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Abstract

Place can be understood, and represented, not only as an attribute of a location but also as the emotional attachments that characterize a relationship between an individual and a location. We demonstrate the development and application of this principle in place-based geographic information systems (GIS) through the use of georeferenced ecological momentary assessment (EMA), an approach for gathering real-time, in-situ data on individuals' mood states, behaviors, and social interactions via brief surveys delivered on a mobile phone. As a case study, we focus on the representation and analysis of the effect of activity space exposure to vacant housing on perceived safety among a sample of 139 urban adolescents enrolled in a longitudinal, georeferenced EMA study.

1. Introduction

Researchers have distinguished place-based geographic information systems (GIS) as emphasizing subjective interpretations of locations (Elwood *et al.* 2013). It has been suggested that geographic information scientists should look to research in cognitive science and humanistic geography for inspiration to developing representational and analytical approaches to place-based GIS (Winter and Freksa 2012). Such a perspective has informed research on extracting place information from linguistic descriptions, formalizing computational notions of place, georeferencing place data, and reasoning with place data (Gao *et al.* 2013; Scheider and Janowicz 2014; Vasardani *et al.* 2013). Health behavior is a domain that is particularly appropriate for place-based GIS (Goodchild 2015), as environmental influences on health behaviors are often moderated by the characteristics of the individual, including not only group characteristics such as race, age, and gender, but also the unique prior life experiences each individual carries with them (Mennis and Mason 2011). Thus, environmental influences on health behaviour can be interpreted to occur through subjective constructions of place.

Drawing from research in humanistic geography that posits place-making as construed through personal experience (Tuan 1977), we argue here that place-based GIS can represent place not only as a property of a location (as with conventional GIS), but also as a relationship between an individual and a location – a relationship that is molded by the unique characteristics and experiences of the individual (Mennis *et al.* 2013). We demonstrate the application of these principles using georeferenced ecological momentary assessment (EMA), an approach for gathering real-time, in-situ data on individuals' mood states, behaviors, and social interactions via brief surveys delivered on a mobile phone. EMA combined with global positioning systems (GPS) for georeferencing enables the collection of integrated longitudinal survey and activity space data (Epstein *et al.* 2014; Mason *et al.* 2015). As a case study, we focus on the representation and analysis of place-based perceptions of safety among a sample of 139 adolescents enrolled in a longitudinal, georeferenced EMA study of substance use in Richmond, Virginia.

2. Case Study Sample and Research Question

The sample is composed of 13 and 14 year old adolescents recruited between 2012 and 2014, primarily from an adolescent medicine outpatient clinic, and followed for one year. Subjects received georeferenced EMA surveys 4-6 times per day over a four day period every other month, yielding 1,629 georeferenced EMA responses with no missing data. These EMA responses include only those taken outside the home, e.g. at a friend's house, at a park, etc. Here, we investigate whether an environmental variable, the percentage of vacant housing within a U.S. Census tract, influences the perception of safety at that activity space location, measured according to the EMA item "How safe are you right now?" with responses given on a 1 ("Not at all safe") to 9 ("Very safe") scale.

Drawing on theories of neighborhood disorder we hypothesize that higher vacant housing is associated with lower perceived safety. We also hypothesize that this association will differ according to characteristics of the individual, both in terms of gender and the percent vacant housing that occurs at the subject's home neighborhood, as we consider that an individual's personal experience with vacant housing nearby their residence will affect their emotional response to vacant housing in their activity space away from home. To this end, we condition the EMA activity space location percent vacant housing variable on the percent vacant housing value that occurs at each subject's home tract by subtracting the latter from the former, a variable we call the 'relative percent vacant housing.' Positive values of relative percent vacant housing indicate a subject traveling to an activity space location with a higher level of vacant housing as compared to their home tract.

3. Conceptual Representation

The basic conceptual model for data representation is shown in Figure 1. There are three entities: subjects, locations, and places, the last of which is defined as time-varying relationships between subjects and locations. Subjects have attributes which do not change, collected during a full battery assessment at baseline, which include attributes such as gender, age at enrolment, and race. Location in this case study is represented by a tessellation of U.S. census tracts with associated attributes, including percent vacant housing, which is assumed to be constant over the one year span of the study. Place is represented as the relationship between a subject and location as captured by an EMA observation at particular time, when a subject is at a particular location, for example the perception of safety an individual has at a particular activity space location when completing an EMA survey.
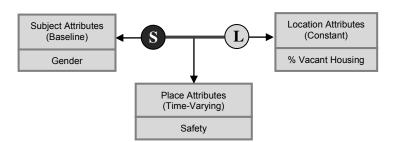

Figure 1. Conceptual model of subject (S), location (L), and place data.

4. Case Study Analysis and Results

To test the hypothesis that higher relative percent vacant housing is associated with lower perception of safety we employ Generalized Estimating Equations (GEE), which allows us to control for effects at the tract, subject, and survey wave levels, while also controlling for age, race, and gender. We then test whether the effect of relative percent vacant housing on safety

differs between boys and girls by entering an interaction term. Results are presented in Table 1, where Model 1 shows that higher relative percent vacant housing is associated with lower perceived safety (β=-0.015, $p<0.05$). Model 2 shows that this association is moderated by gender (β=-0.051, $p<0.005$), as is illustrated in Figure 1, which shows the relationship between relative percent vacant housing and perceived safety for boys versus girls. Clearly, the effect of exposure to vacant housing on perceived safety is stronger for boys as compared to girls, for whom the effect is near zero. We speculate that this is due to the greater propensity for violence among boys and the greater risk of violence, or of other illicit activities, in communities with high levels of disorder.

Table 1. Results of GEE Models of Perceived Safety (controlling for age and race; coefficients reported; *$p<0.05$, ***$p<0.005$).

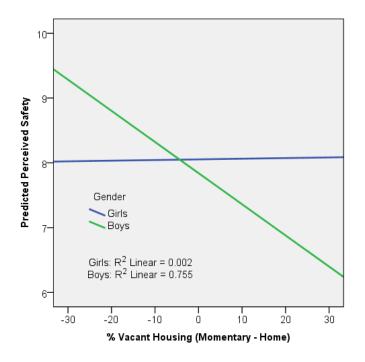| Year	Model 1	Model 2
Female	0.174	0.163
Rel. % Vac	-0.015*	-0.049***
Fem. * Rel. % Vac		0.051***
Intercept	7.365***	7.376***

Figure 2. Gender moderates the effect of relative percent vacant housing on perceived safety.

5. Conclusion

This research demonstrates an approach to place-based GIS that differs from previous approaches in terms of how place is conceptualized and encoded, and in how place may be operationalized analytically. Here, we emphasize that place characteristics can be viewed as subjective and ambiguously defined interpretations of one's environment, and can thus be represented as a relationship between an individual and a location. We explicitly distinguish

between objectively observable attributes of a location, e.g. the percent vacant housing in a tract, and the emotional interpretation of that location at a given moment in time, e.g. the sense of safety an adolescent has at that location. This approach thus agrees with research that posits place-attachment as a relationship between an individual's perceptions and the qualities of a location (Brown *et al*. 2015).

Further, by incorporating gender as a moderator, and by conditioning the momentary exposure to vacant housing on the exposure experienced in an adolescent's home tract, we demonstrate that modeling place characteristics on individual outcomes can benefit by incorporating characteristics of the individual, including prior experiences. We believe this approach has the potential to better incorporate a humanistic geography perspective into place-based GIS for health applications, where place-based models of environmental effects on health behaviors can more effectively capture how people subjectively relate to places, as compared to more common analytical approaches where an objectively observable environmental condition is hypothesized to exert some effect on an entire population regardless of individual differences and personal experiences. We note that although we focus here on a relatively simple example of modeling the effect of exposure to vacant housing on the perception of safety, the same approach can easily be extended to address a variety of more complex environmental conditions and affective and behavioural outcomes.

Acknowledgements

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