Journeying Through Sense of Place with Mental Maps: Characterizing Changing Spatial Understanding and Sense of Place During Migration for Work

ZIHAN GAO, Information School, University of Wisconsin-Madison, Wisconsin, USA
JUSTIN CRANSHAW, Maestro AI, Washington, USA
JACOB THEBAULT-SPIEKER, Information School, University of Wisconsin-Madison, Wisconsin, USA

Millions of people move for work yearly, but this labor migration risks social and cultural challenges, hindering migrants' integration into new communities. Software tools could support this transition, but the design space around, and the mechanisms behind, how individuals develop spatial understanding and "sense of place" is unclear. In our study, we leverage mental maps to explore migrants' "sense of place". We conduct a mixed-methods study with 12 participants, spanning two sessions — one before and one after their relocation, totaling 24 data sessions. We discover that post-relocation, mental maps not only widen coverage and generalization but also decrease in cartographic complexity and accuracy, reflecting a nuanced blend of personal narratives and spatial awareness. We also find that strategies for rebuilding and reshaping "sense of place" span a complex set of dimensions spanning personal, social and environmental challenges, post-move. Our findings lay the groundwork, and underscore the need, for "platial" (versus spatial) understanding and tools to rebuild sense of place, and foster better community cohesion. We highlight design opportunities for creating tools, especially those capturing personal nuances, to help migrants reestablish themselves and their sense of place.

CCS Concepts: • **Human-centered computing → Empirical studies in collaborative and social computing**.

Additional Key Words and Phrases: sense of place, mental map, spatial understanding, migration, relocation, placemaking

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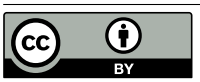
1 Introduction

Labor migration is a prevalent phenomenon worldwide, with individuals and families moving to new locations in search of better employment opportunities. In 2022, the United States Census Bureau reported that approximately 26.8 million people moved within the country, with 4.5 million of these moves being employment-related [22]. Similarly, China's National Bureau of Statistics reported approximately 172 million migrant workers in the country in 2021 [78]. Despite the potential benefits of labor migration, such as increased economic opportunities, improved living conditions, and regional growth in less populated places [53], adapting to new environments presents numerous challenges for people who move. For instance, cultural differences can create

Authors' Contact Information: Zihan Gao, zihan.gao@wisc.edu, Information School, University of Wisconsin-Madison, Madison, Wisconsin, USA; Justin Cranshaw, justin@cranshaw.me, Maestro AI, Seattle, Washington, USA; Jacob Thebault-Spieker, jacob.thebaultspieker@wisc.edu, Information School, University of Wisconsin-Madison, Madison, Wisconsin, USA.



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difficulties in adapting to unfamiliar customs, languages, and traditions. Difficulties in integrating socially can lead to isolation and identity confusion [11, 12, 105], as well as loneliness and exclusion [3, 59, 81]. Migrants also experience challenges economically [15, 29], and in accessing healthcare and education because of unfamiliarity with local systems, language barriers, or discrimination [80, 113]. Overall, migrating and adapting to a new environment can create significant psychological stress and anxiety, as well as harm general mental health and well-being [13, 93].

Due to these various difficulties, people who move for work are left to adapt to their new home independently, which involves reconstructing their *sense of place*. Sense of place refers to the emotional and psychological connections that people form with a particular area, such as a neighborhood, city, or region [95]. Methods for measuring sense of place vary [55, 74, 86, 109], but these emotional and social connections encompass place attachment, place dependence, and place identity. These emotional and social connections often stem from personal experiences, memories, and cultural traditions, as well as place meanings like adjectives, symbols, and characters associated with the place [74]. Moreover, people are able, to some extent, to spatially map these emotional and social connections, as well [67]. In other words, because of a generalized sense of place and the emotions and social connections one has, people construct their own "mental maps", relating their emotional and social ties in the place to specific spatial locations as well. A strong sense of place provides belonging and connection to one's surroundings, and supports well-being, satisfaction, and social integration [1, 2, 30, 95].

However, when labor migrants move for a job, their sense of place and mental maps are disrupted, and they are left needing to navigate the social, emotional, and spatial uncertainty associated with their move. Unfortunately, dedicated tools to support this social process of adapting to and integrating with the communities in one's new home do not exist. While some HCI research has addressed related issues, such as supporting temporary tourism [27, 75, 110, 112] or studying geofenced online communities like NextDoor [72], these efforts do not fully address the unique challenges faced by labor migrants. Existing studies have explored the use of mental maps and local knowledge to enhance location-based services, but these are often in the context of prototypes or specific applications [10, 32, 33, 47, 51, 57, 84]. In contrast, traditional location-based services frequently provide a uniform, normalized view of places, overlooking the rich diversity of individual experiences and perceptions [42]. This gap in support for labor migrants, coupled with the significant impact of migration on individual well-being, presents a vital area for development in social computing and HCI research. There is a pressing need for innovative, empathetic tools and systems specifically designed to assist labor migrants in rebuilding their sense of place and integrating effectively into their new communities.

Therefore, in this study, we take an initial step towards characterizing this phenomenon to help shape the design space by analyzing migrants' spatial understanding and emotional ties to places. We achieve this by focusing our work here around migrants' *transition*, studying how labor migrants' mental maps and sense of place *change* upon relocation. Our research involved 12 participants, each partaking in two sessions—before and after their move, totaling 24 data sessions. This approach allowed us to capture detailed insights into the dynamics of sense of place during the migration process. Our work makes four primary contributions:

(1) We introduce a comprehensive and comparative analysis of mental maps as a method to explore migrants' spatial experiences. Our findings show that participants' mental maps widen the number of points of interest (POIs) and geographic area mapped, but decrease in terms of specificity of mapped entities, visual cartographic complexity and overall accuracy. These changes in spatial knowledge are intricately linked to individual traits, social interactions, and physical surroundings, laying a foundation for future HCI applications.

(2) Through our interviews, we show how labor migrants' "sense of place" is built, how it changes, and what kinds of challenges people face in reestablishing their sense of place when they move for work. We find that migrants face a complex set of challenges when seeking to rebuild their sense of place that span personal, social, and environmental dimensions.
(3) By relying on "platial" (rather than "spatial") methods, some of which are new to the field of HCI, we enable visibility into how moving for work disrupts migrants' sense of place and mental maps. In doing so, our work builds on and extends the long-standing body of research in HCI on "place", and lays the groundwork for re-focusing much geographic HCI work through a "platial" lens, echoing and adding nuance to Harrison and Dourish [44]'s foundational work.
(4) We develop a set of design recommendations towards extending current location-based technologies with place-based tools to better support people in reestablishing their sense of place and mental maps, and towards supporting labor migrants in more effectively adapting to and integrating with their new home.

2 Related Work

2.1 Migration

Migration, as defined in prior work, refers to the movement of people from one geographic location to another with the intention of settling temporarily or permanently in the new location [17]. This movement can be within a country (internal migration) or between countries (international migration), and it can be voluntary or involuntary, driven by a variety of factors including economic, social, political, or environmental issues [25]. A particular form of migration that has garnered significant scholarly attention is labor migration. Labor migration is the movement of people from their home area to another region or country for the purpose of employment [49]. This form of migration is often driven by economic disparities and job opportunities, and it plays a significant role in global economic development [71].

Nevertheless, labor migration presents a myriad of challenges for the individuals involved. Migrants often face language barriers, cultural adjustments, social isolation, discrimination, and precarious employment conditions [24]. Moreover, they often have limited access to social protection and health services, which exacerbates their vulnerability [111]. Focusing on related topics, HCI scholars have delved into the challenges faced by refugees and asylum-seekers, leading to the development of technologies aimed at facilitating their transition, such as aiding social integration by increasing accessibility of information and services [6], and predicting migration flows [65]. However, there remains an opportunity to better support labor migrants' transition and reintegration.

2.2 Sense of Place

Simplistically, migration entails moving from one "place" to another. However, "place" is a complex scholarly concept that encompasses more than just a physical location or a point on a map. In human geography, place is often defined as a location that has been given meaning through human experience and social relationships [34], a particular, unique, "spot" in space that humans endow with meaning and value [4]. This process of meaning-making may be influenced by a wide range of factors, including cultural practices, historical events, or personal memories associated with that location [73]. While space refers to the physical dimensions of a location, place is imbued with a sense of belonging and identity [87]. Spaces become places by combining locations, social relationships, and subjective or emotional attachment, i.e., sense of place [87]. In other words, places are socially constructed, and imbued with human value and meaning.

For an individual, "sense of place" involves emotional bonds to particular locations, as well as the values, meanings, and symbols attributed to those places [108]. This concept further encompasses "place attachment" and "place meaning" [74, 94, 104], which represent emotional connection and subjective attachment people form with a place [34, 107], as well as the significance that gets ascribed to a specific location by individuals or groups [94, 104]. Importantly, sense of place — and related concepts like place attachment and place meaning — is not merely emotional connection, but has been shown to support people's well-being [74, 95] and social integration by fostering belonging and supporting sensemaking in new environments [74, 95]. For this reason, sense of place may influence how people respond to changes and disruptions in their lives, like relocating for a job [1, 74]. Labor migration and relocation disrupts sense of place by disrupting place identity and weakening place attachment [82]. This disruption which may lead to loss of identity, association, or detachment from previous places and communities [82], and can reshape individual identity through changes in both the spatial environment and self-perceptions [82].

Because sense of place is so multi-faceted, a number of methods for assessing it exist. Quantitatively, standardized instruments like the one developed by Jorgensen and Stedman [55] assess place attachment, place identity, and place dependence, offering a structured framework for data collection and analysis. Qualitatively, researchers have also sought to capture deeper and richer understandings of personal experiences and emotions linked to specific places. Beckley et al. [9], for example, utilized photography to evoke strong personal and emotional responses of sense of place, providing insights into the connections individuals have with their environments. Brown and Raymond [18] used spatial mapping techniques to spatial visually represent place attachment and highlight significant areas or places for individuals or communities. Russ et al. [88] conducted narrative interviews, enabling individuals to articulate connections and meanings associated with places in their own words. Notably, different techniques capture different aspects of sense of place, but prior work suggests researchers may need to use them in conjunction with one another to develop a more holistic understanding of sense of place [19, 56, 74, 94]. We follow this recommendation in our work here, and combine a number of these methods, in order to capture both quantifiable data and the rich experiential aspects of migrants' sense of place *during their transition.*

2.3 Mental Maps

"Mental maps," also referred to as "cognitive maps," represent another key mechanism for understanding the dynamics of labor migration. These maps are internal representations of an individual's spatial environment, shaped by personal perception, experience, and purpose [36, 61]. Rather than being exact geographic blueprints, mental maps consist of significant elements that contribute to the map's "imageability," such as paths, edges, districts, nodes, and landmarks [67]. Researchers have used mental mapping exercises to evaluate an individual's sense of place. Jorgensen and Stedman [56] used subjective mapping methods to allow participants to draw spatial boundaries of meaningful places and rate their sense of place, assessing aspects like place identity, dependence, and attachment. Harrington Jr [43] used mental maps to assess Kansas third graders and their community-based sense of place. Manrique-Sancho et al. [69] explored the use of mental maps for personalizing city maps for tourists in Madrid, demonstrating how mental maps can provide valuable insights into the perception and experience of city spaces. Montello [76] showed substantial variation in the spatial knowledge that people have from their direct experiences, suggesting that mental maps are heavily individualized, complicating the potential benefit to research in assessing sense of place. Some research [20] has merged traditional mental map techniques with Geographic Information Systems (GIS) to construct a "social landscape," overlaying areas of community interest and identifying spatial areas significant to larger groups. Some research focuses specifically on collective spatial knowledge, Akbar et al. [5] highlighted mental maps' significance in achieving

Sustainable Development Goals (SDGs), especially in contexts where geospatial data is scarce. Jang and Kim [51] introduced crowd-sourced cognitive mapping through social media data analysis, offering a novel perspective on urban spaces' collective cognitive perceptions. Similarly, Huang et al. [48] found that digital traces left by social media users could serve as modern-day mental maps, reflecting individuals' perceptions and experiences of places in a dynamic, real-time manner.

In our study, we leverage mental maps as a crucial component in measuring the changes in sense of place as labor migrants transition. These maps provide a unique perspective on how individuals perceive and adapt to new environments during the process of migration. The inherent subjectivity and individualization in mental maps form an important aspect of understanding the spatial dynamics of psychological experiences in various places. Therefore, mental maps serve a dual purpose in our research: they are tools for spatial understanding and lenses for exploring the emotional and psychological connections that migrants form with their new environments.

2.4 Place and Mental Maps in HCI

2.4.1 Place in HCI. The concept of place as distinct from space has long been an important consideration in HCI research and system design. Nearly 30 years ago, Harrison and Dourish [44] argued that place is a more fitting metaphor than space for collaborative systems and interactions. They highlight how place emphasizes sociality, meaning, and connectedness, whereas space connotes distance and separation. This distinction was revisited a decade later by Dourish [35], who examined how developments in mobile and wireless technologies influenced the understanding and application of place and space. The research emphasized viewing space as a social construct much like place, and highlighted the interplay between space, spatial practice, and information technologies. Building on this conceptual foundation, Harrison and Tatar [45] delved deeper into the relationship between space and place, focusing on how the distinct contexts of individuals, events, and locations (termed loci) together constitute meaningful places through lived experiences in a physical space. They introduced the notion of a "semantic tangle" of people, events, and loci that shapes place meanings. Our current work builds on these foundational conceptualizations by examining how the interplay between people (migrants), events (relocation), and loci (physical environments) influences the evolution of migrants' sense of place when they move for work.

2.4.2 Digital Placemaking. Recent HCI research has explored the potential of technology for digital placemaking. Sun [97] advocated for incorporating playful, open-ended interactions in such systems to enrich user experiences. Cranshaw et al. [31] introduced Journeys & Notes, a mobile application designed to transform "non-places" — spaces devoid of historical or cultural significance — into hubs of community interaction. Using location-based social computing, the application aims to enrich these transient spaces by allowing travelers to log journeys and engage with others anonymously and asynchronously, thereby infusing these areas with communal and cultural relevance. Sun et al. [98] introduced MoveMeant, a system designed to bolster local community awareness through shared, anonymous location histories. In a follow-up study, Sun and Naaman [99] extended its deployment across diverse communities, revealing the system's potential to heighten community awareness.

2.4.3 Mental Maps in HCI. Mental maps have also found broad application in HCI for designing and evaluating location-based services and applications. For example, Bentley et al. [10] explored how mental maps reveal differing perceptions of urban environments, demonstrating their value for more nuanced understandings of city spaces. Similarly, Quercia et al. [83, 84, 85] employed psychological mapping techniques in several projects related to urban computing, including creating a web-based community engagement platform in London, recommending beautiful, quiet, and happy walking routes in cities, and investigating the digital life of walkable city streets. Other

Table 1. Items/Content of Each Procedure

Procedure	Items/Content	References
Demographic Information Survey	Age, gender, education, income, occupation, cultural background, language proficiency	[60, 64]
Migration Information Survey	Migration date, departure, destination, distance, duration, nature, partner, and travel mode.	[60, 64]
Mental Mapping Exercise	We instruct participants to sketch a map of their current residence, incorporating elements such as buildings, roads, and natural features. We also ask them to label each object on the map and annotate their experiences using visual cues like emojis. During the mapping process, we encourage participants to verbalize their thoughts. We audio-record these think-aloud sessions for subsequent analysis.	[20, 36, 54, 56, 61, 67]
Sense of Place Instrument	Place identity, natural bonding, place dependence, family bonding, and friend bonding	[74, 86]
Semi-structured Interview	We prompt participants to articulate their sense of place, delineating the process of its formation. We further ask them to pinpoint both the aids and challenges they encounter in cultivating their sense of place and to elucidate how they leverage these aids and navigate the challenges. For further analysis, we audio-record all interviews.	[34, 74, 95, 104, 108]

researchers have used mental maps to understand city dynamics reflected in social media data [32, 33, 89], explore heritage visitors' spatial perceptions [63], map perceptions and emotions about air pollution [66], and support sensory navigation for blind and partially sighted people [47]. Moreover, Thebault-Spieker et al. [102] suggest that sharing economy workers' mental maps shape and limit their willingness to complete tasks, which contributes to systemic disparities in sharing economy services.

3 Method

In our work here, we aim to deeply explore how the transition resulting from labor migration affects an individual's sense of place, and how people rebuild their sense of place and reintegrate into a new community after their move disrupts these previously stable aspects of their lives. To do so, we bring together a variety of methods that enable us to characterize an individual's "sense of place" and their mental "spatialization" of the social, emotional, and personal connections they have to places. To pursue this agenda, our study here focuses on three primary questions:

RQ1: How does labor migration influence an individual's mental maps and sense of place?

RQ2: Following relocation, how do individuals adapt and adjust their mental maps and sense of place to their new surroundings?

RQ3: What specific challenges do migrants encounter in constructing their new sense of place and mental maps post-relocation, and what support systems do they utilize to navigate these obstacles or leverage available resources?

3.1 Study design

To address the dynamic nature of labor migration, we adopted a two-phase approach, capturing the pre- and post-migration experiences of our participants. With this dual-phase design, we gathered 24 data sessions from 12 participants, enabling us to directly study participants' *transition* process. In both phases, we asked participants to complete a three-step data collection process: (i) mental

map elicitation, (ii) sense of place instruments, and (iii) semi-structured interviews. By triangulating the labor migrants' transition using these three different methods, we strengthened the reliability of our results and deepened our understanding of how moving for work reshapes and changes participants' sense of place.

We first asked participants to complete two short surveys, focusing on their demographics and the details of their migration. For the demographic survey, we asked about their age, gender, education, income, occupation, cultural background, and language proficiency. For the migration survey, we asked participants to share their migration date, migration characteristics (distance, duration, frequency, and companions), and their travel mode in the new place. These surveys served to contextualize individual experiences and identify patterns in their migration processes. After completing the surveys, we held two sessions with each participant. One pre-move session that occurred before they moved, and one post-move session after they had successfully moved. In both sessions, we asked participants to go through the three-step process.

In the mental mapping exercise, we asked participants to draw — with a pen and paper — a map of where they currently live, while verbalizing their thoughts. The mapping and think-aloud process was designed to elicit participants' cognitive spatial understanding and qualitative sense of place. Upon completing the mapping exercise, participants took a photo of their map and shared it with us. We then asked participants to complete Raymond et al. [86]'s sense of place scale, which provides a high-level, comprehensive overview of participants' attachment and the elements influencing their sense of place. Finally, through semi-structured interviews, we explored participants' migration experiences and the resultant shifts in their sense of place, delving into personal narratives of how their sense of place transformed.

We designed our methodological approach here to integrate three distinct techniques for measuring sense of place, in a two-phase approach, to try to holistically capture the dynamic process of migration and its multifaceted effects on individuals. However, in order to be confident in the approach we planned to take and make sure that it would support our research objectives, we first conducted a pilot study with five participants. From the pilot study, it became evident that an ideal session ranged from approximately 1 to 1.5 hours. Participants' feedback in the pilot was instrumental in enhancing the procedure of each component, particularly in improving the clarity of the instructions and language used during interviews. Table 1 presents the refined study procedures along with their respective components in detail. The pilot study also helped increase our confidence in our approach: combining a mental mapping exercise, a sense of place instrument, and interviews yielded a comprehensive understanding of the shifts in individuals' sense of place due to migration. This triangulated approach, which leverages multiple data sources, is designed to develop a nuanced understanding of labor migrants' experiences and perceptions about the transition itself, and how this transition disrupts their sense of place, as well as their spatial and emotional connections to their environments.

3.2 Participants

In recruiting participants, we sought to authentically represent the experiences of individuals migrating for work, while also capturing a broad spectrum of perspectives. The criteria for participant selection were as follows:

Migration Timing and Status: To effectively study this process, we required participants within a specific timeframe. We held the first session with participants within one month prior to their scheduled move. Similarly, after participants moved, we held our second session with participants within a month. However, in order to give participants a chance to develop some understanding of their new home, we also did not conduct the second session until at least 2 weeks after they moved.

Geographical Context of Migration: Following the classification from King [60], we recognized that migration experiences vary with geographical contexts, including rural-to-urban, urban-to-rural, rural-to-rural, intra-urban, and inter-urban transitions. We classified rural and urban settings using the NCHS Urban-Rural Classification Scheme for Counties [37]. Our recruitment strategy aimed to encompass participants representing these diverse spatial experiences.

Demographic Representativeness: More broadly, we also aimed to include participants from diverse backgrounds, and worked to diversify along dimensions like age, gender, education, income, occupation, and cultural background.

Our initial recruitment strategy involved distributing flyers via social media platforms like Twitter, Facebook groups, and WhatsApp groups. However, given the study's focus on work-related migration, this method had limited reach. To counteract this, we implemented a snowball sampling technique, wherein existing participants referred potential candidates fitting our criteria. This approach effectively broadened our participant base.

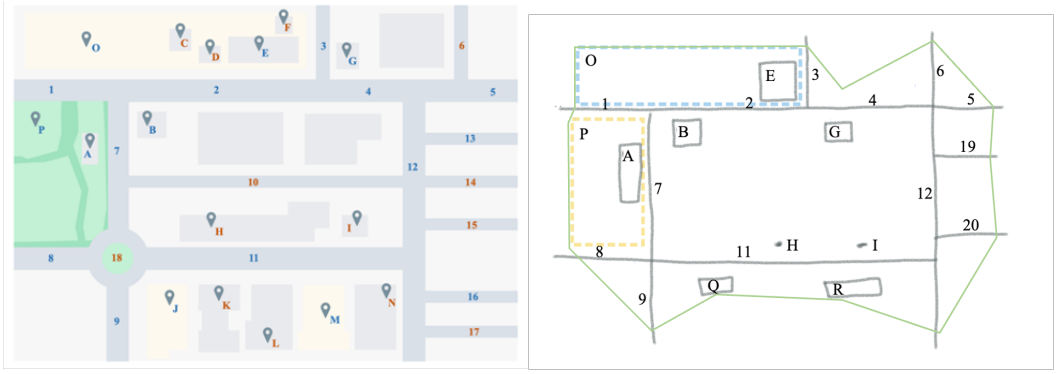
Participants received compensation in the form of $15 Amazon gift cards per hour of participation. Additionally, to encourage consistent participation across both sessions, we introduced a raffle, offering participants who successfully completed both sessions the opportunity to win a $30 Amazon eGift card.

3.3 Data Analysis

A consequence of our data collection approach was the accumulation of both quantitative and qualitative data. For our interviews and the mental mapping think-aloud transcripts, we relied on a grounded theory-style approach. We began by transcribing the audio recordings from participants' think-aloud sessions during mental map creation and their interviews. The first author then conducted multiple rounds of iterative coding. Initially, we began by open coding our transcript data, and iteratively revisited our codes a number of times as we developed an understanding of our data, following a constant comparative approach throughout the coding stages. This involved continuous juxtaposition of data against evolving categories and themes, ensuring thoroughness in our analytical process. Additionally, within this qualitative framework, we placed a strong emphasis on the narratives and descriptions shared by participants. Our aim was to grasp not only the content represented in their mental maps but also their perceptions and articulation of place experiences. This approach enabled us to capture the subjective and nuanced dimensions of migrants' experiences, essential for a comprehensive understanding of the impact of migration.

To analyze the final hand-drawn maps, we follow techniques from a number of prior studies [7, 8, 14, 28, 41, 46, 77, 90, 91]. Our work here introduces these techniques to the CSCW and HCI communities, and we hope it can help further expand HCI researchers' toolkit in understanding "platial" dynamics. We return to this in more detail below. We introduce five different metrics for comparing participants' mental maps, which broadly fall into two categories: **map coverage** and **familiarity**.

Map Coverage Prior work suggests that mental map coverage can be thought of in terms of the percentage of possible objects that were mapped, and the scale reflected in the maps [8, 90, 103]. We operationalized these two map coverage metrics as *Map Object Percentage* and *Area Coverage Percentage*. Drawing on the classifications of mental map objects in prior work [7, 8, 40, 62, 67], and guided by the objectives of our metrics analysis, we categorized the objects on participants' mental maps into two primary types: features and roads. Here, "features" refer to non-road elements like buildings, landmarks, or other spatial entities depicted on the map. To measure *Map Object Percentage*, we tallied the total number of features and roads depicted on each of the participants' mental maps. Due to variations in spatial scale, we normalized this count against the total number of POIs and unique roads (distinctive by road names). To gather the total number of POIs within



(a) Example Base Map (b) Example Mental Map

Fig. 1. Alphabetic characters replace feature labels, and numeric identifiers mark road segments. Dotted line rectangles delineate specific regions. The base map employs color coding to indicate segment alignment: orange denotes generalized or incorrect segments, and blue signifies segments that accurately align with the mental map. Green polygons represent the map coverage.

a region, we used the `findNearbyPOIsOSM` API from Geonames [39] to extract all entities in OpenStreetMap that are considered POIs by the OpenStreetMap community for that city. Geonames does not include road information, so we similarly extracted all roads in the city in question from OpenStreetMap. By computationally gathering the full dataset for each city in question, this approach captures variation in the number of POIs or roads, and establishes a regional baseline of POIs and roads, which we then use to normalize the number of POIs and roads reflected on participants' mental maps. By comparing the number of objects in participants' mental maps against the number of objects from more complete map data, we computed a normalized object percentage for each mental map. To compute our *Area Coverage Percentage* variable for participants' mental maps, we digitized these maps using QGIS, an open-source geographic information system application. We began by identifying and locating precise coordinates of specific points on the mental maps. From these points, we segmented the mental maps into polygons and calculated the geographic area within these polygons. This process enabled us to compute the total spatial area of each participant's mental map. We then normalized this total area of each mental map, relative to the entire city or town area, data for which we sourced from the United States Census Bureau [21]. Thus, *Area Coverage Percentage* reflects the extent to which a participant's mental map encompasses the total area of the city or town, expressed as a percentage.

Familiarity Whereas our map coverage metrics, above, use an external ground truth denominator to measure how well participants' mental cover what "should be" on the map, our next set of metrics aim to characterize how familiar participants are with the region mapped. In this spirit, we implemented three metrics in prior mental mapping literature: *Cartographic Complexity*, *Map Generalization* and *Qualitative Map Accuracy*. The *Cartographic Complexity* variable in our study describes the complexity of the topological and positional characteristics represented on participants' maps. Appleyard [7] developed a schema for cartographic complexity that categorizes the cartographic complexity of *spatial* and *sequential* aspects of the map. Spatial elements include things like buildings, and landmarks, and sequential elements include things like roads. Appleyard [7]'s schema assigns a categorical score to each mental map, from 1 (least complex) to 4 (most complex) along both dimensions. For the spatial dimension, the four categorical labels are *Scattered*, *Mosaic*, *Linked*, and *Patterned*. Similarly, the four sequential complexity category labels are

Fragmented, *Chain*, *Branch* and *Loop*, and *Netted*. For both the spatial and sequential dimensions, we followed Appleyard [7]'s categorical definitions and categorize each of our participants' mental maps along these dimensions, assigning a spatial complexity score and a sequential complexity score.

The next metric we introduce to describe participants' familiarity is *Map Generalization*, which measures the degree of abstraction or granularity in a participant's mental map, reflecting how abstract or specific participants' spatial knowledge is about the region. We relied on best practice from Manivannan et al. [68], and adopted their seven-tiered model to assess participants' mental maps. Based on their schema, we focused on two primary categories, that align with the content of our participants' maps: road generalization and feature generalization. "Road generalization" encompasses various sub-categories, such as collapsing adjacent roads into one, representing of roundabouts as standard four-way intersections, or a reduction in the total number of streets represented. Similarly, "feature generalization" involves sub-categories such as representing building or landmark footprints as points, merging clusters of features into a singular entity, or simplifying the actual geometry of these features. Notably, to measure these two types of generalization, we again compare participants' mental maps to a corresponding real-world map. If a participant's mental map corresponds one-to-one with the real-world map, that would indicate no generalization. However, in most cases, mental maps are do not align perfectly. We present an example of this in Figure 1. For example, comparing the two maps in Figure 1, we see that buildings labeled J, K, L, M, N alongside Street 11 in the base map are not well represented in the mental map on the right, but instead are somewhat generalized. Manivannan et al. [68]'s schema would describe this example as one instance of generalization, in which the mental map simplified the actual geometry of these features.

To measure this kind of map generalization systematically, we counted the number of road and feature generalizations in each mental map and normalized these numbers against the total number of roads and features in the areas depicted by participants. We then also computed an overall generalization metric by averaging the values for road and feature generalizations. Specifically, our map generalization values range from 0 to 1, and represent the percentage of features on the map that were abstracted or generalized compared to a ground truth map. A generalization score closer to 1 indicates a higher level of generalization, while a score closer to 0 suggests lower generalization. We provide a detailed analysis of the map generalization for example mental map (Figure 1), in Appendix A.

Our *Qualitative Map Accuracy* metric follows the seven qualitative metrics for sketches as presented by Schwering et al. [91], and this measure is designed to characterize how spatially correct the mental maps were. To better align with our study's focus, we have reorganized these seven metrics into two primary categories: road accuracy and feature accuracy. Road accuracy evaluates aspects such as the connectivity of street segments and directional relationships at intersections. Feature accuracy, in contrast, involves assessing the topological relationships of landmarks and regions, the interaction between street segments and landmarks or regions, the order of landmarks and intersections on a road, and the relative positioning of landmarks in relation to nearby street segments. For instance, in Figure 1, building G is positioned on the "northern" side of street 4 in the base map, whereas in the mental map, it appears on the "southern" side. This kind of discrepancy would be categorized as an incorrect relative position between street 4 and building G in our metric.

Similar to our map generalization analysis, the qualitative map accuracy assessment begins with a comparison between elements in the base map and their counterparts in the mental map (as depicted in Figure 1). For each base map element, we determined its qualitative accuracy using the aforementioned metrics. The accuracy for each sub-category was computed by dividing the count

of correctly represented element relationships by the count of all related element relationships in the mapped area. We then computed average accuracy for across the roads and features in the map, resulting in two values, average road accuracy, and average feature accuracy. We also computed the overall accuracy across both roads and features. An accuracy score closer to 1 denotes higher qualitative map accuracy, while a score closer to 0 indicates lower accuracy. As above, we provide a detailed example of the qualitative map accuracy for our example mental map (Figure 1) in Appendix A.

Statistical Analysis Given our relatively small participant pool, and to ensure a conservative approach regarding the distributional assumptions underpinning our analysis, we turned to descriptive and non-parametric methods for our data investigation. Because outliers or data skewness can heavily influence the mean in small samples, we report the median as a more robust measure of central tendency. To explore differences in our map data and sense of place instrument before and after participants moved, we employed the *Wilcoxon Signed-Rank Test*. This statistical test is designed for paired data, but without the assumption of normally distributed (parametric) differences. We report our findings from this test in two ways: the *median difference* (*MD*) between pre- and post-move sessions across our different metrics, and statistical significance indicated by p-values (p). In some cases, we also explored potential associations between different variables, and measured these correlations using the non-parametric *Spearman Rank Correlation*. For these results, we report the correlation coefficient (denoted as r), and p-value (p) to indicate the statistical significance of these correlations.

3.4 Methodological Limitations

Our study, detailed in Section 3.2, was conducted with a designated timeframe: one month prior to and following migration, with the second session scheduled at least two weeks following migration. This timeline was designed to allow participants ample opportunity to familiarize themselves with their new environment, while still enabling exploration of the *transition* phenomenon itself. However, future work should, using methods like those we use here, explore what the optimal timeline is for fully capturing this phenomenon. We also operationalized five distinct metrics to assess participants' spatial understanding, which involved comparing participants' *mental maps* against *complete* maps intended for general audiences. We describe these complete maps as "ground truth" and "baseline" data, in order to facilitate comparison. Of course, participants' *mental maps* are subjective (intentionally so), which allows capturing aspects of participants' sense of place. It may be that using more objective complete maps as a baseline to compare participants' subjective "platial" understanding is not the most appropriate approach. Such "baseline" comparisons may not fully encapsulate the more contextualized perspective that mental maps facilitate. As such, it is unclear the extent to which our quantitative findings generalize beyond the subjective context of our study setting, and we see this as an important direction of future work. While we conducted interviews to delve into these personalized perceptions, they were insufficient in fully capturing the individualized "localness," a topic we will expand upon in Section 5.3. Finally, our participant recruitment ceased when theoretical saturation was achieved with 12 educated U.S. citizens. While this methodological choice was pragmatic, it inevitably restricts the generalizability of our findings. Similarly, specific subgroups of labor migrants — undocumented agricultural labor migrants for instance — were not included in our study sample, pointing towards a necessary avenue for future research to address diverse migrant experiences. In particular, our results here may not generalize to settings where migration is caused by external factors — like changing climate, political instability, or economic need — and we see this as an important domain for future work.

Table 2. Statistics of Mental Map Metrics Pre- and Post-Relocation.

Dimension	Metric	Session 1		Session 2		Wilcoxon Test	
		Median (IQR)	Mean	Median (IQR)	Mean	MD	P-value
Map Coverage	POI Number (#)	10 (9.75)	11.667	15.5 (14.25) ↑	15.717 ↑	3.5	0.176
	Normalized POI Number (%)	2.821 (7.901)	7.571	7.849 (14.047) ↑	11.273 ↑	1.578	0.027 *
	Road Number (#)	5 (5.5)	5.333	3.5 (7.5) ↓	5.583 ↑	0	0.97
	Normalized Road Number (%)	7.881 (21.723)	3.08	4.767 (16.107) ↓	1.143 ↓	0.047	0.97
	Positive Experience Score (#)	0.5 (3.5)	2.333	0.5 (2.75)	2.917 ↑	0	0.888
	Negative Experience Score (#)	0 (1)	0.75	0 (0)	0.333 ↓	0	0.336
	Normalized Area (%)	0.037 (0.654)	0.467	0.925 (4.265) ↑	7.812 ↑	0.202	0.052 *
Familiarity	Spatial Complexity (#)	3 (2)	2.583	2.5 (1) ↓	2.083 ↓	-0.5	0.132
	Sequential Complexity (#)	3 (3)	2.917	2 (1.25)↓	2.5↓	-0.5	0.222
	Overall Generalization (%)	27.704 (17.924)	37.482	47.83 (23.711) ↑	63.448↑	14.825	0.176
	Feature Generalization (%)	25 (4.323)	23.894	25 (0.688)	25.975↑	0	0.398
	Road Generalization (%)	22.5 (24.554)	25.174	56.25 (20.833) ↑	80.094↑	33.125	0.005 *
	Overall Accuracy (%)	56.458 (27.445)	52.556	33.583 (15.903) ↓	39.109↓	-9.165	0.027 *
	Feature Accuracy (%)	58.854 (15.517)	59.005	32.18 (29.011) ↓	39.021↓	-10.692	0.007 *
	Road Accuracy (%)	40 (34.241)	39.658	36.607 (23.438) ↓	39.284↓	-1.786	1
	Mapping Time (#)	16.5 (7.75)	17.25	21 (13.75) ↑	22.25↑	5	0.003 *

Note: IQR stands for Interquartile Range. The symbol "#" is used to denote raw counts or absolute numbers, such as the total quantity of an item. The symbol "%" represents percentages, a relative measure expressed as a fraction of 100, indicating proportions of the total considered.

4 Results

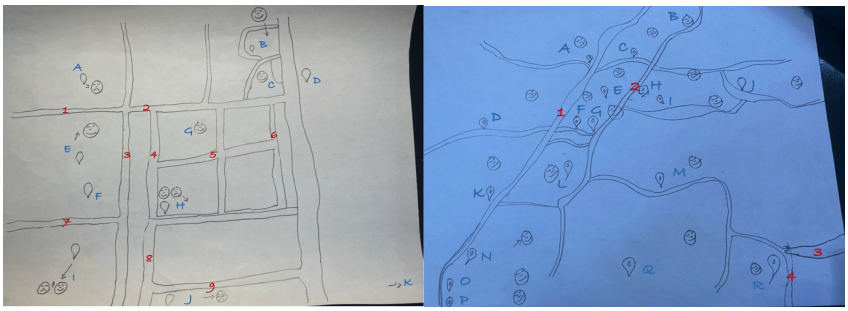
4.1 Participants Overview

We recruited 12 participants across the U.S., covering a broad spectrum including moves within the same city, between cities, and across different urban and rural settings. Many participants were first-time movers, making a permanent move to another state. The ages of participants were predominantly within the 25-40 range. The 2022 United States Census Bureau reports that of the 4.5 million employment-related relocations, approximately 2.7 million involve individuals aged 20-44 [22]. This suggests that our participants' age distribution mirrors broader labor migration trends. Further demographic and migration details about the study's participants are available in Table 6 and Table 7 in Appendix A. Our participants' diverse relocations and backgrounds enhance our study, expanding our insight into the various migration orientations.

4.2 Mental Maps

Mental maps, as noted above, serve two purposes in our analysis: they provide a lens into participants' sense of place and act as spatial representations of individuals' experiences, perceptions, and interactions within the mapped environment. We initiate our analysis by focusing on participants' mental maps, examining both the mapped elements themselves and the accompanying narratives as described by participants. Additionally, our analysis employs the five map metrics described above. Importantly, as noted earlier, to help guide intuition we categorize the five metrics into two groups: metrics representing participants' mental *map coverage*, and metrics representing participants' *familiarity* with the area. Our results here follow these categories as well, as shown in Table 2.

4.2.1 Coverage. In our study, participants were consistent in how they drew their mental maps – participants typically began mapping from their home, gradually expanding to encompass nearby areas. We observed this consistent starting point and expansion pattern across both sessions.



(a) P10's Pre-Relocation Mental Map in Session 1

(b) P10's Post-Relocation Mental Map in Session 2

Fig. 2. P10's Pre- and Post-Relocation Mental Maps. The normalized POIs number in pre-relocation mental map is 4.508%, the normalized road number in pre-relocation mental map is 1.137%. The normalized POIs number in pre-relocation mental map is 9.677%, the normalized road number in pre-relocation mental map is 1.515%. To ensure confidentiality, personal identifiers on the maps have been omitted; alphabetic characters replace feature labels and numeric identifiers substitute for road labels.

Intuitively, participants seem to orient themselves and their understandings of space by reference to where they live.

Increase in Mapped POIs Post-Relocation Turning to our results, we first focused on *how many* objects were mapped on participants' mental maps. We measured this both according to mapped POIs, as well as mapped roads.

Overall, we found a significant shift in the number of mapped objects after relocation. In session 1, the median of POIs number was 10, normalized to 2.821% of all POIs in the area, and the median number of roads was 5, normalized to 7.881% of all roads in the area. However, these numbers changed substantially in session 2. We found an increase in mapped POIs in session 2, with a median of 15.5 and a normalized value of 7.849% of all POIs in the area. Meanwhile, the median of roads decreased to 3.5, and their normalized value decreased substantially to 4.767% of all roads in the area. When normalized, the Wilcoxon Signed-Rank test showed a significant increase in mapped POIs between session 1 and session 2 (MD = 1.578%, p = 0.027). This uptick seems to represent participants exploring their new home after they moved. For example, P10 described:

> "I drove around the area to familiarize myself with the local places, like neighborhood, restaurants, grocery stores, and other points"

Beyond the statistical and descriptive results, this increase is visible when examining participants' mental maps visually as well. In Figure 2, we show P10's mental maps from session 1 and session 2, and immediately visible is a notable increase in mapped POIs.

However, this increasing trend in POI mapping did not extend to the mapping of roads, where the MD of normalized road number was 0.047%, and the change was not statistically significant (p = 0.97). This discrepancy may be related to details of how people learn about geographic areas. For instance, participants may be interacting with or relating to POIs, which could serve as a type of landmark, more than they do with roads when exploring their new homes.

Trend and Shift in Object Categories In examining participants' mental maps (like P10's, above), we noticed that participants tended to highlight places that they visited frequently, or that had some personal significance to them. These primarily included religious institutions, healthcare facilities, educational establishments, retail outlets, dining venues, and recreational areas, as well as the connecting roads. This emphasis on certain sites was articulated by P1 in Session 2, who noted,

> "Here is the school. This school is superior to the one in my previous residence, this is why I accepted the job and moved here."

Similarly, P8, in Session 1, remarked,

> "These locations are en route to my workplace, so I encounter them daily. I often purchase items, like groceries, during my commute home."

We also noticed that these patterns shifted, in terms of how POIs were represented pre- and post-relocation. Before relocation, the most frequently mentioned POIs were churches (29%), educational institutions (20%), coffee shops (20%), and parks (16%). Following relocation, while the overall pattern of place representation remained similar, we found a substantial shift in specific categories: the frequency of churches increased to 45% (up by 16%), whereas parks dropped to 4% (down by 12%). While participants mapped more POIs on their mental maps after moving, *what* they mapped differed. This shift may indicate other kinds of goals or needs that participants were trying to meet after they move, above and beyond exploration. For instance, P4, P6, P7, P9, P10, and P12 all expressed that integrating into a church community played a crucial role in establishing new social connections with locals and fostering a sense of belonging. P7 described this phenomenon as:

> "Last Sunday, I hit up the church to find local people. I met a few locals there and they filled me in on some stuff about the place...just went to worship and chill a bit; it's always so calming."

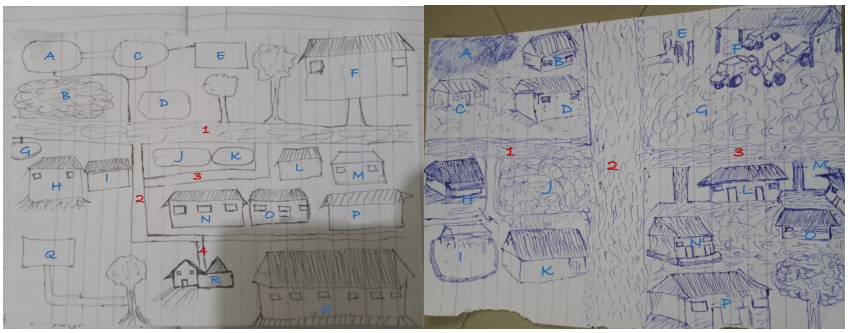
Expansion in Area Coverage Post-Relocation Beyond mapped POIs, we also found that participants' mental maps showed a notable increase in *geographic area* mapped, compared to their pre-move maps. This expansion is quantified as a proportion of the total city or town area. Specifically, the median normalized geographic area of participants' post-relocation maps was 0.925%, compared to a median of 0.037% for their pre-relocation maps. While the Wilcoxon Signed-Rank test (MD = 0.202%, p = 0.052) did not show significance at the $p < 0.05$ level, this is likely due to the size of our data. Descriptively, participants tended to widen the geographic areas in their post-relocation maps. This trend may provide further evidence of participants exploring their new homes after moving, echoing our POI and interview results above.

4.2.2 Familiarity. The second type of metrics we focused our mental maps analysis around were metrics designed to understand participants' *familiarity* with the region they were mapping. Specifically, rather than focusing on aspects like the area mapped or counting the number of POIs, our *familiarity* metrics instead focus on how participants represent their environment in their mental maps, in terms of cartographic complexity, how generalized their maps are, and how accurately their maps represent the space, both pre- and post- relocation.

Decreasing Cartographic Complexity Turning to our *cartographic complexity* results, we found that participants' mental maps were more complex in session 1 than in session 2. We saw decreases in both spatial and sequential complexity, with session 1 showing a median complexity of 3 for both spatial and sequential complexity, and session 2 showing a median complexity of 2.5 and 2 for spatial and sequential complexity, respectively. Notably, we also found that participants spatial and sequential complexity levels were correlated in both sessions, with a correlation coefficient of 0.935 ($p < 0.001$) in session 1, and 0.793 ($p = 0.002$) in session 2. This suggests a strong linkage between spatial and sequential perceptions, highlighting the interconnected nature of these cognitive processes.

Moreover, during the think-aloud segment of mental mapping, six participants expressed difficulty in recalling the absolute or relative positions of map elements. For instance, P7 stated:

> "I remember driving by the barber shop, so it's around here somewhere, but the street name and exact location are slipping my mind...there's that McDonald's I went to in



(a) P8's Pre-Relocation Mental Map in Session 1

(b) P8's Post-Relocation Mental Map in Session 2

Fig. 3. P8's Pre- and Post-Relocation Mental Maps. To ensure confidentiality, personal identifiers on the maps have been omitted; alphabetic characters replace feature labels and numeric identifiers substitute for road labels.

> the south part when I just moved here - it's got to be close by. I just can't pin where exactly."

Figure 3 illustrates P8's mental maps, showcasing a transition from more complex "Patterned" spatial category and "Netted" sequential category before they moved, to a less complex "Mosaic" spatial category and "Chain" sequential category after moving. This trend is echoed by participants like P7 (above) who reported difficulties in spatial recall after they move.

Generalization Increase We also observed that participants' mental maps were more *generalized* after moving. We found that the overall normalized generalization level in session 1 (*median* = 27.704%) was lower than in session 2 (*median* = 47.83%). More specifically, we saw this trend carry through when considering normalized road generalization, which was significantly higher in session 2 (*median* = 56.25%) compared to session 1 (*median* = 22.5%), though this trend did not occur for map feature generalization (session 1: *median* = 25%; session 2: *median* = 25%). Our Wilcoxon Signed-Rank test results further suggested that the degree of generalized streets on participants' mental maps increased after moving (MD = 33.125%, p = 0.005).

Participants also describe this trend. P11 said, for instance:

> "You know, I mostly remember the road I take to work every day and maybe a few side streets... I'm new around here, I don't have a clear picture of the place in my head yet... Remember all the roads to the spots I've put on the map? That's tough."

P11's example underlines the increased simplification of road details in mental maps post-relocation, which likely reflecting challenges in memorizing new and complex road networks. To further understand the relationship between the generalization of streets and features, we employed Spearman's Rank Correlation. In pre-move maps, we found a strong negative correlation between street and feature generalization (r = -0.578, p = 0.049), suggesting that as street generalization increased, feature generalization decreased, or vice versa. However, this pattern did not continue in post-move maps (r = -0.113, p = 0.727). This difference before and after a move may suggest that moving disrupts how participants process spatial information in new environments. It may be that participants were in an early stage of familiarizing themselves with their new environment, so they were unable to be more specific about the road network they experienced.

Decrease in Qualitative Accuracy Participant's qualitative accuracy on their mental maps decreased after they moved. Specifically, we found the overall normalized accuracy in session 1

(*median* = 56.458%) was substantively larger than in session 2 (*median* = 33.583%). This pattern carried through both road accuracy (session 1: *median* = 40%, session 2: *median* = 36.607%), and feature accuracy (session 1: *median* = 58.854%, session 2: *median* = 32.18%). The Wilcoxon Signed-Rank test results corroborated these observations, showing a significant decrease in accuracy between session 1 and session 2 (MD = -9.165%, p = 0.027), particularly in feature accuracy (MD = -10.692%, p = 0.007). However, while we descriptively observed a difference in road accuracy, this trend was not statistically significant (MD = -1.786%, p = 1). To explore this further, we also wanted to understand relationship between road and feature accuracy. A Spearman's Rank Correlation analysis between road and feature accuracy prior to moving showed a mild positive correlation (r = 0.577, p = 0.049), suggesting that maps that were accurate for either roads or features were also accurate for the other dimension as well. However, this pattern did not persist post-relocation (r = 0.112, p = 0.728). This change might reflect an adaptation phase when moving to a new environment. Participants may prioritize becoming familiar with certain spatial elements over others, depending on their immediate needs and experiences in the new location.

More Difficult Mental Maps Post-Relocation Participants consistently reported difficulties in constructing mental maps after relocating, which aligns with our findings above regarding the increased generalization and decreased cartographic complexity and accuracy in post-relocation maps. Further, we found that participants took longer to construct their mental maps in session 2, with the median duration extending from 16.5 minutes in session 1 to 21 minutes in the session 2. This difference was statistically significant according to a Wilcoxon Signed-Rank test (MD = 5, p = 0.003).

Delving into the participants' think-aloud segments, we identified two primary types of difficulties in mapping the new location: recalling details and translating these recollections onto paper. The challenge of recalling details aligns with our earlier discussion about the changes in structure complexity level between the two sessions. The second challenge, translating mental images onto paper, involves the cognitive process of converting spatial understanding into a visual representation. This could be attributed to their still-developing familiarity with the new environment, leading to less precise and more generalized representations in their maps.

4.2.3 Summarizing Mental Maps Results. Overall, our mental map analysis found a number of key results. After they move, participants increase the number of POIs they mapped, and the geographic region represented on the map. However, conversely, participant's mental maps were more general, less complex, and less accurate after they moved. Participants also took longer to complete the mapping exercise after they moved. Participants seem to interact with and explore their new environment more, and show difficulty in recalling their new environment during a mental mapping exercise. This duality exemplifies how dynamic the adaptation and re-integration process is, and holistically, these results paint a clear picture: relocation for employment reasons is highly disruptive!

4.3 Sense of Place

Our participants' mental maps tell a clear, albeit incomplete, story of the disruption that accompanies employment-related relocation. As described above, "sense of place" is a broader concept than the spatialized view captured by mental maps, because some aspects of "sense of place" are not "mappable". Rather, "sense of place" also encapsulates broader social, cultural, and personal experiences tied to a specific locale. Prior work conceptualizes "sense of place" as encompassing both people's attachment to a place [34, 95], and the meaning people derive from a place [16, 70, 94, 96]. In this section, we describe our findings from Raymond et al. [86]'s place attachment instrument, and also unpack our semi-structured interview findings. This dual approach adds additional context

Table 3. Statistics of Sense of Place Pre- and Post-Relocation.

Metric	Session 1		Session 2		Wilcoxon Test	
	Median (IQR)	Mean	Median(IQR)	Mean	MD	P-value
Sense of Place (#)	80 (19.25)	81.833	67.5 (20.5) ↓	68.5 ↓	-9	0.033 *
- Place Identity (#)	27.5 (3.25)	26.083	20.5 (6.5) ↓	19.917↓	-6	0.013 *
- Natural Bonding (#)	22 (2.25)	22.167	18.5 (4.5) ↓	18.5↓	-3	0.021 *
- Place Dependence (#)	18 (7.25)	18.833	16 (5) ↓	16.25↓	-4.5	0.176
- Family Bonding (#)	6.5 (2.5)	6.667	7 (1.25) ↓	6.417↓	-1.5	0.420
- Friend Bonding (#)	8.5 (3)	8.083	7.5 (2.5) ↓	7.417↓	-1	0.504

and details to our mental maps results above, and reflects a more holistic view of how individuals adapt and maintain their sense of place amidst the challenges of new environments. Our findings reveal the diverse strategies employed by participants to establish new connections and the resilience of sense of place during migration, highlighting the intricate process of reestablishing one's environmental and social connections in unfamiliar territories.

4.3.1 Decrease in Place Attachment. Our place attachment instrument results provided further evidence of the disruption that comes with an employment-related move. In Table 3, we observed that participants initially demonstrated a strong connection to their environment, as indicated by a high median sense of place score of 80 in session 1. However, this place attachment score decreased substantially post-relocation in session 2, dropping to a median of 67.5. These findings are significant, according to a Wilcoxon Signed-Rank test (MD = -9, p = 0.033). Moreover, examining the details of Table 3, we further saw decreases for all sense of place dimensions in session 2, especially in place identity and natural bonding, with statistically significant decreases (MD = -6, p = 0.013; and MD = -3, p = 0.021, respectively). In our interview results, we also saw a marked decrease in sense of place and place attachment perspectives after participants moved.

4.3.2 Sense of Place Reestablishment. While participants' place attachment declined after they moved, our interview results also indicated that this is not a static outcome. Participants shared that they were in a transitional period, working to reestablish a sense of familiarity and comfort in their new environments. Indeed, echoing some of the themes from Harrison and Dourish [44] germinal paper on "place", during this "reestablishment phase", participants indicated their need and active effort to build "platial" connections in unfamiliar settings.

Strategies of Reestablishment The concept of a "transitioning sense of place" emerged as a key adaptive strategy. Participants actively recreated familiar aspects of their previous environments in their new locales. They aligned personal characteristics and values with their new settings, a process evident in the consistency of object categories on their mental maps (refer to Section 4.2.1) and in their personal narratives. We found that this reestablishment process tended to encompass three distinct dimensions for our participants: ***individual adaptation***, ***social integration***, and ***environmental engagement***. Regarding ***individual adaptation***, participants tended to align their *personal attributes* — including identity, past experiences, and preferences — with the new environment. Examples of this transition strategy include P2's pursuit of sports-related activities and appreciation of serene settings, enhancing their sense of place in the new environment:

> "I like this place because it's also a very serene environment...I joined the basketball team. That's exactly what's helping increase my sense of place."

This approach is visible in P2's mental maps before and after migration, where they included a basketball court. They also depicted trees surrounding their new home, highlighting their appreciation for the serene settings of the new environment. Many participants also sought to *establish personal and emotional connections* with their new location, forging new memories and experiences. This included frequenting local establishments to interact with community members. Four of our participants mentioned that they went to nearby restaurant/bar/coffee shop aiming to meet new people nearby or know more about the community. P9, for instance, shared that interactions with restaurant staff offered valuable local insights while they were drawing the restaurant near their home:

> "The folks at the restaurant are super nice. I popped in there the first night after I moved, and they filled me in on all sorts of stuff about the area... I end up going there a lot since it's just around the corner from where I live. They're always really chatty and welcoming whenever I stop by."

Adjustments in daily routines and activities were another facet of this transition, aiding participants in acclimatizing to their new social and environmental context. For example, P1 made significant changes from their pre-migration mental map by adding a park and playground to their post-migration map. They explained that they have been actively integrating into the new community and getting to know their neighbors by taking regular walks in the nearby park and frequently visiting the community playground with their children. Likewise, P12 went jogging in the afternoon as a strategy to familiarize themselves with the new locale and its residents. While these examples illustrate individual adaptations, they also suggest a blurry boundary between personal adaptation and ***social integration***, where establishing relationships within the community became a core focus for our participants. All of our participants worked to *establish relationships* within neighborhoods, with friends or family, or by joining local communities or social groups. A notable example is P9, who valued their local library prior to moving, and formed a similar bond with a library in their new location. They included the library in both their pre- and post-migration mental maps. P9's connection to the library is also illustrated in their words:

> "There's a bus stop near my home that takes me to the library...The librarians there are very helpful, especially one local friend...I asked her where to buy something, and she knew exactly where."

Environmental engagement was another aspect through which participants worked to reestablish themselves, immersing themselves in the *physical* and *cultural* landscape of the new area. For example, P11 maintained their preference for familiar local amenities by including cafes, diverse food establishments, and public laundry facilities near their home on both pre- and post-migration mental maps, reflecting the continuity of their environment and enhancing their sense of comfort and belonging:

> "The presence of diverse food options and good public facilities, like the public laundry, made me feel more 'at home' and love the place more."

Cultural immersion also played a significant role, necessitating an understanding and embracing of the local culture, traditions, and social norms. For instance, P3 and P12 reported actively seeking knowledge about local customs and cultural communities. They expressed that unfamiliarity with these local cultural aspects initially contributed to feelings of insecurity.

Tools for Mediating the Reestablishment Phase In this process of reestablishing their sense of place, participants leveraged a range of tools to help mediate and ease this transition. This ranged from digital platforms to personal networks, each helping to facilitate the transition to new environments. Seven of our participants used *social media platforms as a bridge* to connect with

local information. For instance, P5 proactively used social media to forge connections with local people:

> "I'm trying to get to know the place more. And these Facebook groups help me meet more people."

In a similar vein, P8's involvement in a local WhatsApp group, created by neighbors and friends, helped facilitate information sharing and support, making it an invaluable resource in adapting to the new setting.

However, for other participants, relying on *support from neighbors* became an important factor. P9, for instance, described how they received significant assistance from their neighbors, which they highlighted by depicting their neighbors' houses on their post-migration mental map. This form of support was more direct and personal, involving physical interactions and assistance in the new environment. P7 and P12, already had some *pre-established social connections*. Their friends played a crucial role in introducing them to various local places and imparting valuable local knowledge, aiding significantly in their adjustment to the new environment.

4.3.3 Navigating the Challenges of Establishing a New Sense of Place. While participants exercised a number of different approaches to reestablish their sense of place, this process was not without challenges.

Personal Level Challenges Not all participants had clear strategies for rebuilding connections in their new settings. Some faced uncertainties in trying to transition familiar aspects from their previous environments to their new ones. This lack of a clear path often led to exploration and discovery as part of the reestablishment process. For example, P5, initially unsure how to forge local connections, started exploring the area and visiting museums. However, this exploration did not help clarify how to build deeper "platial" connections. P5 expressed:

> "I felt everything is good for me so far. And I had explored many different places...but I just moved here and I am still exploring, now I have no idea about how will I build connection with this place. I will explore the better way."

P5 was using the tools they had, but when those tools did not help facilitate P5 in reestablishing themselves, they were left with a degree of uncertainty about how to proceed.

In contrast, P4 faced a different challenge in forming personal connections. They quickly connected with the new environment, especially enjoying a local flower shop, which they included on their mental map. However, extending this connection to form personal relationships proved more challenging:

> "I visited a flower shop and felt elated by their offerings. However, I haven't explored elsewhere to forge new friendships."

P12 adopted a more structured approach by first familiarizing themselves with the city's layout. Their post-migration mental map, which includes all main roads and most features near these roads around their house, demonstrate this familiarity. Their planned next step involves building social relationships with neighbors and colleagues. However, P12 articulated the pressure of juggling multiple tasks during this transition:

> "There are a lot of things waiting me to do to settle down. It's quite overwhelming. I have been driven around this city and explored different places... Next step I want to make friends with my neighbor and people in my workplace."

Our participants commonly expressed that the multifaceted nature of reestablishing oneself in a new community contributes to the difficulty of the process. Due to the open-ended nature of the process, participants like P5 took an initial step, yet remained unsure of how to proceed further. P4 found some traction in finding connection with the environment, but could not translate this into

social relationships, and despite having a plan, P12 found the multi-faceted nature of this process overwhelming.

Social and Community Integration Challenges In their new communities, participants often also faced significant obstacles in integrating into the social fabric of the place. This was predominantly due to challenges balancing work commitments with social life, and the lack of pre-established social networks. P8's experience highlights a common challenge for our participants, who moved for work — a tension between their work, and their personal life:

> "It was difficult to meet new people due to my busy work life. I'd leave early and return late, leaving little time to socialize in community spaces like parks or cafes."

P8 turned to online social media groups as a way to build social connections, providing some support and sense of belonging despite limited physical availability. However, in some cases even this approach was difficult. P6 encountered difficulties because they lacked any pre-existing social ties in a new location:

> "Starting from scratch in forming friendships was tough without existing connections here, and my work left little room for social endeavors."

Local Knowledge Assimilation Challenges Adapting to a new environment involves more than just physical relocation and reestablishing social connections; it also requires an in-depth understanding of local knowledge, including social dynamics, norms, and physical geography. This process often posed significant challenges to our participants. P3's experience underscores the challenge of understanding the nuances of different city zones, particularly regarding social dynamics and safety:

> "Learning about different city zones, especially those with unique social norms or safety issues, was crucial yet challenging without direct local interactions."

Even gathering and interpreting this kind of information can be complex and difficult. P11 described the need to navigate fragmented or superficial insights based on preliminary research, which led to unexpected challenges:

> "Despite thorough research, I encountered unexpected issues. Choosing a residence near a church for peace, I ended up next to frequent loud events, contrary to what I had anticipated."

5 Discussion

In our research, we show that employment-related migration significantly impacts individuals' sense of place and their mental maps. More than just a geographical shift, this transition encompasses changes in personal habits, emotional attachments, spatial perceptions, social networks, and connections to the environment. Participants in our study faced a number of challenges that extended beyond physical relocation. These included the psychological process of adapting to and embedding oneself into a new cultural and social milieu, as well as reconstructing a sense of identity and belonging in a novel context.

5.1 Beyond Space: The Evolving Mental Maps

The act of crafting mental maps offers an insightful glimpse into the cognitive frameworks individuals use to understand their environments. Beyond serving as individual spatial representations, these maps "spatialize" people's emotional and experiential worlds, revealing how people perceive and interact with the spaces around them. Our research shows that as labor migrants transition from one location to another, their mental maps — which reflect their continuous interaction with the environment — shift. Notably, participants' post-relocation maps showed larger numbers of

POIs, and a wider geographic area, being mapped. Our results suggest that this likely reflects exploration behavior or an amplified focus on novel surroundings. Importantly, we see a noticeable decline in the familiarity of these spaces. The pronounced *generalizations* in participants' maps after moving might hint at a more pragmatic approach to understanding the new locale, focusing initially on functional navigation. We see similar trends in decreased *cartographic complexity* and *accuracy* of mental maps after moving. While migrants may invest in exploring their new settings to establish enriching their mental maps, their spatial comprehension remains fragmented after moving. Exploring opportunities to help rebuild people's spatial understanding could be fruitful, particularly given that digital navigational tools have been shown to hinder developing spatial understanding [38, 50, 79].

Our participants' mental maps prominently featured places they frequented or those imbued with deep personal significance, such as churches, schools, coffee shops, and parks. The consistent representation of these categories, notably churches, post-relocation, suggests a deliberate desire to reestablish some degree of normalcy in new environments through familiar societal markers, which participants also shared in their interviews. However, by contrast, the diminished presence of parks post-move may indicate shifting routines or priorities after moving. While it may be intuitive to anyone who has moved that priorities shift when moving, our results here suggest that *not all* priorities shift, some aspects of people's lives — like social or religious community — become more salient. This pattern emerges as participants begin their mapping process from their homes and gradually expand to encompass nearby areas, emphasizing the personal dimension of their spatial perspectives. Notably, while churches featured on the post-move maps of nearly 50% of our participants, they were absent from the maps of the others. More deeply understanding how individual people prioritize aspects of their social lives is a key aspect of effectively designing to supporting labor migration. Personalization technologies like as recommender systems may be a critical aspect of tools to support this transition, to help customize migration support tools based on individual needs and priorities.

5.2 Reconfiguring Spatial Ties: Migration's Influence on the Multidimensional "Sense of Place"

Building on prior understandings of sense of place, our research here shows that people's sense of place transcends mere physical interactions, but is instead rooted in the socio-cultural fabric and unique aspects of a place. Migration disrupts people's connection to these dynamics, leading to a recalibration of how they interact in their new locations. Our results show that place identity and bonding with the natural world were key dimensions of sense of place that were impacted by a participant's move. In other words, migration is not merely a geographical transition, but also disrupts people's emotional and social contexts. While this is reflected in general measures of sense of place, we also saw this effect in our participants' mental maps and interviews. Place identity and bonding with the natural world correlated with how granular, specific and accurate participants' mental maps were, both pre- and post-migration. This may suggest that people's emotional and cultural connections to a place go hand in hand with their spatial understanding of the area in question.

However, the question arises: What are the threads that weave together to form this "sense of place"? Our study highlights that people's individual characteristics influence how participants perceived and interacted with their surroundings. However, our results also suggest that this dynamic is not only about the individual. We found that social interactions, from family to broader community groups, helped to anchor participants. In adapting to a new environment, we saw participants' overall sense of place decline. To counteract this, some participants sought familiar settings, like P2's search for tranquility and a basketball community, or P9's connection to the local library.

Others, like P5, took a more exploratory approach, using their move as an opportunity to discover new facets of their sense of place. In many cases, participants in our study relied on mediating bridges to find "a starting point", in the words of P6. These bridges helped participants make these connections, whether through digital platforms, community groups, or personal networks. These revelations emphasize the need to holistically evaluate the cognitive, emotional, and communal facets of individuals' sense of place.

Importantly, the novel transition-focused method we employed here *enabled* visibility into these "platial" dimensions of labor migration. A point-in-time mental mapping exercise cannot capture this kind of transition. Nor could administering a place attachment instrument after someone moves. Taking a holistic, temporal perspective on understanding sense of place, and how sense of place connects spatially to new locales, allowed our study here to observe and measure the multifaceted disruption that came from employment-related relocation. Indeed, Harrison and Dourish [44]'s work called on the HCI community to recognize the value of "platial" understanding, rather than merely thinking about creating spaces. 10 years later, Dourish [35] emphasized that mobility enables the creation of new kinds of spaces that had not existed previously. With humility, our work here re-emphasizes a "platial" lens, *particularly* in settings where mobility is fundamental, like labor migration. Methods to observe and understand platial disruption or platial mobility, and computational tools to support remaking place are important next steps from our work here.

5.3 From Spatial Transition to "Becoming Local": Navigating Labor Migrants' Mental Maps and Sense of Place

Despite tendencies to operationalize "localness" quantitatively (e.g. [52, 100, 101]) in HCI, some prior work [58] has begun to recognize that "localness" is a deeper, more multifaceted concept than common localness-inference computational approaches enable. Indeed, our results here provide strong evidence that "localness" is likely a much richer concept than geographic HCI research has explored previously. Within the context of our study here, mental maps and the sense of place may be important tools in characterizing what it means to "be local", and what the process of "becoming local" actually entails.

Mental maps are more than mere geographical imprints; they reflect individualized understandings of the world. These individualized maps can represent vibrant illustrations of our shared experiences, interactions, memories, and emotions tied to specific places [33, 67]. Individuals with deep-rooted ties to their communities — "locals" — likely hold intricate mental maps that encapsulate not only the physical contours but also the cultural heartbeat of their home [67]. Take, for example, someone who has lived in a neighborhood their entire life. Their mental map might both accurately reflect a neighborhood park's location and, simultaneously, encapsulate the park's "placeness" as a weekend hub for family gatherings or the specific bench that neighborhood locals like to use to watch a sunset. These detailed insights — present in one's internal mental map, and elicitable through a mental mapping exercise like the one we conduct here — reflect more than physical proximity, but also include knowledge and emotions from being integrated within the social community of that place.

Based on our results, sense of place is built on, and through, significant relationships, established routines, and community rituals. An established sense of place, therefore, may serve as a key aspect of "becoming local" and assimilating into a community. Someone who has years of fond memories at a neighborhood cafe has likely established a strong emotional bond with that cafe, and the community that participated in the creation of those memories. They may be more likely to actively contribute to community-focused goals and outcomes, and may be more likely to receive the benefits of others' efforts as well.

As such, we see clear opportunities for geographic HCI studies to take on more complex definitions of "localness". As a scholarly community, we might consider alternative quantitative ways to define what "localness" actually is, or explore ways of enriching current location-based tools with more detailed characterizations of local experiences. We see our results here as complicating common ways of defining and operationalizing "localness" in HCI. Therefore, below, we discuss design ideas for how technological tools may be able to help support rebuilding sense of place for labor migrants, or more broadly might facilitate "becoming local".

5.4 Design implications

The findings from our study underscore the significant impact of labor migration on individuals' sense of place. This disruption extends beyond practical concerns, deeply affecting the emotional and social well-being of those who relocate. Our results suggest that rebuilding sense of place is likely important part of integrating oneself into a new place.

Despite the important nature of this process, there is a notable lack of tools specifically designed to aid in the reestablishment of a sense of place. This gap presents a key area of opportunity for social computing and HCI scholars. We now shift our focus to identifying and discussing these design opportunities. These considerations and explorations are essential for developing innovative solutions that can effectively support migrants, both labor and others, in adapting and thriving in new settings after relocation.

5.4.1 Rich, Computable Representations of Sense of Place. Our methodology in this work involved a number of different data collection strategies to triangulate and holistically understand the phenomenon around labor migrants' sense of place and mental maps. Through this novel approach to gaining insight into the transition and disruption that occurs because of labor migration, we were able to develop an understanding of participants' sense of place, both through our interviews, the place attachment survey instrument, and our mental mapping exercise. While this mixed-method approach solidly grounds our findings in comprehensive evidence, it presents challenges when scaling up due to the difficulty in quickly computing people's sense of place with our current methods. A critical next step, that will be necessary for the design opportunities we discuss below, is developing a method of collecting and effectively representing the rich, individualized, emotional, social, and otherwise contextual facets of one's sense of place. Mental maps are one, albeit incomplete, mechanism by which to understand sense of place, and prior work has made some progress in eliciting mental maps (e.g. [33]). However, future HCI research should investigate ways to elicit a more holistic, richer characterization of someone's sense of place, which may necessitate alternative mechanisms of structuring this information. Whereas a mental map may serve to spatialize someone's sense of place, we propose that knowledge graphs, or other structures for representing data may enable a more relational, generalized, representation of the various facets of sense of place. Graph structures are currently used to represent social networks [92, 106], for instance, as well as to capture structured metadata about people, and the relationships between people [23]. Exploring methods to populate such structured data, to elicit relevant information from people, and to construct a more holistic, multi-faceted characterization of one's sense of place is a critical next step to enable the kinds of tools we discuss below.

5.4.2 "Packing Up" One's Sense of Place. Because sense of place is likely important in reestablishing oneself after a transition, we see a potentially exciting opportunity to help migrants find points of interest, religious communities, sports organizations, or other personally meaningful facets of a new locale, and reestablish familiar locations and routines more quickly. Metaphorically, what might it mean for someone who is moving to "pack up" their sense of place, and take it with them to their destination? Mobile tools like [98] demonstrate one step in this direction — passively

capturing individually meaningful places prior to someone's move might allow for personalization technologies to recommend similar venues after a move. We might consider extending work like [85] to explore highly personalized navigational routing that evokes landmarks or scents or experiences in someone's former locale. Making mental maps computationally actionable does not need to rely on passive technologies either, it may be possible to elicit high quality mental maps from someone as input, similar to prior solutions for mitigating the "cold-start problem" in recommender systems [26].

5.4.3 Beyond Individual Sense of Place. On a macro scale, aggregating migrants' mental maps from before they move could also provide insights that might enable policy-makers, government entities, or even community organizations to more effectively support migration to their area. That is, rather than focusing on the individual experience of migration as we do above, it may be possible to help the broader community *where people are migrating to* assimilate with and support migrants joining their community. After all, communities are not static, portions of communities are always transitioning. In places where large amounts of migrants move to, the influx of new people can ripple through the community that was present before. HCI as a field is well situated to consider both individual goals and consequences for individuals as well as community goals and consequences for communities. Beyond helping individual migrants assimilate and reestablish sense of place, how might collaborative computational tools help communities assimilate with migrants and redefine the broader community's sense of place as well?

6 Conclusion

In this study, we delved into the impact of employment-related relocation, a phenomenon impacting millions globally, on individuals' spatial understandings and psychological connections. Our focus on the mental maps of migrants has unveiled a rich tapestry of transition experiences, illuminating their evolving "sense of place." This research contributes methods for comprehensive and comparative analysis of these mental maps. Our research found that participants' map coverage and map generalization increased, while cartographic complexity and accuracy decreased post-relocation. Our analysis revealed the intricate interplay between personal traits, social connections, and physical surroundings in reestablishing sense of place. Crucially, our findings emphasized the importance of considering "platial" elements, beyond just "spatial" ones, in addressing the needs of migrants. This shift in perspective opens up a realm of design opportunities, calling for a fusion of location-based and place-centric tools. Such tools should be designed to embrace the complexities of migrant experiences, aiding in their journey towards rebuilding a sense of place and fostering community integration. The insights gained here lay a foundational framework for future research and development in creating more inclusive and effective support systems for migrants navigating new environments.

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A Appendix

Table 4. Generalization of Example Mental Map

Metric	Analysis	Number
Generalization	Average of feature and road generalization	0.442
Feature Generalization	Count of feature generalization / number of feature	0.5
- Collapse for buildings	Buildings H and I are represented as two distinct points, simplifying their footprints	2
- Amalgamation for buildings	C, D, E, F are amalgamated to one single entity, building F	1
- Abstraction to show existence for buildings	In the mental map, Q and R do not correspond to specific real buildings; instead, they symbolize the presence of buildings (J, K, L, M, N) on the base map	2
Road Generalization	Count of road generalization / number of road	0.385
- Geometric merging for streets	Street 10 is left out	1
- Abstraction to show existence for streets	Streets 19 and 20 in the mental map are not direct representations of actual streets; rather, they signify the presence of streets (13, 14, 15, 16, 17) on the base map	2
- Junction merge	The absence of a connecting street results in the merging of junctions for streets 6 and 12	1
- Roundabout collapse	Roundabout 18 is left out	1

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Table 5. Qualitative Accuracy of Example Mental Map

Metric	Mental map	Correct	Analysis	Number
Qualitative Accuracy				0.958
Feature Qualitative Accuracy				0.974
- Topological relations between landmarks/regions	45	45		1
- Linear order of features along the route	45	43	Building G position change	0.956
- Left/right relation of landmarks with respect to the street	31	30	Building G position change	0.968
Road Qualitative Accuracy				0.941
- Topological relations between landmarks/regions and street segments	130	130		1
- Connectivity of street segments	40	35	Roundabout 18 is left out; the junction merge between street 6 and 12	0.875
- Orientation of street segments	78	74	Street 6 position change	0.949

Table 6. Participant Basic Information

Participant	Age	Gender	Education	Income	Occupation	English proficiency
P1	40	Female	Bachelor's degree	$40,000-$59,999	Business	Fluent
P2	28	Male	Bachelor's degree	$40,000-$59,999	Engineer	Native speaker
P3	26	Male	Bachelor's degree	$40,000-$59,999	Designer	Native speaker
P4	30	Female	Bachelor's degree	$40,000-$59,999	Teacher	Fluent
P5	29	Female	Bachelor's degree	$80,000-$99,999	Graphic designer	Fluent
P6	28	Female	Bachelor's degree	$60,000-$79,999	Real estate agent	Fluent
P7	25	Female	Bachelor's degree	$80,000-$99,999	Nurse	Fluent
P8	28	Male	Bachelor's degree	Over $100,000	Contractor	Fluent
P9	28	Female	Bachelor's degree	$60,000-$79,999	Nail technician	Fluent
P10	29	Male	Bachelor's degree	$80,000-$99,999	Architect	Fluent
P11	30	Male	Master's degree	Over $100,000	IT consultant	Native speaker
P12	28	Male	Bachelor's degree	$80,000-$99,999	Software Engineer	Fluent

Table 7. Participant Migration Information

Participant	Move from	Move to	Distance	Duration	Nature	Moving partner	Travel mode before	Travel mode after
P1	Urban	Urban (inter)	Another state	Permanent	First-time	With family	Car (driver)	Car (driver)
P2	Rural	Urban	Another state	Permanent	Repeat move	With family	Car (passenger)	Public transit
P3	Urban	Urban (inter)	Another state	Temporary	First-time	Individual	Public transit	Public transit
P4	Urban	Urban (inter)	Another state	Permanent	First-time	With family	Car (passenger)	Public transit
P5	Rural	Urban	Another state	Permanent	First-time	Individual	Public transit	Public transit
P6	Urban	Urban (intra)	The same city	Permanent	First-time	Individual	Car (passenger)	Car (passenger)
P7	Urban	Urban (intra)	The same city	Temporary	Serial move	Individual	Car (passenger)	Car (passenger)
P8	Rural	Urban	Another state	Permanent	First-time	With family	Car (passenger)	Car (passenger)
P9	Urban	Urban (intra)	The same city	Permanent	First-time	Individual	Car (passenger)	Car (driver)
P10	Rural	Rural	Another state	Permanent	Repeat move	Individual	Car (driver)	Car (driver)
P11	Urban	Rural	Another state	Permanent	First-time	With family	Car (passenger)	Car (driver)
P12	Rural	Rural	Another state	Permanent	First-time	Individual	Car (driver)	Car (passenger)