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Exposure to urban and rural contexts shapes smartphone usage behavior

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Smartphones have dramatically changed the reality we experience. Increasing evidence shows that using smartphones impacts many aspects of our lives - from how we sleep [1] to how we interact [2]. That smartphones impact our behaviour and well-being is well documented. But does the world around us also impact our smartphone usage? Some researchers have argued that our experiences in the physical world and contextual factors shape the use of smartphones for different purposes [3]. While plausible, this hypothesis lacks a solid empirical demonstration, due to the limited availability of logged data that captures both offline and online activities, exacerbated by the fact that self-reported data suffers from biases [4].

In this study, we exploit a longitudinal smartphone app usage dataset from 500k anonymised users worldwide and a quasi-experimental design to explore a key question: How does the environment that we live in shape the relationship we have with smartphones? Specifically, we focus on a key feature of the physical environment - the level of urbanization - by studying users that live in predominately urban vs. rural environments.

We start our analysis by comparing the median daily phone usage across the sample under study, and find it is 152.2 ± 0.5 minutes for rural users, and 174.9 ± 0.2 for urban users. By using a simple linear regression model, explaining 14.6% of the variance in the data, we, however, find that some differences in phone usage are strongly influenced by demographics, with the most important feature being age, followed by gender, country, and urbanization level.

To understand the key urban/rural split, we thus need to control for the effect of demographic variables. Here, we use a strategy of matching [5], where we compare rural and urban individuals having the same self-reported gender, age-group, and country of residence. By using this method, we confirm findings from previous small-scale studies, showing that the use of smartphones in rural areas is lower than in more urbanized areas. We indeed learn that urban individuals use the phone 5.12% more than their rural counterparts ($p \ll 10^{-20}$).

However, we also find that the higher smartphone usage in urban areas is only true for a certain subset of mobile applications. For each individual, we compute the fraction of the total smartphone time allocated to different uses. We focus on three different dimensions of smartphone usage: (i) the two broad types of smartphone uses, identified by gratification theory [6] as the *recreational use*, when the smartphone is used for diversion, or *instrumental use*, when the smartphone is used to pursue an actual goal; (ii) the Google Play Store categories of applications; and (iii) the specific applications. Figure 1 (a-c) shows the results of our matching experiment across the three dimensions of use. We find larger recreational use of smartphones in rural environments with e.g. increased use of gaming and social apps. In contrast, individuals rooted in urban areas tend to use smartphones more for instrumental purposes, e.g. Communication, Navigation, Travel, Business, and Productivity apps. Finally, in terms of single applications, we note that individuals in rural areas use social media such as Facebook (+17.8%) and Snapchat (+22.5) more, while urban individuals spend a larger fraction of time on Instagram (+14.3) and Twitter (+24.2).

These differences in smartphone use could i) be driven by differences between individuals who choose to live in urban vs. rural environments or ii) emerge because the environment itself affects online behavior. Using a quasi-experimental design based on individuals that move from

the city to the countryside – or vice versa – we confirm hypothesis ii) and find that urban/rural contexts causally regulate how individuals use their phone. Specifically, we use a difference-in-differences approach, matching each residential mover with all individuals that have the same urbanization level (preceding the move), self-reported gender, age-group, and median daily phone usage (in the period between 36 and 14 weeks before the move, $\pm$15 minutes).

Our results show that, in the period following the move, the median daily phone usage for individuals moving from urban to rural areas is $14.7\%\,[90\%CI : 14.1\%, 15.5\%]$ lower than baseline; for individuals moving from urban to other urban areas it is $5.5\%\,[90\%CI : 5.4\%, 5.6\%]$ lower than baseline; for individuals moving from rural to urban areas it is $11.7\%\,[90\%CI : 10.5\%, 12.9\%]$ higher than baseline; and for individuals moving from rural to other rural areas is $6.1\%\,[90\%CI : 5.3\%, 6.7\%]$ lower than baseline (see Fig. 1(d-e)). Moreover, we design an *urbanness* index, that measures the relative adoption of apps in urban areas compared to rural areas, to capture which apps are highly used in urban areas and not used rural areas and *vice versa*. By following the same difference-in-differences approach, we then study the evolution of daily smartphone urbanness, i.e. average urbanness of the apps used, for individuals who experience a residential move. We observe that in the period following the move, the smartphone urbanness for individuals moving from rural to urban areas is $52.3\%, [90\%CI : 48.0\%, 55.6\%]$ higher than baseline; for individuals moving from urban to rural areas it is $37.0\%, [90\%CI : 34.3\%, 39.3\%]$ lower than baseline (see Fig. 1(f-g)).

Taken together our results provide evidence that the environment people live in directly impacts their smartphone usage patterns. Our work represents a step towards understanding how our experiences in the real-world shape our relationship with technology. As such, our findings could provide information to better regulate persuasive technologies embedded in smartphone apps.

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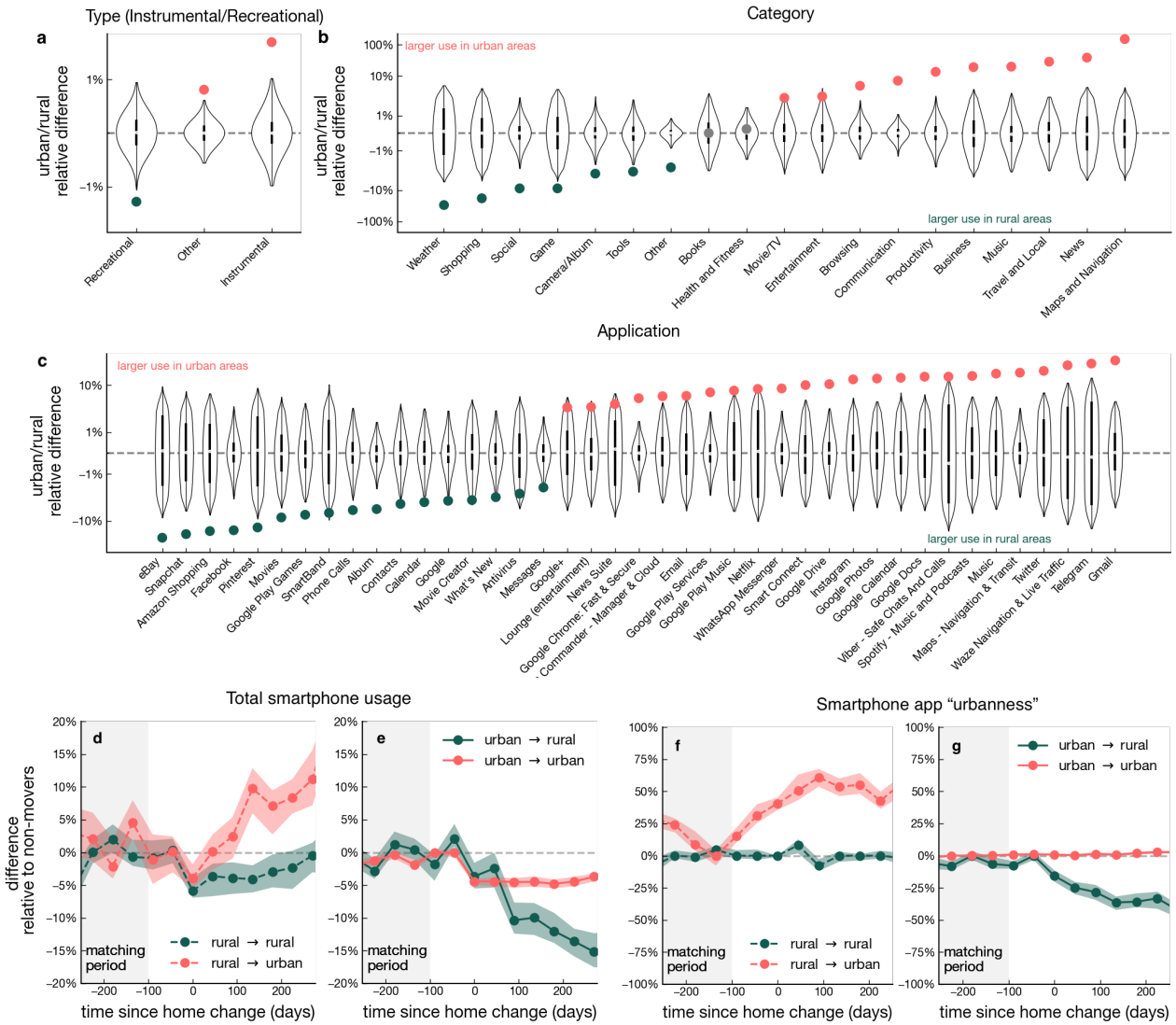

Figure 1: **Urban/rural differences in allocation of smartphone usage.** Relative difference between urban and rural individuals in fraction of smartphone time by type of usage (recreational/instrumental) **(a)**; category of application **(b)**; and single applications **(c)**. Each subplot shows the distribution of the median difference in randomized pairs (violin plots), and the actual median difference (dots). Dots are colored in red when the difference is significantly positive (larger usage in urban individuals), in green when the difference is significantly negative (larger usage in rural individuals), and in gray elsewhere. In panel **(c)** we display only the subset among the selected applications such that the median urban/rural difference is significantly different than 0. **Evolution of smartphone usage for residential movers.** Relative median difference in daily phone usage (d-e) and urbanness of apps used (f-g) between residential movers and their non-movers counterpart. Results are shown for **(d-e)** individuals moving from rural areas to urban (red dashed line) or to rural (green dashed line) areas; and **(f-g)** individuals moving from urban to rural (green plain line) or urban (red plain line) areas. The line corresponding to no difference relative to non-movers is shown as a gray dashed line. The period considered to match residential movers to their non-movers counterpart is displayed as a gray shaded area. Errorbars correspond to 90% confidence intervals computed by bootstrapping.