Returners and Explorers: An Analysis of Destination Choice Patterns in a 28 Day Travel Diary

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1. INTRODUCTION

Destination choice is a core component of modern activity-based transportation models. However, most studies rely on a single-day travel diary, assuming the observation day represents a "typical day". GPS-based travel diary phone apps now allow us to extend the observation period to a week, or even a month or longer. These data facilitate analyses of how travel is scheduled within longer time horizons and its variation across days (1–3).

According to Berger-Tal et al. "[t]he trade-off between the need to obtain new knowledge and the need to use that knowledge to improve performance is one of the most basic trade-offs in nature" (4). We are motivated in this work by the sociological study of such phenomena in humans defined by explore-exploit (explore-return) dynamics over the life course. Following Carstensen's socioemotional selectivity theory (SST), Frederickson and Carstensen find that people become more selective in their partner choice with age (5). SST further posits that motivations change as a function of age based on a shift in priority from exploration to emotionally meaningful connection. Childhood is understood as a solution to the explore–exploit tensions, providing a period of learning under the protection of parents (6). Gopnik provides the motivating example for our destination choice study (6). She contrasts the choice of a reliable restaurant that one has visited many times against trying a new restaurant that may provide a better or worse experience. The first option is dependable but provides no new information. Our hypothesis, following the return-explore paradigm, is that individuals tend to explore new destinations in their early years and return to the same destinations as they grow older.

With the increased availability of GPS trace data, there have been several studies exploring the return-explore dichotomy in human mobility patterns. The first work is by Pappalardo et al. using data for Pisa, Italy (7). Shan et al. refine the metrics originally defined by Pappalardo et al. and extend them to include duration, or stay-space (8). Wang et al. find that results are strongly dependent on the observation duration, with the returner:explorer ratio stabilizing at approximately 25-35 days (9). Zhang et al. provide the most similar study our work (10). They define data-driven destination choice models that use returner-explorer classification in the construction of choice sets. Their focus is on the ability to increase prediction accuracy using this metric.

2. METHODS OF ANALYSIS

We test several formulations of a return-explore metric based on total radius of gyration. The metric is outlined in equations 1-3 and illustrated in Figure 1. The total radius of gyration is the average distance between locations r_i and the centre of mass r_{cm} for L trips to each location i and N trips. The return-explore dichotomy is defined by the ratio of total radius of gyration r_g to the radius of gyration for the k most visited location, $r_g^{(k)}$.

$$r_g = \sqrt{\frac{1}{N}\sum_{i \in L} n_i (r_i - r_{cm})^2} \tag{1}$$

$$r_g^{(k)} = \sqrt{\frac{1}{N_k}\sum_{i=1}^{k} n_i \left(r_i - r_{cm}^{(k)}\right)^2} \tag{2}$$

$$\frac{r_g}{2}\begin{cases} < r_g^{(k)} \ (returner) \\ > r_g^{(k)} \ (explorer) \end{cases} \tag{3}$$

In Figure 1, the red and blue dots are the two most visited locations. For the same r_g, a returner is distinguished from an explorer by having an $r_g^{(2)}$ that is at least half its r_g. That is, a large portion of the explored space is described by the two most visited locations.

The above metrics can be modified in several ways. A simple change is to replace the centre of mass with the home location. A second change incorporates stay space defined as the time at a destination (8).

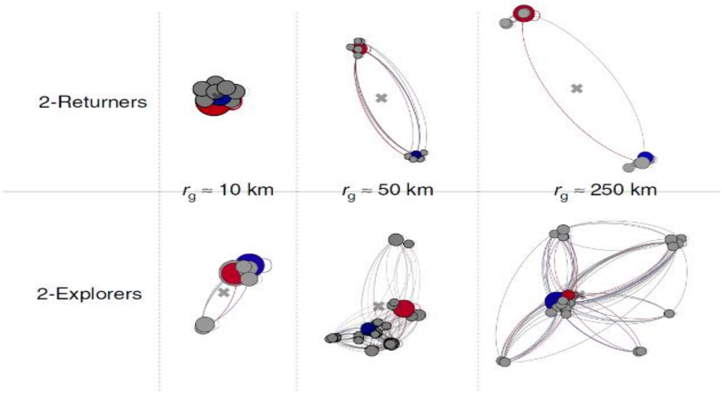

Fig. 1. Individual mobility networks of returners and explorers.

$$r_{gs} = \sqrt{\frac{T_i}{T_s}\sum_{i \in L} n_i (r_i - r_{cm})^2} \tag{4}$$

where r_{gs} is the radius of gyration by stay space, T_i is the total time spent at destination i, and T_s is the total time spent at all destinations. Other relationships are as defined above, with the same time weighting applied to Equation 2.

We postulate that the return-explore dichotomy characterizes long-term preferences in a similar way as dwelling and vehicle ownership decisions. As such, we follow the approach of Vij and Walker applied to mode choice in our destination choice by defining a latent class with feedback model structure (11).

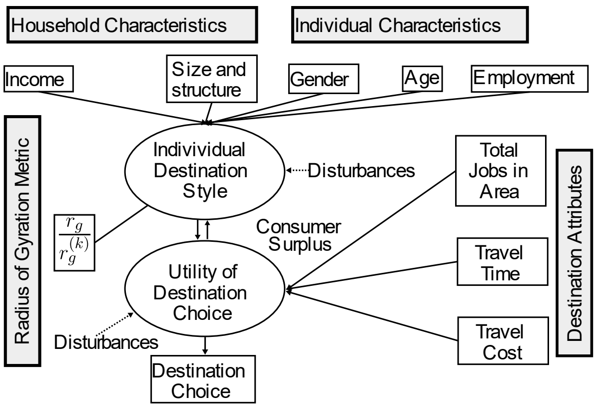

Fig. 2. Influence of individual destination style on destination choice.

3. DATA

Our dataset is the TimeUse+ survey collected over a 4-week period in German-speaking Switzerland (12). The time use diary was collected via a smart-phone app for 1,329 participants using passive GPS tracking. The response rate was 2.1% of invited participants and 35.4% of those who registered to complete the survey. In contrast to most other return-explore studies (with the exception of Zhang et al. (10)), the TimeUse+ dataset comprises more than simple GPS traces. It collected socio-demographic characteristics, mode inference, and time use details. The time use information was collected for "stay events" (i.e., the time between inferred trips) and included eight activity types at workplaces and 16 activity types at location other – e.g., chores/errands, digital entertainment, eating/cooking, leisure, shopping, sleeping/resting, working/studying, self-care, and other. The survey also includes expenditure questions.

4. RESULTS AND DISCUSSION

We present a subset of our initial results below. The GPS trace data are provided as coordinates, so there is a need to aggregate them to destination locations. We explore two methods of aggregation. The first is to use a 20-metre radius as a specific destination location. This radius was chosen as a starting point and gave reasonable results (see Figure 3), but larger radii will be explored in subsequent work. Our second aggregation is zip codes, which represent relatively large areas in Switzerland but are useful for understand long-distance travel over the 28-day period. Wang et al. use a DBSCAN clustering approach, which also seems a promising alternative (9). Figure 3 illustrates the radius of gyration distributions for various values of k and contrasts them with the total radius of gyration considering all points. In this initial work, we have included all purposes in the analysis. Ongoing work is extending the analysis to distinguish between destination purposes and filter out home and work locations.

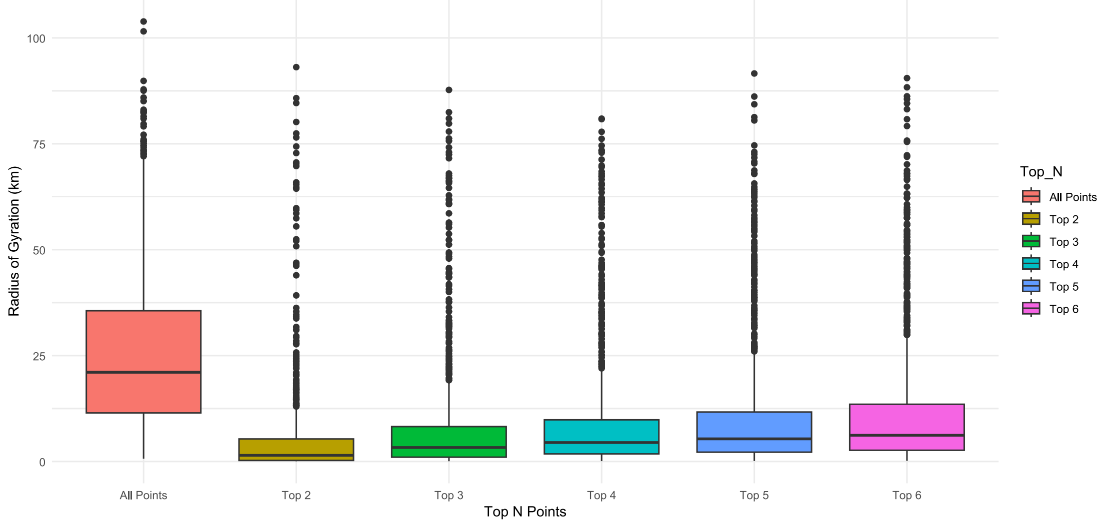

Fig. 3. Radius of gyration distributions by 20m radius.

A motivating question when comparing the returner-explorer dichotomy is the effect of age on destination exploration space. Figure 4 shows the results using the standard location-only radius of gyration for the five most visited locations. The pattern does not fit the expectation from the sociology literature than exploration decreases with age. However, the current analysis includes work locations. As such, it is likely the case that older persons who no longer work will exhibit more variation in their destinations relative to those of working age with regular daily travel schedules. Figure 5 provides the corresponding results for the stay-space metric. The results by this metric are similar to those considering location only and do not suggest an age effect.

Fig. 4. Proportion of returners/explorers for k=5 by age for location-only radius of gyration.

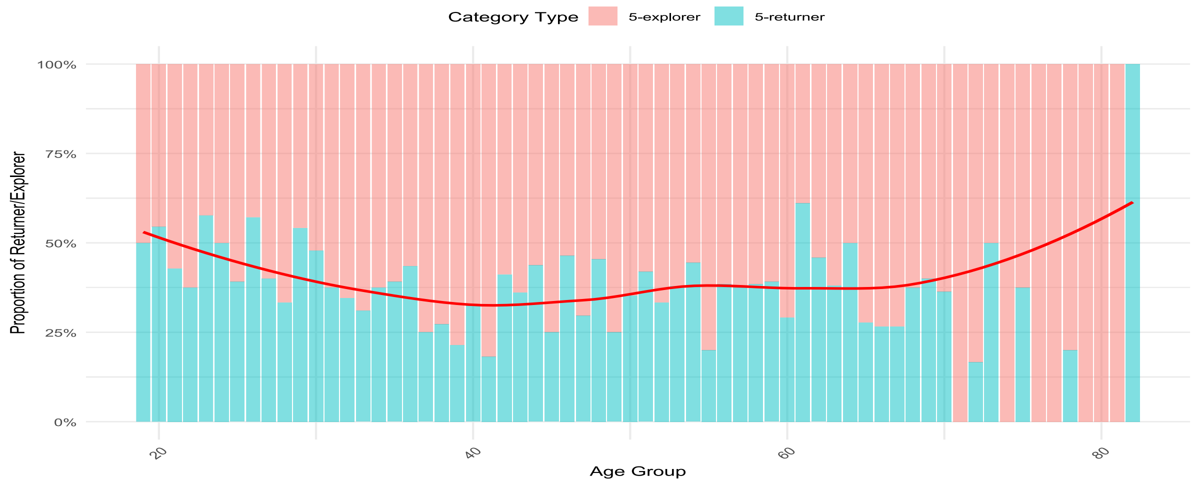

Fig. 5. Proportion of returners/explorers for k=5 by age for stay-space radius of gyration.

We considered ages clustered into ranges and multiple k values with minimal effect on results. Comparisons by employment status, vehicle ownership, and income also show minimal variation in the proportion of returners to explorers.

5. NEXT STEPS

We present initial results for this study, which we plan to expand prior to the ISTDM conference. First, we will distinguish between destination purposes by removing home and work locations from the results, as well as comparing results by purpose category. Second, we will finalize our analysis of sensitivity of results to radius of gyration definition and k value. These results will be incorporated into the latent class with feedback destination choice model. Multiple radius of gyration metrics (e.g., by destination purpose) could be incorporated into the latent destination style measure. The model will provide insights into the demographics that influence destination style and more fully test the hypothesis of variation as a function of age according to the sociology findings. Another modification arises from the standard explore-exploit framework in computer science. This approach defines a regret minimization function, which we can parallel using a random regret minimization assumption in the destination choice model, similar to Santos Mauad and Isler (13).

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