound. However, in order to compare participants, a continuous qualitative measure of loudness would still be needed if the effect of direct exposure to noise is to be taken into account.

Author Contributions

IPG, NL, GH, and FJP conceptualized the present work. IPG, NL, and FJP designed and implemented data acquisition procedures. IPG, NL, and FJP analyzed the data. IPG, NL, AGC, and FJP wrote and edited the current manuscript version for publication.

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Conflict of Interest Statement

The authors declare that the present work was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Captions

Figure 1. Data acquisition. Participants arrived at the starting point and gave informed consent and filled up an initial interview. Equipment was mounted, calibrated, and synched. Finally, participants walked following the established route, while the in-situ interview was executed, and data was collected. Research team members agree to appear in the figure. Participants' faces has been anonymized.

Figure 2. Noise and proportion of events. Both amounts of environmental noise and proportion of positive-to-negative events were averaged and split into 5 spatial bins representing percentage of the 600 m distance. Points in the left of each graph represent data at the beginning of each walk. Red = Low-income neighborhoods, Blue = Middle-income neighborhoods, Green = High-income neighborhoods. **(A)** Normalized noise from both 'Positive' and 'Negative' events per spatial bin. **(B)** Proportion of positive-to-negative events per spatial bin.

Figure 3. Probability of reporting a positive experience (i.e. positive mood). The univariate model describes the general effect of noise levels on the probability of experiencing such a positive mood during the walk. Higher noise levels decrease the probability of reporting a positive experience.

Figure 4. Interaction effects of noise by income. Whereas **(B)** and **(C)** are similar to the univariate relationship trend between normalized noise levels and the probability of reporting a positive experience, **(A)** shows a somewhat inverse relationship. As normalized noise levels increase, the probability of experiencing a positive mood also increases. Additionally, is to be noted that in low-income neighborhoods the highest probability of experiencing a positive mood is significantly lower than both middle- and high-income neighborhoods.

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a

b

	Estimate	Standard Error	Wald's Chi-Squared Value	p-value (dF)
(Intercept)	0.232	0.137	2.852	0.091 (1)
Noise	-26.215	5.599	21.921	<0.001 (1)

	Estimate	Standard Error	Wald's Chi-Squared Value	p-value (dF)	LR test
High	-53.9	13.1	16.896	<0.001 (1)	p < 0.001
Middle	-26.215	5.599	21.921	<0.001 (1)	
Low	22	8.2	7.168	0.007 (1)	