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Urbanization is positively associated with global perceptual style

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ABSTRACT

More and more people are moving to cities, resulting in more than half of the world's population living today in urban areas. The impact of the physical environment on cognition has been a subject of study in environmental psychology, but the findings have been inconclusive due to its complexity. While some studies have indicated a negative correlation between urbanization and cognitive abilities, others have found no significant effects. The current study investigates the relationship between urbanicity, multitasking abilities, and perceptual style. Specifically, the study aims to determine whether individuals living in highly urban environments exhibit different multitasking abilities compared to those living in low urbanicity environments and whether perceptual style mediates this relationship. Previous research suggests that rural residents show a local perceptual bias and better attentional control, which may affect their multitasking abilities. Participants were recruited from two distinct postcode areas in the UK classified as urbanicity-high and urbanicity-low based on the percentage of urban features present. Our study found no association between urbanicity and multitasking abilities. However, additional analyses revealed that other variables related to the engagement with their physical environment, such as time spent outdoors, and time spent in nature were associated with multitasking abilities. This goes in line with the previous research showing the restorative effects that short-term exposure to nature can have on cognition. Additionally, we examined the relationship between urbanicity and perceptual style using a global-local visual processing task. In line with previous research, dwellers living in highly urban areas showed a global bias as compared to those living in less urban areas. Overall, our results suggest that the physical environment in which people live is associated with the way they process visual information.

1. Introduction

Urbanization has become increasingly prevalent in the past years, leading to more than half of the world's population living in cities (United Nations, 2019). People are living in an environment that constantly exposes them to constant and complex stimulation (e.g., traffic situations, crowds in a shopping mall) that may require different cognitive resources than the ones demanded in natural environments. Previous cross-cultural research suggests that the novelty and unpredictability of this excessive amount of stimuli in urban environments might lead to an overload of the attentional system and chronic over-arousal, resulting in attentional deficits (Linnell & Caparos, 2020). Such deficits could potentially impact cognitive processes that rely on attentional control, such as multitasking and perceptual style. Multitasking refers to one's ability to perform two (or more) tasks at the same time or to rapidly switch between tasks (which hence implies switching one's attention allocation, Koch, Poljac, Müller, & Kiesel, 2018), while perceptual style refers to the way people process and attend to information (both visually and conceptually). For example, physical objects can be processed visually by focusing on the details (i.e., local processing style) or the objects' overall shape (i.e., global processing style, Kimchi, 1992).

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Differences in cognition in these two different types of environments have been studied in western populations, but findings are still mixed. On the one hand, there is a body of research that demonstrates that brief contact with nature, such as walking in nature is beneficial to both affect and cognition (Bratman, Daily, Levy, & Gross, 2015; McMahan & Estes, 2015; Stenfors et al., 2019). On the other hand, some studies focusing on ageing and cognitive capacities report lower rates of dementia, and better cognitive performance among older adults in urban compared to rural areas (Georgi et al., 2019), possibly due to the greater social engagement and availability of education and public health services in urban areas (Glaeser, 2011; Robbins, Scott, Joska, & Gouse, 2019). However, these two strands of research operate on a different timescale; many of the studies that linked living in rural regions to dementia or lower cognitive performance mostly focus on elderly populations and use general measures of cognition often targeted at older ages. Therefore, they may not be optimal to pinpoint the specific aspects of cognition involved in the association between the physical environment in which people live and their cognitive abilities (Besser, McDonald, Song, Kukull, & Rodriguez, 2017). Furthermore, most of the research showing a cognitive decline in rural dwellers comes from studies that define urban vs. rural environments based on home address, focusing on one's permanent living environment (Besser et al., 2017; Robbins et al., 2019), while the studies that report beneficial effects of nature focus on short-term real life or virtual exposure to nature, such as walks in nature, or viewing of nature images (Bratman, Hamilton, Hahn, Daily, & Gross, 2015; Stevenson, Schilhab, & Bentsen, 2018; Sudimac, Sale, & Kühn, 2022). Therefore, it is still unclear whether the differences observed between urban and rural environments might be selective for certain cognitive domains (such as multitasking or perceptual style), and whether they occur on a long- or short-term basis.

In this study, we aim to provide a deeper understanding of how the living environment may influence attentional control and the allocation of attentional resources. In particular, we will examine whether people living in areas with different degrees of urbanization (high vs. low) exhibit different multitasking abilities, and whether perceptual style mediates this relationship. We build on previous research that suggests a potential link between multitasking and perceptual processing (Duff & Sar, 2015; Kazakova, Cauberghe, Pandelaere, & De Pelsmacker, 2015), as well as on the implicit connection of multitasking (Redick et al., 2016; Szumowska & Kossowska, 2017) and perceptual processing (Nisbett & Miyamoto, 2005; Van Der Helm, 2012) with attentional control and the allocation of attentional resources. Research has shown that different environments can influence perceptual processing. Cross cultural studies have repeatedly found that urban environments are likely to promote a perceptual bias toward the context (i.e., global perceptual style), while rural environments are more likely to promote a bias towards the details (i.e., local perceptual style, Bremner et al., 2016; Caparos et al., 2012; de Fockert, Caparos, Linnell, & Davidoff, 2011). In order to control for cross-cultural differences, Caparos et al. (2012) and Linnell, Bremner, Caparos, Davidoff, and de Fockert (2018) replicated these results between traditional Himba and urban Himba. Both studies found that traditional Himba showed a stronger local perceptual style than their urban Himba counterparts. The Himba, whether urban or rural, experienced a traditional upbringing and were therefore illiterate and uneducated, suggesting that education and literacy may affect perceptual style (Caparos, Linnell, & Blanchette, 2020; Spray, 2018).

Caparos et al. (2020) further tested normally developing educated Rwandan participants and found that dwellers from non-urban areas in Rwanda had an even more local perceptual style than Rwandan city dwellers. Furthermore, Western urban dwellers have a significantly enhanced global bias compared to educated Rwandans. These results suggest that variations in both education and urbanization may drive cross-cultural differences in perceptual style In line with these findings, and with a range of other cross-cultural findings concerning selective attention, Linnell and Caparos (2020) found that the abundance of stimuli competing for attention inherent in urban environments may have a detrimental effect on the ability to select and maintain attention on specific tasks, both overtly (i.e., visually and intentionally), and covertly (i.e., mentally, unconsciously filtering out irrelevant visual information).

Overall, these and particularly other cross-cultural studies focused on comparing selective attention suggest that rural environments promote attentional styles in which individuals have better concentration and attentional control, while urban environments promote a non-selective exploration of the heterogeneous stimulation they provide (Linnell & Caparos, 2020). They also suggest that socio-ecological factors such as the adoption of the fast-paced way of life associated with WEIRD societies might contribute to the cross-cultural differences in attentional style.

1.1. *The present study*

In this study, we aim to replicate previous cross-cultural findings by using a Western sample from the United Kingdom (UK) that exclusively differs in terms of urbanicity, and not in education, literacy or socio-economic status, and that comprised a more homogeneous group than the ones used in previous studies. This way, we expect to be able to draw conclusions based on the physical environment (i.e., levels of urbanization) while controlling for socioeconomic factors. Moreover, here we characterise the differences between urban and rural environments not only in terms of population density - like previous studies did - but also in terms of geographical features, such as buildings, road and rail networks, airports, etc.

More concretely, we set out to investigate whether people living in more urban (henceforth Urbanicity-high) places will be better in multitasking abilities than people living in less urban areas (henceforth Urbanicity-low), or vice versa. We hypothesised that Urbanicity-high dwellers would show better or worse multitasking abilities than Urbanicity-low dwellers. This hypothesis is pointed in both directions because (1) previous studies have shown that rural dwellers have better attentional control (Linnell & Caparos, 2020), which would make Urbanicity-high dwellers worse multitaskers. On the other hand, (2) Urbanicity-high dwellers may be more accustomed to multitasking as a result of the high levels of visual clutter[1] present in urban environments (Miyamoto, Nisbett, & Masuda, 2006), making Urbanicity-high dwellers better multitaskers. Further, we also address the question of whether there is a difference between individuals living in high vs. low-urbanized regions in the UK in terms of processing style that may mediate the effects of multitasking (Duff & Sar, 2015; Kazakova et al., 2015). To investigate this question, we use a dispositional measure to assess participants' global or local perceptual style. We hypothesised that participants living in Urbanicity-low areas would show a more local perceptual style than people living in Urbanicity-high areas, consistent with prior research (Caparos et al., 2020). The study preregistration can be found here (https://aspredicted.org/ft2gn.pdf). In a more exploratory analysis step, we examine the effect that variables related to time spent in nature or outdoors might have on multitasking abilities (RQ4).

2. Methods

2.1. *Sample*

205 participants were recruited through the online crowdsourcing platform Prolific (Palan & Schitter, 2018). Participants were stratified by geographical properties of the postcode area (rural or urban, see details below). The sample consisted of 99 males and 106 females, aged between 18 and 68 years; *M(SD)* = 35.2 (12.11). All the participants

[1] Visual clutter refers to the abundance or excess of visual stimuli in an environment that can interfere with one's ability to focus or process information efficiently (Rosenholtz, Li, Mansfield, & Jin, 2005).

were from the UK, 101 of them living in postcodes with a predominance of urban features (hereafter referred to as "Urbanicity-high") and 104 living in postcodes with a low predominance of urban features (hereafter referred to as "Urbanicity-low"). Each participant signed an informed consent form, and the study was approved by the Local psychological ethical committee of the University Medical Center Hamburg-Eppendorf (LPEK-0234). Participants received monetary compensation for their participation.

2.2. Postcode classification

Participants were classified as urban vs. rural dwellers depending on the UK postcode of their current home address. We used Geographic Information System (QGIS Development Team, 2021) tools to select postcodes with a high vs. low number of indicators of urbanicity. To achieve this classification, we used the CORINE Land Cover (CLC) Atlas which provides information on the bio-physical characteristics of the earth's surface and therefore allowed us to extract the surface geographical features of the UK. It contains classes such as Continuous urban fabric, Discontinuous urban fabric, etc. (Table 5.2; Büttner, 2014 shows an overview of all the different land use categories of the CLC). Simultaneously, we used shapefile polygons of the 2881 UK postcode districts (consisting of the first part of the alphanumeric UK postcodes, and containing between two and four characters, e.g., AB10). These polygons were blended with the CLC Atlas, to extract the percentage of different land use features and objects present in each district.

Next, we selected the CLC objects characteristic of 'urban' land, them being: (1) Continuous urban fabric (where >80% of the land surface is covered by impermeable features like buildings, roads and artificially surfaced areas. Non-linear areas of vegetation and bare soil are exceptional), (2) Discontinuous urban fabric (consisting of urban structures and transport networks associated with vegetated areas and bare surfaces are present and occupy significant surfaces in a discontinuous spatial pattern. The impermeable features like buildings, roads and artificially surfaced areas range from 30 to 80% land coverage), (3) Industrial or commercial units, (4), Road and rail networks and associated land, and (5) Airports. Then, we calculated the percentage of 'urban' features for each postcode district. This was done by computing the sum of the areas of each object falling into the 'urban' category, divided by the total area of the postcode:

$$\%\ urban\ features\ in\ Postcode\ x = \frac{\sum_{i=1}^{n} A_i}{A_{Postcode\ x}} \times 100$$

where A represents the area in m^2, i is the CLC category classified as 'urban' (e.g. continuous urban fabric), and n is the number of district postcodes.

Postcodes with higher than 75% of urban features were classified as 'Urbanicity-high' and postcodes with lower than 25% of urban features were classified as 'Urbanicity-low' postcodes. For more details on the procedure and decisions about this method, see Appendices.

2.2.1. Urbanicity based on physical features compared to population density

To provide comprehensive insights and align with previous studies that predominantly focus on population density as a measure of urbanicity, we examined the relationship between population density and our measure of urbanicity, which incorporates various geographical features (e.g., airports, roads and railways, commercial and industrial units, buildings, etc.). The correlation analysis revealed a strong positive correlation ($r = 0.818$, $p < 0.05$), indicating a significantly large association between the two measures, supporting the notion that results based solely on population density would have been similar.

2.3. Measures

2.3.1. Basic questionnaire – current living conditions

Participants responded to a questionnaire about their current living conditions that included the following questions: (1) '*How much nature (trees, lake, grass, flowers, bushes …) is there around your house?*', (2) '*How important is time in nature for you?*' (3) '*For how many years have you lived in the city/town you are currently living in?*', (4) '*How much time do you spend outdoors on an average day?*', (5) '*How often do you visit nature?*'. For a more detailed breakdown of the questions, see the Appendices.

2.3.2. Early life urbanicity score

We asked participants for their residence from birth to age 15, as previous epidemiological research has highlighted this period as particularly vulnerable in the prediction of later mental health problems (Pedersen & Mortensen, 2001). To quantify the early-life urbanicity score (ELUS) we took the same categories used by Lederbogen et al. (Lederbogen et al., 2011); Participants filled a small table with the number of years spent in (1) cities with more than 100.000 inhabitants, (2) towns with 10.000–100.000 inhabitants, (3) rural areas. To calculate the ELUS we multiplied the category number by the number of years spent in the respective category and then summed them up. For example, for a participant that spent 10 years in cities with more than 10 000 inhabitants (i.e., category 1) and 5 in rural areas (i.e., category 3), the score would be $10x1 + 5x3 = 25$. Final ELUS ranged from 15 to 45, with high values indicating higher urban exposure during early life.

2.3.3. Tasks

Multitasking tasks. Participants underwent three different multitasking paradigms: Multitasking tasks (Fig. 1), Cued-switching task (Fig. 2A), and Psychological refractory period (PRP) paradigm (Fig. 2B), all programmed and presented using Psytoolkit software (Stoet, 2010, 2017). For an extended description of the tasks, see Appendices.

2.3.3.1. Multitasking task. The Multitasking paradigm provided two different types of comparisons. Firstly, it assessed the difference in performance between blocks where participants only performed one task and blocks where two tasks were combined and participants had to rapidly interleave them. Second, within the multitasking blocks, we compared the difference between repeating one task compared to switching between different tasks. This second comparison makes this paradigm a task-switching paradigm like the cued-switching paradigm explained below. However, the difference between the two tasks is that in the multitasking task, the cue was implicit and present at the same time as the presentation of the stimulus, while in the cued-switching task, the cue was presented previously and separately from the stimuli.

In the multitasking task, there were three dimensions of interest: (1) Task switching costs (RT difference between switch vs. repeat trials), (2) Mixing costs (RT difference between mixing vs. pure trials), and (3) Congruency costs (RT difference between congruent vs. incongruent trials, Fig. 1B). Only the first two were of interest to our study. Repeating trials were those focusing on the same type of task (shape or filling) while switching trials were those following the opposite type of task. 'Mixing blocks were those in which switch and repeat trials were interleaved, while pure trials were those including one single type of trial (repeat or switch).

2.3.3.2. Cued-switching paradigm. The cued-switching task essentially consisted of a task-switching paradigm that assessed the ability of participants to quickly switch between two different tasks. In this paradigm, participants carried out two different types of tasks, where a shape and a colour task were randomly alternating. Additionally, explicit cues instructed participants on which task to perform on every trial. The cue for the colour task was the word *colour* and the cue for the shape task was the word *shape* (Fig. 2A). In the shape task participants responded to

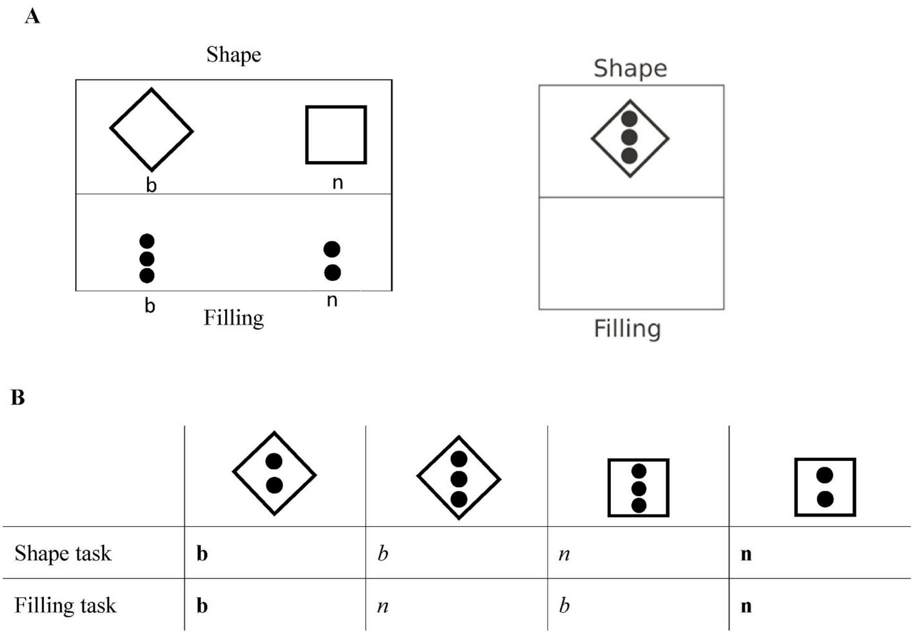

Fig. 1. Schematic representation of the multitasking paradigm. *Note*: A. Stimuli and set-up. The upper section corresponded to the ‘shape’ section and the lower section to the ‘filling’ section. When stimuli appeared in the shape section, participants had to respond to the shape (diamond or square) and when stimuli appeared in the filling section, participants were instructed to only pay attention to the dots (two or three) filling the shape. B. In the shape trials, ‘diamond’ required a ‘b’ button press, and a rectangle an ‘n’ button press. In the filling trials, three circles required a ‘b’ button press and two circles required an ‘n’ button press. Congruent trials (bold) were those where both stimuli required the same button response, and incongruent trials (italics) were the ones where stimuli required opposite responses.

circles and rectangles while ignoring the colour, and in the colour task participants responded to the colour while ignoring the shape. In the shape trials participants had to respond with a *b* button-press when they saw a circle and with an *n* button-press when they saw a rectangle. In the colour trials, a *b* button-press was required for a yellow target, and an *n* key press for a blue stimulus. Repeat trials were those that followed the same task (colour task following colour task) and switching trials were those following the opposite task (shape task following colour task). Similar to the multitasking paradigm, congruent trials required the same response for both the colour and the shape condition, and incongruent trials were those in which opposite responses were required for the two task types.

The main indicators for the cued-switching task used for the between-subject analyses were (1) switching costs (i.e., the difference in RT between switching and repeat trials): and (2) congruency costs (i.e., the difference in RT between congruent and incongruent trials).

However, only switching costs were of interest in the present study.

2.3.3.3. Psychological Refractory Period (PRP) Paradigm. This paradigm is targeted at investigating the period during which the response to a second stimulus is significantly slowed because a first stimulus is still being processed. The experiment consisted of two tasks. First, an auditory two-choice reaction time and after a certain (150ms, 250ms, 600ms or 1,100ms) stimulus onset asynchrony (SOA), a visual two-choice reaction time. Participants were instructed to respond to Stimulus 1 first, and then to Stimulus 2. For a more detailed explanation, see Appendices.

2.3.3.4. Perceptual style. To assess individual differences in dispositional global or local bias, which is the default and persistent (at least for several days) preference for processing global or local visual information (Dale & Arnell, 2013), we used the material for the global/local task adapted from Kimchi and Palmer (1982) as well as Fredrickson & Branigan (2005). The stimuli in each trial consisted of a triad shape composed of three separate smaller shapes. There was a target figure on the top and two comparison figures on the bottom (see Fig. 3A). Each triad shape was formed by 3–4 small square or triangle shapes (local level) that made a larger square or triangle (global level). There was a total of 24 trials with different triad combinations; 16 were ‘filler’ trials and 8 were ‘test’ trials. In the test trials, both bottom figures matched the target figure on the top, either on a local or a global level. In the filler trials, only one of the figures matched the target figure, making only one response the correct one. In the test trials, matching on a global level would mean that the overall shape outline matched the target while matching on the local level meant the smaller shapes matched the top shape. Fig. 3 depicts a test trial, in which the bottom left shape matches the target shape on a local level (both are formed by triangles), while the bottom right shape matches the target shape on a global level (both are formed by 4 figures that compose a square).

Each trial started with a blank screen of 1s. Next, the triad figures were presented until the participant’s response. Participants had to respond with right or left key-presses, to which of the bottom figures matched the top one. After the button press, the selected figure was framed with a black square around it to provide visual feedback for the selected response. The experiment was programmed in NeuroTask (www.neurotask.com).

2.4. Procedure

Participants were redirected from the Prolific website to the platform Qualtrics, where they completed a self-report online questionnaire (Fig. 3B). This questionnaire included socio-demographic questions (including age, sex, social-economic status, etc.) and questions related to the engagement with participants’ close physical environment. Secondly, participants were redirected to the first behavioural experiment, the Cued-switching paradigm. Thirdly, participants were redirected back to Qualtrics, where they carried out the Media Multitasking questionnaire. Fourthly, they did the second behavioural experiment, the Multitasking paradigm. Then, they underwent a Dispositional measure task, which determined whether they had a local or global perceptual style. Finally, they performed the last behavioural task, which consisted of a Psychological refractory period (PRP) paradigm.

2.5. Exclusion criteria

For the Dispositional measure task, data from 20 participants with a score below 12 (which meant participants made more than 4 mistakes out of the total 16 trials) in the filler condition were excluded. The exclusion of these participants in the different tasks resulted in missing data for certain tasks or, in other words, an unbalanced sample for each of the models built for the different cognitive task indicators.

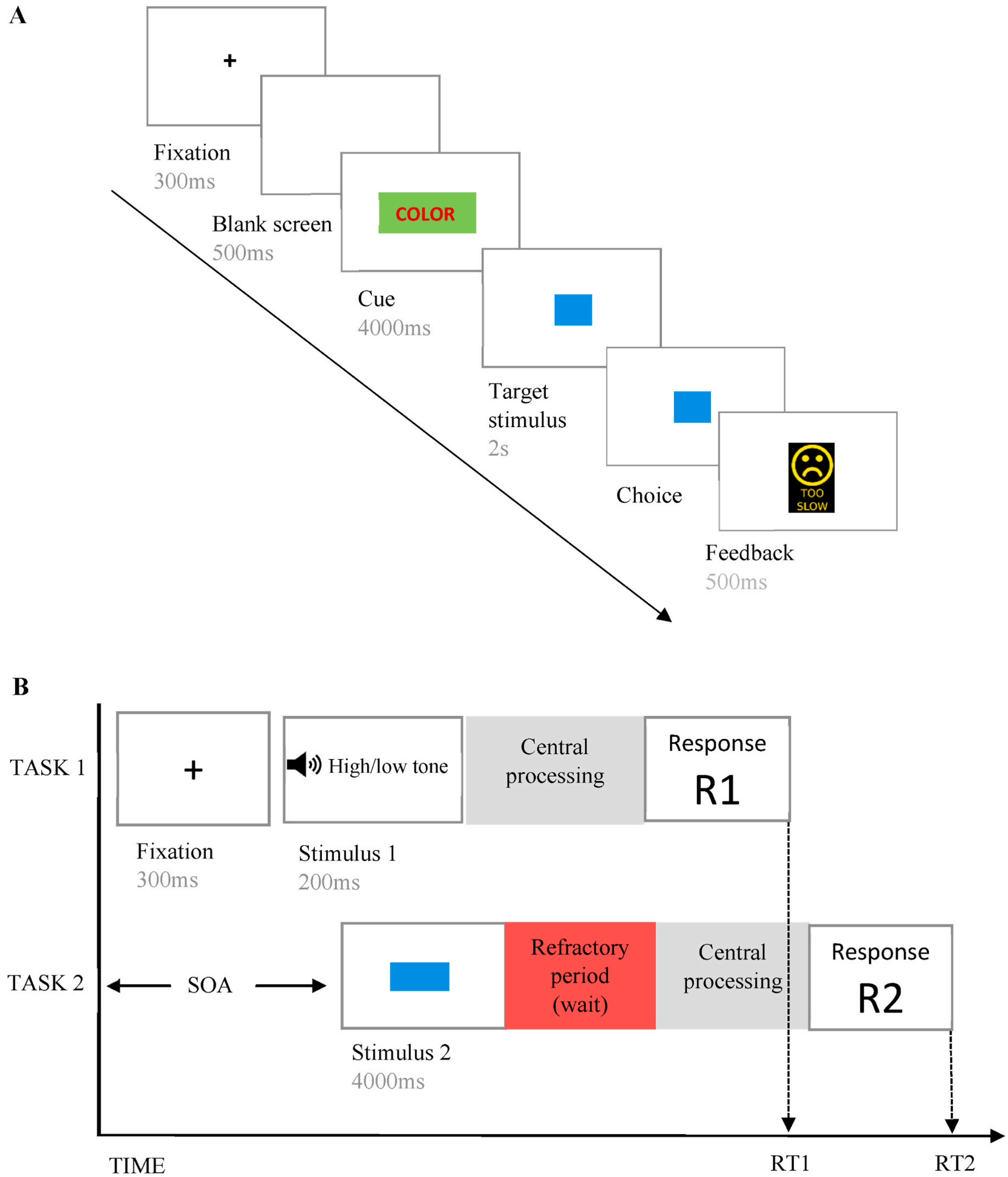

Fig. 2. Example trial for the Cued-switching paradigm and the PRP paradigm. *Note.* A. Example of a trial in the Cued-switching paradigm. B. Example of a trial for the PRP task and hypothetical sequence of psychological processing stages.

2.6. Power analysis

We determined the number of participants needed based on a power calculation using G*power with an anticipated effect size of $d = 0.5$, a power of .95 and a two-tailed *t*-test. Our goal was to include 210 participants in the study. We recruited more than 210 but some had to be excluded due to missing data, which therefore made the last sample size N = 205. Our power analysis was not supported by an earlier study, it was instead calculated from the ground up, given that we took an exploratory approach for this analysis.

2.7. Statistical analyses

Firstly, we carried out within-subject analyses to evaluate if the tasks worked as expected and if we could use them for further between-subject analyses. Secondly, the relationship between multitasking and the cued-switching task indicators was examined by constructing a correlation table between them. Thirdly, between-subject analyses were carried out to examine the preregistered question about differences between Urbanicity-high vs.

Urbanicity-low dwellers in multitasking abilities. To do that, different multiple linear regressions were carried out to predict the different cognitive indicators resulting from the cued-switching

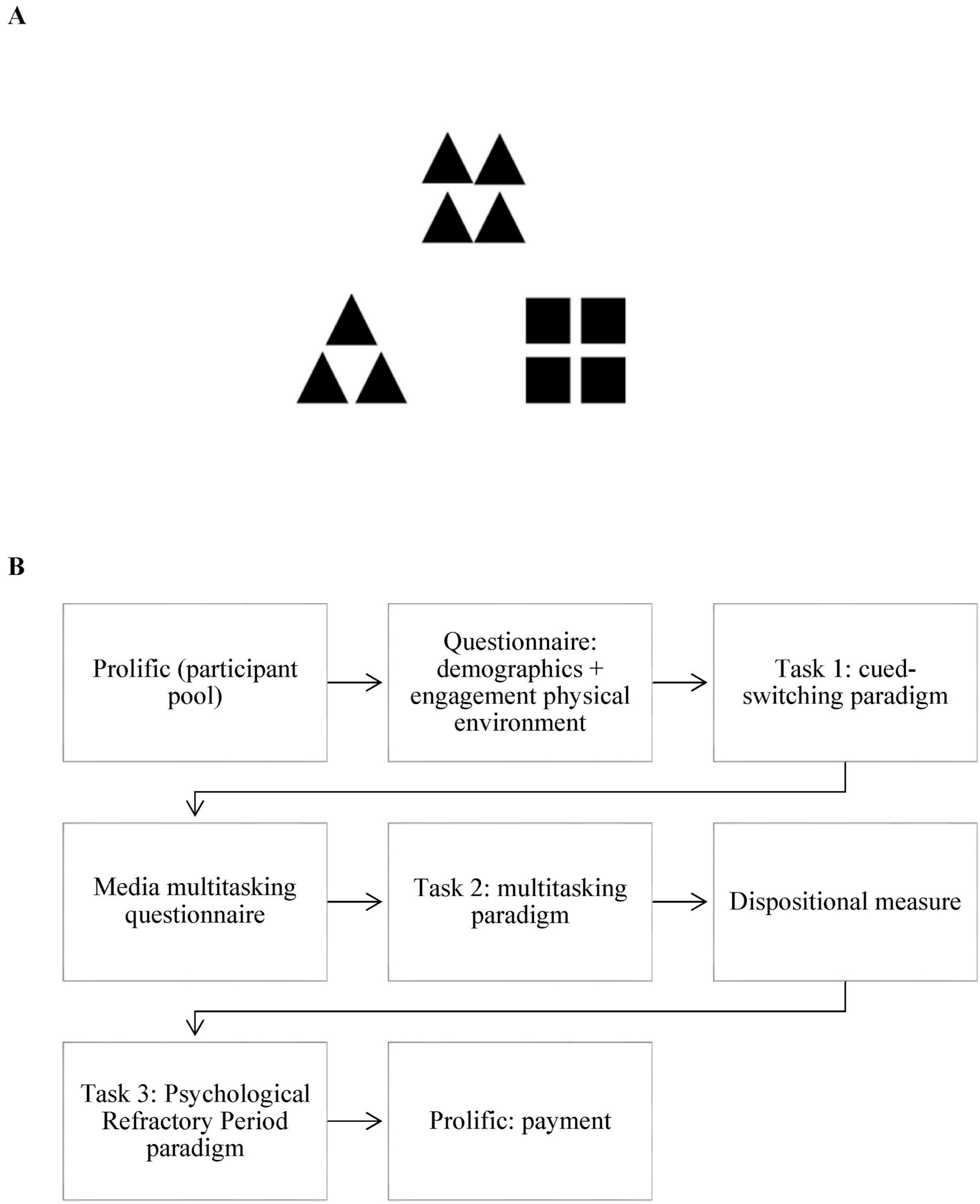

Fig. 3. Methods illustration. *Note.* A. Example of test triad in the perceptual global-local style task. The bottom left shape matches the top one at a local level (triangles) and the bottom right figure matches the top target one at a global level (both are formed by four figures making a square). B. Outline different stages of the experiment.

paradigm and the multitasking paradigm: (1) Switching costs in the Cued-switching paradigm, (2) Switching costs in the Multitasking paradigm, (3) Mixing costs in the multitasking paradigm. Different models were built for these indicators, using Urbanicity (two levels: High vs. Low) as the main independent variable and controlling for age, gender education, and income. Furthermore, two more models were built using the same independent variables to predict Media Multitasking and Perceptual style. We planned to add the later variables as predictors in case they were significantly predicted by high vs. low urbanicity. In a more exploratory approach, more models were built to investigate the effect of variables related to engagement with the physical environment (i.e., nature visit, time outdoors, and nature importance) on the aforementioned cognitive indicators. A correlation table (Table D9) was created between several of these variables related to engagement with the physical environment, together with other demographic variables such as age, education and income. A sample size estimation using G*Power resulted in the need for 205 participants to enable a medium effect size. All statistical analyses were carried out using R Studio Version 1.4.1106 (Rstudio Team, 2021).

3. Results

3.1. Perceptual style

Participants' perceptual global bias mean score was $M = 2.95$ ($SD = 1.95$, min = 0, max = 8). For the filler trials, the accuracy was $M = 86.77\%$ ($SD = 12.25$).

Multiple linear regression was carried out to predict perceptual style based on postcode (Urbanicity-high or Urbanicity-low) while controlling for age, gender, education and income (see Appendix D). The data met the assumptions of independence, homoscedasticity (equal variance), linearity and normality of residuals.

The results revealed that Urbanicity was a significant predictor of perceptual style ($\beta = 0.862$, $p = 0.018$), indicating that Urbanicity-high dwellers show a more global perceptual style than Urbanicity-low dwellers (Fig. 4). Given the potential interaction between these two variables, we decided to run further analyses including perceptual style as an additional predictor in the models (see Table D6). Moreover, including Perceptual style in these models improved the fit of the models, as evidenced by a lower Akaike information criterion (AIC) in all of the models.

Age was a significant predictor of perceptual style ($\beta = 0.043$, $p = 0.004$) showing that older individuals tend to show a more global style. Income was a significant negative predictor of perceptual style ($\beta = -0.450$, $p = 0.011$) indicating that people with higher income tend to have a more local perceptual style than individuals with a lower income.

An additional model for perceptual style as a dependent variable was run to test if there was a relationship between the effect of urbanicity on perceptual style, the years spent in the current place, and the ELUS (see Table 1). In this model, age was significant positive predictor ($\beta = 0.043$, $p = 0.009$), income was a significant negative predictor ($\beta = -0.449$, $p = 0.011$), and urbanicity was again significant ($\beta = 0.979$, $p = 0.009$). No other significant predictors were found to be significant. The fact that the ELUS and years in the current place were not significant suggests that the effects of urbanicity are related to the current place where the person is living and not to the amount of time spent there.

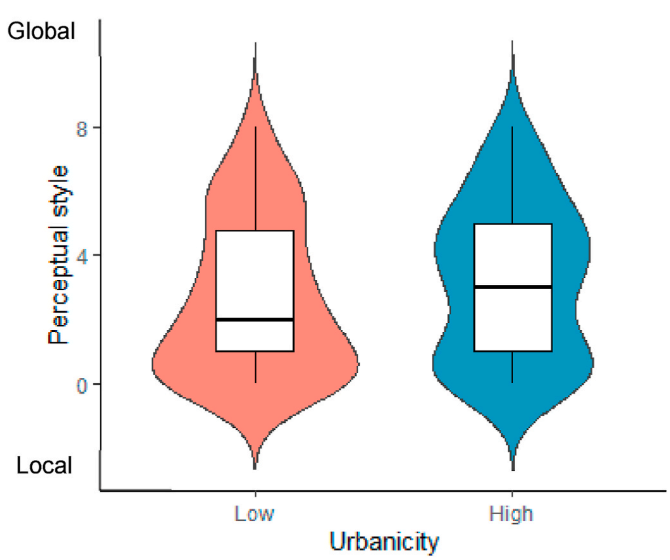

Fig. 4. Relationship between perceptual style and urbanicity. *Note*: Higher scores in perceptual style indicate a more global style, while lower scores indicate a more local perceptual style. The violin plots outline illustrates kernel probability density, i.e., the width of the coloured area represents the proportion of the data located there.

Table 1
Regression models including Urbanicity, ELUS and years in current place as predictors of Perceptual style.

Predictors	*Dependent variable:*			
	Perceptual style			
	B	*95% CI*	*β*	*p*
Age	0.043	[0.011, 0.074]	0.220	**0.009**
Gender – Male	0.458	[−0.235, 1.150]	0.095	0.197
Education	0.036	[−0.344, 0.416]	0.014	0.855
Income	−0.449	[−0.792, −0.105]	−0.194	**0.012**
Urbanicity – high	0.979	[0.249, 1.708]	0.203	**0.010**
ELUS	−0.021	[−0.052, 0.010]	−0.099	0.184
Years in current place	0.005	[−0.021, 0.032]	0.031	0.691
Constant	2.031	[0.062, 4.000]	0.00	**0.045**
AIC	849.3			
Observations	185			
R^2	0.093			
Adjusted R^2	0.058			
Residual Std. Error	2.339 (df = 177)			

Note: A higher score in a perceptual style meant participants had a more global style. ELUS refers to the Early life urbanicity score. SE refers to standard error. AIC refers to the Akaike information criterion. Higher values indicated higher urban exposure during early life.

3.2. Multitasking abilities

To test whether the cognitive tasks showed results typically reported in the task switching, multitasking and PRP literature, we conducted several analyses. For more details on these see Appendix D.

All in all, the data confirmed the classical cued-switching and multitasking paradigm effects, but not the typical effects seen in PRP paradigms. Therefore, we excluded PRP indicators from further analyses, and in further between-subject analyses, we examined: (1) *switching costs* from the task-switching task, and (2) *mixing costs* and *switching costs* from the multitasking paradigm[2].

Three different multiple linear regression models were carried out to predict scores of each cognitive task indicator based on Urbanicity (Urbanicity-high or Urbanicity-low) while controlling for age, gender, education, and income (see Appendix D, Table D6). No differences in multitasking abilities[3] were found, which confirmed that urbanicity, defined exclusively by the number of urban features does not explain multitasking or switching skills.

Age was found to be a significant positive predictor of *switching costs* in the Cued-switching task ($\beta = 1.255$, $p = 0.038$), for the *mixing costs* in the Multitasking task ($\beta = 2.975$, $p < 0.001$), and for the switching costs in the Multitasking task ($\beta = 1.597$, $p = 0.016$). This shows that older individuals manifest higher costs when switching between tasks or when performing more than one task at once and therefore, have lower multitasking abilities (Crews & Russ, 2020).

[2] As a clarification and a reminder: on the one hand switching costs refer to the response time difference between switch and repeat trials. This is, the difference between responding to trials that came after a different type of task (i.e., colour task vs. shape task in the cued-switching task, and filling vs. shape task in the multitasking task) and to trials where participants were responding to the same type of task as presented in the previous trial. On the other hand, mixing costs refer to the difference in RT between pure and mixing trials. Mixing blocks were those in which switch and repeat trials were interleaved, while pure trials were those including one single type of trial (repeat or switch).

[3] Note that throughout this paper we refer to multitasking abilities in general to facilitate language but given this low correlation among the multitasking paradigms it is important to remember that we are speaking of multitasking as seen through these specific paradigms.

3.2.1. Multitasking and engagement with the physical environment

A third set of regression analyses (Appendices, Table D8) were performed on the same cognitive task indicators, adding three more independent variables: Time outdoors was a significant predictor of the switching costs in the cued-switching task ($\beta = 25.195$, $p = 0.002$), and of the mixing costs in the multitasking task (β = 15.31, p = 0.362) indicating that people who spend more time outdoors are less skilled in switching between or carrying multiple tasks. Nature visit was a significant negative predictor of the Switching costs in the cued-switching task ($\beta = -12.576$, $p = 0.047$) and for the Mixing costs ($\beta = -15.232$, $p = 0.007$), indicating that people who spend more time in nature show less switching and mixing costs and therefore are more skilled in switching between tasks and in performing multiple tasks at the same time. Nature importance was also a significant predictor of Mixing costs in the multitasking task ($\beta = 0.685$, $p = 0.022$), showing that people for whom nature is more important have a harder time carrying out two tasks at the same time. We also found a significant negative relationship between perceptual style and mixing costs in the multitasking task ($\beta = -6.047$, p = 0.026), suggesting that people with a more local style (lower score at the Dispositional measure) have fewer mixing costs and are therefore more skilled when performing two tasks at the same time.

4. Discussion

Urbanization is an inevitable aftermath of our society's evolution, expecting to affect 68% of the population living in cities by 2050. In this paper, we aimed to investigate differences in perceptual style and multitasking abilities in western dwellers from areas with a higher number of geographical urban features compared to dwellers from areas with fewer urban features. Our results show that people living in highly urban contexts showed a more global perceptual style compared to people living in contexts with low urbanicity levels. Moreover, even though cities provide a forceful multitasking environment, that does not mean that urban dwellers are better at multitasking. Instead, we have observed that multitasking abilities were superior for people spending more time in nature and less time outdoors. Our result showing that time spent in nature is related to improved cognitive abilities supports previous cross-cultural findings (Linnell, Caparos, de Fockert, & Davidoff, 2013). We discuss each result in detail next.

We found Urbanicity to be a significant predictor of perceptual style when controlling for age, gender, education and income. Our results replicate and confirm previous findings reporting that urbanization induces the adoption of a more global perceptual style (Bremner et al., 2016; Caparos et al., 2012; Linnell et al., 2018). Previous studies mostly used samples that differed in terms of socioeconomic, educational, and cultural aspects from the city dwellers to whom they were compared. Moreover, they have primarily investigated differences in perceptual style between Western and non-Western populations, or between different non-Western populations. In our study, we controlled for these differences and used a sample from the United Kingdom split into two groups that only differed in the number of urban features around their postcode. Remarkably, our study provides evidence for the association between urbanicity and a more global perceptual style within a Western industrialised population.

Notably, we found that income was related to a more local perceptual style, whereas education was not significantly related to perceptual style. In contrast to previous studies (Caparos et al., 2020; Spray, 2018), participants' education was not related to variance in perceptual style. Moreover, and also in contrast to previous findings (Caparos et al., 2020) participants' with higher income tended to make more local matches than participants with lower income, who tended to make more global matches. This is an interesting finding, especially given the positive significant correlation found between income and education (r = 0.23, see Table D9 in the Supplementary Material). Education and income are two variables that, in relation to perceptual style, have only received some more attention in recent years (Caparos et al., 2020; Spray, 2018). Future studies must not neglect the nature of this relationship and its potential underlying mechanisms.

Furthermore, we found no significant relationship between early life urbanicity (ELUS) defined as the number of years spent in an urban or rural environment until the age of 15, and perceptual style. Interestingly, our results showed that cognitive perceptual style was not predicted by the time spent in their current place of living, but rather by the specific features of the environment itself. This implies that the current physical and social environment of a person plays a more significant role in shaping their perceptual style than the length of time they have been living in that environment. Therefore, individuals who recently moved to a new urban or rural environment may experience a change in their perceptual style, regardless of how long they have been living there. This supports research suggesting that perceptual style can be induced. For example, Miyamoto et al. (2006) have shown that perceptual style can be primed just by showing participants pictures from American cities vs. Japanese cities. Future studies may investigate how priming images from one type of culture affects perceptual style and its stability. Additionally, this finding highlights the importance of considering the specific physical and social features of the environment that may influence perceptual style, such as population density, the presence of green spaces, bodies of water and various urban structures, or fast-versus slow-paced lifestyles. Understanding these factors can provide insights into the mechanisms through which the environment shapes human cognition and behaviour, with implications for the design of urban and rural environments.

A primary aim of our study was to investigate the relationship between urbanicity and multitasking abilities. Previous research has found mixed results regarding whether the physical environment influences cognitive abilities and well-being. We bidirectionally hypothesised that dwellers in highly urban areas (Urbanicity-high dwellers) would be better or worse at multitasking, given that they live in a highly stimulating environment that demands engaging in multiple tasks at once. This could therefore bring beneficial effects due to training, or also detrimental ones due to overstimulation, stress and possibly lower contact with nature, typical in highly urban environments. However, we observed that urbanicity was not a significant predictor for any of the multitasking indicators. The lack of an association between multitasking abilities and urbanicity is contrary to expected given (1) the previous research that finds that urbanicity is protective against degenerative illnesses such as Alzheimer's disease or dementia (Besser et al., 2017; Georgi et al., 2019), and also (2) the studies that find a positive relationship between exposure to nature and cognitive abilities such as attention (Ohly et al., 2016) and working memory (Stenfors et al., 2019).

The null results, contrary to our hypothesis, might be due to the variable urbanicity, defined by the number of urban features (buildings, roads, train stations, airports, etc.) and their postcode of residence. Urbanicity may not reflect the actual time people spend in nature or an urban context in their daily lives. We, therefore, performed exploratory analyses to examine whether variables related to time spent in nature and outdoors were associated with multitasking abilities. We found a negative association between nature visits and switching costs in the cued-switching paradigm and mixing costs in the multitasking paradigm, indicating that more time spent in nature is related to better multitasking abilities. These results go in line with the strand of research that has shown that nature is beneficial for cognition, given its restorative effects on attention (Caparos, Linnell, Bremner, de Fockert, & Davidoff, 2013; de Fockert et al., 2011; Linnell & Caparos, 2020; Linnell et al., 2013; Ohly et al., 2016; Stevenson et al., 2018). Moreover, we also observed a positive association between time outdoors and switching costs in the cued-switching paradigm, highlighting that more time outdoors is related to worse multitasking abilities. A potential explanation of the differing effects of time spent outdoors and time spent in nature on multitasking abilities could be that, as Attention Restoration Theory (ART) suggests (Ohly et al., 2016), when being outdoors, people prefer to spend time in spaces which do not require so many cognitive resources (e.g., green environments) and, in turn, do not promote abilities like multitasking that might require practice to be developed. Alternatively, another possibility for these contradictory results could be that time spent outdoors is not equivalent to time spent in nature. This way, people might spend a time outdoors but not necessarily in a natural environment, for example, this would happen to a road worker who spends most of their time in a non-natural environment. It is also worth mentioning that we found a significant positive correlation between time outdoors and nature visit (r = .55). Nonetheless, it would remain critical to developing more accurate measures of how much time people spend outdoors, where this time outdoors is spent, and the type of activities or interactions they have with their environment (also when being indoors). Log data (also known as digital trace data) and real-time self-report measures, such as via experience sampling methods, could be a good options for more precise measurements (Harari et al., 2016; Noulas, Scellato, Lambiotte, Pontil, & Mascolo, 2012).

Finally, we found a positive association between nature's importance and mixing costs, meaning that more importance given to nature is associated with worse multitasking abilities. Again, this finding is in line with the ART, which suggests that individuals 'benefit from engaging with activities that are compatible with their intrinsic motivations' (Ohly et al., 2016, p. 306).

All in all, our results show that urbanicity, as measured by the number of urban features in the participants' postcodes, is not significantly associated with multitasking abilities. However, other variables related to engagement with the environment might play a role in this relationship (Bratman et al., 2019). Our findings suggest that the relationship between urbanicity and cognitive abilities related to attentional control is complex, and additional factors beyond urbanicity measurements may need to be considered. Further research is needed to identify these potentially confounding variables and to determine the specific mechanisms by which they may influence cognitive abilities.

4.1. Limitations and directions for future research

The current study has several limitations that should be considered. First, the generalizability of our results on 'multitasking abilities' is limited, given that our conclusions are on separate indicators of specific tasks because the correlation among them was too low to build a latent factor or composite score. Future studies could further examine the construct validity of the existent multitasking paradigms, as well as explore more ecologically valid and reliable measures of multitasking. Moreover, evaluating the test-retest reliability of the measures employed would be crucial to clarify if (and if so, to what extent) these cognitive constructs change over time.

Second, we exclusively focussed on the continuum of urbanicity and compared people living in postcodes high in urbanicity and low in urbanicity. This made the definition of urbanicity less ambiguous than using two anchors, namely rural (or remote/nature) vs. urban perspective, in which researchers might have been mistakenly assuming that low-urban is equivalent to highly rural or abundant in nature features. However, this might be an alternative approach for future research.

Thirdly, age was a control variable used in all statistical models to examine the effects of other variables on the outcome of interest. The age range of participants was broad, ranging from 18 to 68 years old, which allowed for the examination of age-related changes across the lifespan and improved the external validity and generalizability of the findings. However, the age range was not equally represented in all age groups, with a mean age of 35.2 and the oldest participant being 68 years old. This lack of representation in certain age groups could limit the statistical power and generalizability of the findings and may introduce a bias towards the middle-aged group of participants. Therefore, the generalizations of our results to other age groups, such as seniors, may be limited.

Fourthly, our study sample primarily consisted of participants from WEIRD (White, Educated, Industrialised, Rich, and Democratic) populations. This would have limited the generalizability of our findings to more diverse cultural contexts (Henrich, Heine, & Norenzayan, 2010), had not been for the fact that our study unusually extends previous research on the relationship between rural-urban environments and local-global perceptual style to a Western (WEIRD) sample. Nonetheless, we acknowledge the importance of further research that explores these phenomena in non-WEIRD populations to enhance understanding and provide a more comprehensive view.

Fifthly, much of the existing research on the influence of urbanicity on cognition, including our own study, has primarily utilized cross-sectional designs. In order to elucidate the directionality of the effects of urbanization on cognitive abilities, future research could greatly benefit from intervention studies that involve individuals transitioning from one environment to another (e.g., moving from a rural area to the city) within a context that minimizes variations in socioeconomic variables. Such studies would provide valuable insights into the causal impact of urbanization on cognition and further our understanding of the underlying mechanisms at play.

5. Conclusions

We found that urbanicity defined via one's current place of living is not related to multitasking abilities. Yet, other variables related to the engagement with the physical environment, such as time spent outdoors or in nature, might be related to multitasking abilities (either as a cause, or a consequence). Furthermore, after controlling for educational and socioeconomic factors, we replicated previous findings associating higher urbanicity levels with global perceptual style. Altogether, future research should continue to investigate the effect of urbanization on our cognition and mental health, from an interdisciplinary perspective, and with more objective, and generalizable measures of cognition and behaviour. Rethinking the way urban policymakers build cities and making natural spaces more accessible for urban dwellers will be crucial to making cities more protective environments for people's health and cognition.

Author statement

Marina Picó Cabiró: Conceptualization, methodology, software, formal analysis, investigation, data curation, writing – original draft, writing – review & editing. Emil Stobbe: writing – review & editing, supervision. Sonja Sudimac: writing – review & editing, supervision. Simone Kühn: conceptualization, funding acquisition, writing – review & editing, project administration, supervision.

Data statement

The data required to reproduce the above findings are available from the corresponding author upon reasonable request.

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Declaration of generative AI and AI-assisted technologies in the writing process

During the revision phase of this work, the author(s) used ChatGPT, an AI language model developed by OpenAI, was utilized to assist in refining arguments, improving clarity, offer writing assistance, receive feedback on different research-related questions, and enhancing the overall quality of the manuscript. It should be noted that ChatGPT was employed exclusively during the revision phase and not during the initial stages of data collection, analysis, or interpretation. After utilizing ChatGPT, the author(s) thoroughly reviewed and edited the content as necessary, ensuring its accuracy and relevance. Therefore, the author(s) take(s) full responsibility for the content of the publication, incorporating the insights gained from the interaction with ChatGPT into the final version of the manuscript.

Declaration of competing interest

None.

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Appendix A. Supplementary data

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References

Besser, L. M., McDonald, N. C., Song, Y., Kukull, W. A., & Rodriguez, D. A. (2017). Neighborhood environment and cognition in older adults: A systematic review. *American Journal of Preventive Medicine, 53*(2), 241–251.
Bratman, G. N., Anderson, C. B., Berman, M. G., Cochran, B., de Vries, S., Flanders, J., et al. (2019). Nature and mental health: An ecosystem service perspective. *Science Advances, 5*(7).
Bratman, G. N., Daily, G. C., Levy, B. J., & Gross, J. J. (2015). The benefits of nature experience: Improved affect and cognition. *Landscape and Urban Planning, 138*, 41–50.
Bratman, G. N., Hamilton, J. P., Hahn, K. S., Daily, G. C., & Gross, J. J. (2015). Nature experience reduces rumination and subgenual prefrontal cortex activation. *Proceedings of the National Academy of Sciences of the United States of America, 112*(28), 8567–8572.
Bremner, A. J., Doherty, M. J., Caparos, S., de Fockert, J., Linnell, K. J., & Davidoff, J. (2016). Effects of culture and the urban environment on the development of the ebbinghaus illusion. *Child Development, 87*(3), 962–981.
Büttner, G. (2014). CORINE land cover and land cover change products. In I. Manakos, & M. Braun (Eds.), *Land use and land cover mapping in europe: Practices {\&} trends* (pp. 55–74). Dordrecht: Springer Netherlands.
Caparos, S., Ahmed, L., Bremner, A. J., de Fockert, J. W., Linnell, K. J., & Davidoff, J. (2012). Exposure to an urban environment alters the local bias of a remote culture. *Cognition, 122*(1), 80–85.
Caparos, S., Linnell, K. J., & Blanchette, I. (2020). The local perceptual bias of a non-remote and educated population. *Psychological Research, 84*(5), 1211–1222.
Caparos, S., Linnell, K. J., Bremner, A. J., de Fockert, J. W., & Davidoff, J. (2013). Do local and global perceptual biases tell us anything about local and global selective attention? *Psychological Science, 24*(2), 206–212.
Crews, D. E., & Russ, M. J. (2020). The impact of individual differences on multitasking ability. *International Journal of Productivity and Performance Management, 69*(6), 1301–1319.
Dale, G., & Arnell, K. M. (2013). Investigating the stability of and relationships among global/local processing measures. *Attention, Perception, & Psychophysics, 75*(3), 394–406.
Duff, B. R. L., & Sar, S. (2015). Seeing the big picture: Multitasking and perceptual processing influences on ad recognition. *Journal of Advertising, 44*(3), 173–184.
de Fockert, J. W., Caparos, S., Linnell, K. J., & Davidoff, J. (2011). Reduced distractibility in a remote culture. *PLoS One, 6*(10), Article e26337.
Georgi, H. S., Frydrychova, Z., Vlckova, K. H., Vidovicova, L., Sulc, Z., & Lukavsky, J. (2019). Young-old city-dwellers outperform village counterparts in attention and verbal control tasks. *Frontiers in Psychology, 10*(MAY), 1224.
Glaeser, E. (2011). *Triumph of the city: How our greatest invention makes us richer*. New York: Penguin Press.
Harari, G. M., Lane, N. D., Wang, R., Crosier, B. S., Campbell, A. T., & Gosling, S. D. (2016). Using smartphones to collect behavioral data in psychological science: Opportunities, practical considerations, and challenges. *Perspectives on Psychological Science, 11*(6), 838–854.
Henrich, J., Heine, S. J., & Norenzayan, A. (2010). The weirdest people in the world? *Behavioral and Brain Sciences, 33*(2–3), 61–83.
Kazakova, S., Cauberghe, V., Pandelaere, M., & De Pelsmacker, P. (2015). Can't see the forest for the trees? The effect of Media multitasking on cognitive processing style. *Media Psychology, 18*(4), 425–450.
Kimchi, R. (1992). Primacy of wholistic processing and global/local paradigm: A critical review. *Psychological Bulletin, 112*(1), 24–38.
Kimchi, R., & Palmer, S. E. (1982). Form and texture in hierarchically constructed patterns. *Journal of Experimental Psychology: Human Perception and Performance, 8*(4), 521–535. https://doi.org/10.1037/0096-1523.8.4.521d
Koch, I., Poljac, E., Müller, H., & Kiesel, A. (2018). Cognitive structure, flexibility, and plasticity in human multitasking-an integrative review of dual-task and task-switching research. *Psychological Bulletin, 144*(6), 557–583.
Lederbogen, F., Kirsch, P., Haddad, L., Streit, F., Tost, H., Schuch, P., et al. (2011). City living and urban upbringing affect neural social stress processing in humans. *Nature, 474*(7352), 498–501, 2011 474:7352.
Linnell, K. J., Bremner, A. J., Caparos, S., Davidoff, J., & de Fockert, J. W. (2018). Urban experience alters lightness perception. *Journal of Experimental Psychology: Human Perception and Performance, 44*(1), 2–6.
Linnell, K. J., & Caparos, S. (2020). Urbanisation, the arousal system, and covert and overt attentional selection. *Current Opinion in Psychology, 32*, 100–104.
Linnell, K. J., Caparos, S., de Fockert, J. W., & Davidoff, J. (2013). Urbanization decreases attentional engagement. *Journal of Experimental Psychology: Human Perception and Performance, 39*(5), 1232–1247.
McMahan, E. A., & Estes, D. (2015). The effect of contact with natural environments on positive and negative affect: A meta-analysis. *The Journal of Positive Psychology, 10*(6), 507–519.
Miyamoto, Y., Nisbett, R. E., & Masuda, T. (2006). Culture and the physical environment holistic versus analytic perceptual affordances. *Psychological Science, 17*(2), 113–119.
Nisbett, R. E., & Miyamoto, Y. (2005). The influence of culture: Holistic versus analytic perception. *Trends in Cognitive Sciences, 9*(10), 467–473.
Noulas, A., Scellato, S., Lambiotte, R., Pontil, M., & Mascolo, C. (2012). A tale of many cities: Universal patterns in human urban mobility. *PLoS One, 7*(5), Article e37027.
Ohly, H., White, M. P., Wheeler, B. W., Bethel, A., Ukoumunne, O. C., Nikolaou, V., et al. (2016). Attention restoration theory: A systematic review of the attention restoration potential of exposure to natural environments. *Journal of Toxicology and Environmental Health, Part A B, 19*(7), 305–343.
Palan, S., & Schitter, C. (2018). Prolific.ac—a subject pool for online experiments. *Journal of Behavioral and Experimental Finance, 17*, 22–27.
Pedersen, C. B., & Mortensen, P. B. (2001). Evidence of a dose-response relationship between urbanicity during upbringing and schizophrenia risk. *Archives of General Psychiatry, 58*(11), 1039–1046.
QGIS Development Team. (2021). *QGIS Geographic Information system*. Open Source Geospatial Foundation. Retrieved from http://qgis.org.
Redick, T. S., Shipstead, Z., Meier, M. E., Montroy, J. J., Hicks, K. L., Unsworth, N., et al. (2016). Cognitive predictors of a common multitasking ability: Contributions from working memory, attention control, and fluid intelligence. *Journal of Experimental Psychology: General, 145*(11), 1473–1492.
Robbins, R. N., Scott, T., Joska, J. A., & Gouse, H. (2019). Impact of urbanization on cognitive disorders. *Current Opinion in Psychiatry, 32*(3), 210.
Rosenholtz, R., Li, Y., Mansfield, J., & Jin, Z. (2005). *Feature congestion: A measure of display clutter*.
Rstudio Team. (2021). RStudio: Integrated development environment for R (Version 1.4.1106). Boston, MA: RStudio, PBC. Retrieved from *Journal of Wildlife Management, 75*, 1753–1766.
Spray, H. J. (2018). *The influence of culture, urbanisation, education and gender on local-global perceptual bias*.
Stenfors, C. U. D., Van Hedger, S. C., Schertz, K. E., Meyer, F. A. C., Smith, K. E. L., Norman, G. J., et al. (2019). Positive effects of nature on cognitive performance across multiple experiments: Test order but not affect modulates the cognitive effects. *Frontiers in Psychology, 10*(JUL).
Stevenson, M. P., Schilhab, T., & Bentsen, P. (2018). Attention restoration theory II: A systematic review to clarify attention processes affected by exposure to natural environments. *Journal of Toxicology and Environmental Health, Part B: Critical Reviews, 21*(4), 227–268.
Stoet, G. (2010). PsyToolkit: A software package for programming psychological experiments using linux. *Behavior Research Methods, 42*(4), 1096–1104.
Stoet, G. (2017). PsyToolkit: A novel web-based method for running online questionnaires and reaction-time experiments. *Teaching of Psychology, 44*(1), 24–31.
Sudimac, S., Sale, V., & Kühn, S. (2022). How nature nurtures: Amygdala activity decreases as the result of a one-hour walk in nature. *Molecular Psychiatry, 27*(11), 4446–4452.
Szumowska, E., & Kossowska, M. (2017). Need for cognitive closure and attention allocation during multitasking: Evidence from eye-tracking studies. *Personality and Individual Differences, 111*, 272–280.
United Nations. (2019). World urbanization prospects: The 2018 revision. In *World urbanization prospects: The 2018 revision*.
Van Der Helm, P. A. (2012). Cognitive architecture of perceptual organization: From neurons to gnosons. *Cognitive Processing, 13*(1), 13–40.