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Spatial discounting, place attachment, and environmental concern: Toward an ambit-based theory of sense of place

Asim Zia [a, *], Bryan G. Norton [b, 1], Sara S. Metcalf [c, 2], Paul D. Hirsch [d, 3], Bruce M. Hannon [e, 4]

[a] University of Vermont, Department of Community Development and Applied Economics, Morrill 208E, 146 University Place, Burlington, VT 05405, USA
[b] Georgia Institute of Technology, School of Public Policy, D.M. Smith Building Room 300, 685 Cherry St., Atlanta, GA 30332-0345, USA
[c] University at Buffalo (SUNY), Department of Geography, 105 Wilkeson Quad, Buffalo, NY 14261, USA
[d] Department of Environmental Studies, SUNY Environmental Science and Forestry, 114 Marshall Hall, 1 Forestry Dr. Syracuse, NY 13210, USA
[e] University of Illinois, Department of Geography, 220 Davenport Hall, 607 S. Mathews Ave., Urbana, IL 61801, USA

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ABSTRACT

Sense of Place (SOP) theory can connect environmental discourse across disciplines, provided it is supported by an adequate suite of conceptual tools. Sense of place encompasses both objectivist notions of spatial discounting, generally advanced by economists and geographers, and the subjectivist, phenomenological and psychometric aspects of place attachment emphasized by environmental psychologists. This paper introduces ambit as an integrative tool for developing theories about sense of place that include both subjective and objective aspects of human activity. Signifying the spatial extent of activity over time, the human ambit anchors spatial dimensions of environmental concern to alternative theories about sense of place. We conceptualize ambit as the focal level of a tri-level hierarchy stratifying mechanisms, behavior, and reflexivity associated with place. After developing the observable ambit as integral to a hierarchical theory of place-based behavior, we explore its use in providing a more empirical understanding of human behavior in space–time.

> "There is in fact a sort of harmony discoverable between the capabilities of the landscape within a circle of ten miles' radius, or the limits of an afternoon walk, and the three-score-years and ten of human life. It will never become quite familiar to you." — Henry David Thoreau (1862, *Walking*)

1. Sense of place

References to "sense of place" and "sense of place values" have become common in the literature of many fields, from geography to environmental ethics, from human ecology to sociology, from phenomenology to urban planning, from anthropology to cognitive psychology, and from environmental policy to ecological economics. Sense of place shows promise to better understand how environmental problems are experienced, informally bounded, and collectively formulated (Cantrill & Senecah, 2001; Cheng & Daniels, 2005; Cheng, Kruger, & Daniels, 2003; Ulrich, 2003). Just as sense of place shapes the way people implicitly and explicitly bound environmental concern, sense of place is also shaped by the nature and extent of one's experience with a place, as suggested by the opening quote from Thoreau. Our goal is to illuminate how an account of actual behaviors can represent the nuances of the explanatory concept, sense of place.

One of the greatest attractions of the concept of place, viewed as a term bridging many disciplines, is its apparent inclusion of both the *objective* and the *subjective* aspects of the relationship between humans and their natural habitat, or home (Bott, Cantrill, & Myers, 2003; Norberg-Schulz, 1980). "Placing" someone on a landscape involves locating them in physical space; but "sense of place" in this context also connotes subjective, personal attachments, memories, relationships, and so on. Authors in many fields have explicitly distinguished "place" from "location," with "location" invoking the

* Corresponding author. Tel.: +1 802 656 4695; fax: +1 802 656 4447.
E-mail addresses: asim.zia@uvm.edu (A. Zia), bryan.norton@pubpolicy.gatech.edu (B.G. Norton), smetcalf@buffalo.edu (S.S. Metcalf), pahirsch@esf.edu (P.D. Hirsch), bhannon@uiuc.edu (B.M. Hannon).
[1] Tel.: +1 404 894 6511.
[2] Tel.: +1 716 645 2722.
[3] Tel.: +1 315 470 6669.
[4] Tel.: +1 217 333 1880.

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objective aspect, and "place" adding a connotation of subjectivity and feeling. Stedman (2003b) characterizes these as the "phenomenological" (subjective) and the "positivist, hypothesis-testing" aspects, arguing that phenomenologists have not been aggressive enough in trying to make their claims about place functional, even as the positivists have failed to form hypotheses that will help us to understand the complex, undeniably subjective aspect of sense of place.

Optimistically, one might hope that with suitable conceptual scaffolding, sense of place might enable better integration of theory and scientific practice across disciplines that are concerned with how humans inhabit the landscape. Articles reviewing sense of place (SOP) research have found clear threads and themes that are present across disciplines (Cheng & Daniels, 2003; Jackson, 1994; Norton & Hannon, 1997, 1998; Patterson & Williams, 2005; Stedman, 2002). Lewicka (2011) provides a very useful synthesis of place attachment research and theory development (and the lack thereof). Multi-disciplinary conceptual enthusiasm, however, has not yet been matched with operational success in predicting or interpreting human attitudes and behavior with respect to location and sense of home place (Bott et al., 2003; Cantrill & Senecah, 2001; Stedman, 2002, 2003a, 2003b; Yung, Freimund, & Belsky, 2003).

Scholars have recognized the potential for sense of place to connect environmental discourse across disciplines, provided the concept is furnished with an adequate and diverse suite of conceptual tools (Norton & Hannon, 1998; Patterson & Williams, 2005). This paper develops an integrative and behaviorally measurable notion of ambit as a proxy measure for modeling sense of place and explores the contribution such a concept might offer in understanding human behaviors in space. The ambit of a person or group represents his/hers/its movements through space over a specified period of time. This ambit conceptualization is inspired by our biological brethren.[5] Much as an animal's "home territory" may be inferred from the outline of its movements through space, the human ambit enables people's SOP to be inferred from their activities in space–time. Using ambit-based measures for tracking and learning about the movement of subjects through space, we move toward a theory that integrates both subjective and objective aspects of SOP to facilitate its use as an inter-disciplinary tool for environmental problem formulation and communication, as in context-specific regional development and place-sensitive environmental policy analysis.

How would an ambit concept, if developed as an integral part of a theory of place-based behavior, make sense of place more useful? We address this question by posing, and then answering, two related questions:

1. What can the concept of a person's ambit contribute to a more empirical understanding of a person's SOP?
2. How could a sharpened and more empirical understanding of SOP improve our understanding of human behavior in space?

To answer these questions, it is necessary to be more specific about SOP. We do so by specifying that SOP incorporates models of spatial activities that structure space–time relations around the two axioms of hierarchy theory (Allen & Starr, 1982; O'Neill, DeAngelis, Waide, & Allen, 1986). The first axiom is that all measurements, descriptions, and judgments are taken from a specific place within a nested hierarchy of systems and subsystems. The second axiom is that larger, encompassing systems change at a pace that is at least an order of magnitude slower than the subsystems of which it is composed. This organization of models honors the subjective, inside-out perspective corresponding to the perception of a "placed" person, who views the world from his/her unique perspective; the first axiom directs us to view the world from that local perspective. The second axiom provides a rough principle for organizing space–time relations that emanate outward from that place. Hierarchy theory thus defines a large set of possible space–time relationships and a larger set of possible actions and movements taking place within those spatial models.

Interpreted hierarchically, SOP posits a set of models of space–time relations from any given point of view, and can thus represent the viewpoint of a located person who encounters events and activities that occur at larger and larger scales from that point. As a formalism, hierarchy theory does not resolve substantive questions of space–time relations, but it provides a vocabulary for discussing and illustrating them. Wedding sense of place with hierarchy theory thus provides researchers with possible maps of territory as experienced by a person or community who/that lives in a place. The formalism of hierarchy theory simply provides structure to representations of the world as seen from the inside out.

To answer our first question, we consider how the concept of ambit, as the spatial extent of human activity over time, can sharpen the hierarchical framework for sense of place. Understood hierarchically, SOP can represent behavior – observable actions of a person or organism – as the focal level (0) of a tri-level hierarchical model:

Level +1: *Regulation* (reflexivity, self-organization)
Level 0: *Behavior* of the organism (what is observable)
Level −1: *Mechanism* (laws of physics and biogeochemistry)

Ambit and sense of place each embody a perhaps unique (but at least interesting) way of summarizing data that invokes all three levels required for an explanation of behaviors of autonomous beings in a complex system of space and time in which many factors are governed by the laws of physics and biogeochemistry. There are also, however, self-organizing properties of many organisms, including humans, and also of flocks and schools which make prediction on the basis of physics and biogeochemistry impossible. If we try to model organisms and schools that exhibit self-organizing, regulatory behavior, then the actual behavior that is observed at the focal level (0) cannot be fully explained by factors on level −1, the level of mechanism, because behavior of autonomous (self-organizing) beings also includes the possibility of intent to change, which engages level +1, thereby capturing the reflexive aspect of the behavior observed.

SOP is thus understood as expressing all three levels required for autonomous behavior in a physical place over time. An interpretation of the world through the lens of SOP captures the reflexive evolution of a location becoming a place, *but SOP itself is not observable – it must be interpreted from behavioral data*. Since SOP itself is not observable, the introduction of ambit-based measurements for individuals or groups provides a set of proxy variables that can be empirically observed. Embedding the ambit in a hierarchical SOP theory, we envision multiple ways of creating useful empirical data about place-based human attitudes and behaviors.

We are now prepared to answer our first question. What does the ambit concept add to the study of sense of place? Answer: The ambit concept, when embedded within hierarchical models of place, will allow measurement of proxy variables for SOP. Ambit provides a summary of behaviors occurring in real time that also change as personal tastes and self-identifications change over time. In other words, while we recognize that simply observing subjects' movements through space creates noisy data, such data also have a certain"truth" in reflecting all three levels of hierarchy (mechanism, behavior, and reflexivity/self-organization). Behavior takes place

[5] We are indebted to Jeannette Yen for suggesting this productive analogy.

within a world governed by laws, but actual behavior as captured by ambit will also reflect the co-evolution of a sense of place with community behavior because that behavior expresses reflexivity and self-organization at the higher level (+1). Ambit-based measures such as the time-weighted and trip-weighted centroid provide proxies for SOP that, however noisy, contain patterns that reflect both physical forces and reflexivity as behaviors that express a placed person's SOP.

With this grounding in hierarchy theory, we turn to our second question. What does such a theory of SOP based on empirical ambit data do for our understanding of human behavior? Answer: A hierarchical theory of SOP, augmented with methods to measure and interpret ambit data, provides a structured system for representing space–time relations as choices by a placed person or a placed community. The concept of ambit, based in actual behavior in physical space but also responsive to the self-organizing abilities of autonomous agents, is rich enough to capture the complexity of reflexive as well as physically determined aspects of behavior exhibited by conscious beings. A person's ambit, a record of how s/he moves through space over time, when linked with more fine-grained psychometric information about place attachment (see Lewicka (2010, 2011) for a review of the psychometric methods), provides an empirically derived picture of a person's behavior in space. We hope that, given the way ambit mimics SOP in representing the three hierarchical levels of explanation, it can create an empirical and spatially articulated substrate on which the research of both positivists and phenomenologists can grow and interact.

2. Causes and consequences of SOP

Interpreted through the lens of hierarchy theory, SOP represents a reflexive relationship that emerges when a culture self-consciously enhances or changes its self-image and then further changes its environment to square with that image. For example, denizens of a fishing village express their sense of place in the activity of capturing available fish; but those behaviors are enhanced by the self-image of the fisher as independent and heroic, which leads to modifications of the place to enhance fishing opportunities.

As appropriate for the inherent reflexivity of SOP, Stedman (2003b) argues that research on SOP values and valuation should be concentrated in two areas: (1) the *determinants of sense of place*: What factors form sense of place attachments? And (2) the *behaviors resulting from a strong sense of place*: How do we expect individuals with a strong sense of place to act in various situations? We can think of (1) as an examination of sense of place as a *dependent variable*—an effect of geographic, social, psychological and experiential factors. Examining (2), on the other hand, involves looking at SOP as an *independent variable* affecting the ways people act and make decisions that affect regional development and policy systems.

(1) The study of SOP determinants draws heavily on psychology and cognitive science, as the focus here is on how a person comes to have a sense of place, on whether territoriality is more determined by genetics or by culture, and on the cognitive structures that shape mental maps. This leads us into the fruitful and diverse literature on the formation of mental maps and models and how they change (Bott et al., 2003; Cantrill & Senecah, 2001). A functional form of SOP might provide environmental psychologists with a measure by which to calibrate the effect in units of intensity of feeling for place. This target variable would provide them with a way to rank respondents in degree of intensity of their SOP. It would then be possible to examine various independent variables for correlations with strong deviations from SOP.

(2) Thinking of SOP as an *independent variable* enables consideration of its explanatory power for a range of consequences. In the literature on environmental politics, commentators on processes of environmental problem formation increasingly emphasize that sense of place is an important variable in understanding interactions of stakeholders in the formulation and scaling of problems. This burgeoning literature emphasizes the important role that sense of place may play in creating salience of environmental problems, in bounding and spatially representing the problem, in understanding political processes and, ultimately, in determining how to make political procedures work better (Cantrill & Senecah, 2001; Cheng et al., 2003; Cheng & Daniels, 2003, 2005; Kurtz, 2003; Yung et al., 2003; Zia, 2013; Zia et al. 2011; Also see Ulrich, 1998, 2000, 2003).

Some writers on place treat SOP as if it were an almost unconscious “frame,” more of an “orientation” or “perspective” than a set of explicit beliefs or actions; as such, they may overlook the role of deliberate strategizing and gaming in the formation of SOP. In the politics of discourse, the process of developing SOP can be approached strategically. For example, Yung et al. (2003) describe the influence of environmental groups in promoting a relatively new place name in Montana — “The Rocky Mountain Front.” In this instance, there is both strong evidence that the environmental groups were developing a “place” strategically, and also that this was perceived by longtime residents as an attempt to gain control of resource use over a huge area. Similarly, issues in environmental justice often come down to problems of political framing and to strategic drawing of boundaries (Williams, 1999). More recently, Van Patten and Williams (2008) explored the discursive construction of place meanings as they occurred in relations to people's “seasonal homes,” finding that sense of place, while clearly having a cognitive aspect, nevertheless must also be considered as a strategic articulation. Taking this insight one step further, Di Masso, Dixon, and Pol (2011) explored how the construction of place meanings was an active and important component of larger-scale conflicts about territory and space.

While it may be empowering to think of the impact of a person or group's strong SOP on politics, the relationships are no doubt reciprocal. The processes by which people (individually and in groups) define, bound, and identify with places are intertwined with political practices and institutional structures, as emphasized convincingly by Kurtz (2003). Likewise, the relationship between migratory patterns and SOP may be considered as reflexive if a strong SOP encourages rootedness. The consideration of SOP as both an independent and dependent variable, as endogenous to the system of interest, could enable cross-disciplinary explorations of the concept.

Here one may ask whether a strong SOP could lead to conflicting actions. For example, farmers and local environmentalists could each have a strong but clearly conflicting SOP. Because farmers tend to be more fixed to place than corporate and government employees, they may have accepted the vagaries of their place as essential to their livelihood. We may expect that the corporate or government employee would need much more time and special focusing effort to acquire comparable awareness and attachment to his/her place. In this investigation, we are principally interested in how a strong SOP emerges when change threatens or increasingly threatens a place for which one has developed concern. While the particularities of conflicting SOP are themselves worthy of study, the present inquiry focuses instead on the potential relationships between strong SOP, environmental concern, and citizen action.

3. Spatial discounting of concern

Can "sense of place" be measured directly, as one might provide a meter stick as a measuring rod for boards? The complexity and contextuality associated with sense of place seems to preclude a straightforward, one-dimensional measure. Nevertheless, we would like to know how SOP and SOP values affect the level of concern one has for a place. Concern represents an intuitive idea of intensity of feeling—positive or negative—about an object or change to one's surroundings. For our purposes, sense of place can be thought of as a necessary ingredient for environmental concern (C) that reflects the spatial dimension of one's strength of feeling toward an object or event.[6] While these concepts seem straightforward, they are still difficult to operationalize. Therefore we seek a *useful and measurable proxy variable* for C that could effectively track SOP.

Because of the problematic ambiguity between subjective and objective aspects of place, we begin as conceptually neutral as possible—by examining the measurable phenomenon of *spatial discounting*—which is observable in large, existing data sets. In so doing, we note two prior operationalizations of spatial concern: (a) rejection of a proposed hazard within a specified distance from home, and (b) willingness to pay (WTP) to be near an amenity or far from a hazard.

Hannon (1987, 1994) used two existing data sets to establish the existence of discounting of C across distance. Using data gathered by Mitchell and Carson (1986) from a national mail survey, Hannon (1994) highlighted the decline of concern across distance. The survey asked respondents how far from their home various facilities (a coal-fired power plant, a nuclear generating plant, and a "baseline" office building) would have to be located to make their presence acceptable. Hannon's analysis of the data revealed that (a) the rapidity of decline across distance from home varied according to the type of hazard in question, but that (b) for each hazard, concern for the hazard declined across distance from home for most respondents. Assessing aggregate concern from the fraction of the population rejecting the siting at given distances from home, Hannon revealed an exponential decline of concern of about 4.3% per mile for a coal-fired power plant, and about 2% per mile for a nuclear power plant.

Another way to represent C is to assess a person's willingness to pay (WTP) as a kind of "weighted voting" that uses economic behavior as a means of tracking individual choices "democratically," in the precise—but probably non-standard—sense that it tracks how people choose to spend their assets (Page, 1992). With a little theoretical bridging from work already done by economists who developed models for measuring the intensity of concern about a risk as the WTP for a unit of risk reduction, we might with Page (1992) measure the intensity of individuals' commitment to a place as the amount they are WTP to distance themselves from a hazard, and how much they are WTP to be near an attraction. Such an operationalization—using the methodology of real estate hedonics and choosing WTP as a proxy for C—would at least allow the measurement of how strongly individuals feel about a place, and it would have the advantage of expressing intensity of sense of place values in economic terms.

In a similar vein, sale prices of real estate can be examined to observe how prices vary in spatial relation to hazards and amenities. Using existing housing spatial profile values before and after an event, and drawing on data sets developed by Colwell and associates (Colwell, 1990; Colwell, Gujral, & Coley, 1985; Colwell & Guntermann, 1984; Colwell & Sirmans, 1978), Hannon (1994) showed that real estate prices on otherwise comparable homes declined when a hazard was sited nearby, and increased when an amenity was sited nearby. Farber (1998) reviewed empirical studies that measured the effects of undesirable facilities on property values and came to the same conclusion as Hannon (1994). The psychological study of the "Not In My Back Yard" (NIMBY) attitude underscores the influence of real estate upon spatial relations, highlighting objective and subjective factors involved in the rejection of controversial infrastructures close to one's home (Devine-Wright & Howes, 2010). Such factors extend beyond SOP and market-related dynamics to include ideology, perception of inequity, perceived threats to quality of life and property value.

Using both economic and sociological data, Hannon (1994), Farber (1998), and studies reviewed by Farber (1998) have demonstrated the spatial discounting of concern (C) as a significant and measurable human phenomenon. Distance matters. But we must ask: will it be the only significant factor? To the extent that SOP values are meaningful, they are also contextual: they depend upon detailed and particular relational characteristics of buyers, sellers, and holders that are more intimate than the forces of market exchange allow (Norton & Hannon, 1998). Psychometric research comparing place attachment at different spatial extents (e.g. apartment, home, neighborhood, and city) have found evidence for a U-shaped curve with the degree of place attachment at y-axis and the spatial extent of place at the x-axis (Hidalgo & Hernandez, 2001; Lewicka, 2010). In a relatively large sample of 18-nation study, Gifford et al. (2009) found evidence for spatial optimism bias ("things are better here than there") about the state of current environmental conditions. So, while a measure like WTP can be used to demonstrate the phenomenon of spatial discounting, advocates of a more subjective and individual version of SOP will argue that highly aggregated data loses the richness of detailed experiences and attachments that constitute a strong SOP.

4. Objective and subjective models

In our exploration of spatial discounting, we have considered Null Hypothesis 1 (NH1): Concern is a-spatial. Distance and location have no effect on the intensity of respondents' concern (C) regarding an object or to a proposed or predicted change in a nearby place. According to this hypothesis, relative concern for entities, objects, and processes is not influenced at all by an individual's spatial relationship to those entities, systems, or processes.[7] Concern is determined solely by non-spatial factors of an individual. We now reject NH1 because of the evidence of spatial discounting described above.

Having rejected NH1, our search for sense of place posits two "ideal types" of place-relationships: (A) a "thin" *reductionist* model of location and place and (B) a "thick" or *subjectivist* model. The mixture of the subjective and the objective forms something of a continuum, so the ideal types we introduce for illustration can be thought of as two models that fit near opposite ends of the key continuum between pure objectivity and pure subjectivity.

[6] In earlier work, Hannon (1987) asserted that people normally discount according to five, and five only, independent determinants of concern: time of event, likelihood of event having personal impact, distance from one's home, likelihood of having impact on loved ones, and means of detection of a threat. Here, we wish to concentrate only on spatial relationships and their impact on C.

[7] Formally, Null Hypothesis 1 can be described as: Change in Concern C_i of Agent A_i located at H_i about the Object O_j at Place $P_k = f$[Distance of Agent A_i and Object O_j, Location of object at the Place P_k, Change in the Place P_k over T temporal units] $= 0$. Where P_k is identified as located at x_k, y_k in a two-dimensional spatial coordinate system at time t.

4.1. The reductionist/objectivist model

This is the simplest model for understanding person–place relations; in effect, it rejects the distinction between location and place. If the simplest model explains observed behavior, then subjective factors may be unnecessary to characterize place attachment: one's sense of place is just a relationship between a person and objects measurable as raw distances from their home place. If this model adequately predicts spatially sensitive human behavior, then sense of place may be an unnecessary, or at least a derivative, concept. If dissipation of concern is dependent upon distance alone, we may be able to predict spatially sensitive behavior using only objective measures. This reductionist/objectivist model may be considered as either a simple explanation of space-related behavior (as a model to explain spatial discounting), or as an expression of the null hypothesis with respect to the subjective and emotive aspects of place.

Thus we face Null Hypothesis NH2: Concern is a function of location alone. Spatial Discounting describes the continuous decay of concern across distance in Euclidean space. If the *C* of individuals predictably declines according to the exponential model then those individuals have no sense of place beyond a sense of the distance of a hazard or an attractor from their home or the homes of their loved ones.[8]

According to this NH2, concern for entities, objects, and processes is solely a function of an individual's spatial proximity to those entities, systems, or processes. While recognizing the importance of the limiting factors imposed by its assumptions, Hannon (1987, 1994) has explored this reductionist approach as spatial discounting of concern. This simplified model thus "reduces" the subjective aspect of place to measurable distance. This model does predict much of the behavioral variance as represented in the aggregated data sets of Hannon's (1994) analyses. The dilemma remains, however, whether distance is adequate for assessing SOP, or whether finer-grained data must be assessed to reveal a subjectivist aspect of SOP.

NH2 is a key to understanding the subjective/objective continuum, because its affirmation denies that special and emotional attachments characterized by phenomenologists are a significant contributor to sense of place. Rejection of NH2, on the other hand, signals a shift toward the more subjective end of the SOP continuum, where SOP represents special and individual relationships (not merely measurable-distance relationships).

4.2. A subjectivist model?

If one believes in a stronger, "thicker" concept of place, in place as a function of experiences and affections of individuals, one will reject this simplified model and NH2, pointing out that the model obscures the richness of the idea of place because it looks at data that are too highly aggregated to reveal the individual experiences, attitudes, and behaviors that constitute place attachment. Rejecting NH2 is to adopt positive Hypothesis H3: Concern for a place is a weighted function of individual, subjective experiences, feelings, and attachments as well as objective spatial factors such as the distance from a hazard or amenity.[9] On this hypothesis, relative concern for entities, objects, and processes may be partially determined by spatial proximity, but it also depends on an individual's subjective relationships to the relevant geography that may violate the prediction of spatial discounting NH2. Concern can be said to be a function of an individual's "sense of place" and threat perception (Breakwell, 2001).

Considered as an "ideal type", this more phenomenological model of place encourages the idea that SOP will reveal itself in individual attitudes and behaviors, and that place is not susceptible to quantification and prediction because of its subjective source (Stedman, 2003b). For advocates of this model, the reductionist objective model based on generalizations and averages over whole populations will not reflect the very individual and special relationships that determine the intensity with which one feels concern for a place.

This thicker approach to place locates SOP in individual behaviors and in individual attractions and relations that are otherwise washed out by aggregation. While we are interested in accessing subjective SOP at the individual level, we recognize the importance of social and collective meanings in shaping subjective SOP, as emphasized by others (see Devine-Wright & Lyons, 1997; Gieryn, 2000; Mensch & Manor, 1998; Stokols & Shumaker, 1981). The reflexivity of a hierarchical SOP theory illuminates how individual experience is produced from collective meanings and social practices, an important phenomenon that has been demonstrated in the literature (Di Masso et al., 2011; Dixon & Durrheim, 2004; Prohansky, Fabian, & Kaminoff, 1983).

If we expect, with the phenomenologists, that sense of place is best represented as a subjective characteristic of individuals — dependent upon personal history and experiences (see, for example, Norberg-Schulz, 1980) — then aggregated data will never allow us to make discriminations among the different types and degrees of individual SOP. These experiences are important in the literature of phenomenology, geography, and human ecology; indeed, the plausibility of the idea that place involves intimate details of family and individual identity is part of what gives SOP such cache. The problem is that, to the extent place is characterized in purely subjective terms, it is difficult to operationalize in the form of general theory.

So, those of us who hope to make use of the concept of SOP in regional development analytics face a dilemma. Should we choose a reductionist approach that equates SOP with decay of concern across distance, at the risk of missing the true kernel of the idea of place? Or, should we embrace the thicker, richer concept of place as a function of subjective feelings, and apparently give up all reasonable hope of generalizing the concept?

We dramatize this dilemma to emphasize the importance of the choice. As noted above, however, we face a continuum rather than a stark choice of analytical frameworks. We have the opportunity to develop multiple models or to create an integrative model that acknowledges both subjective and objective aspects. To test the null hypothesis, we need independently observable and measurable behavior that is expected to vary with the more personal and emotive aspects of living in a place if we are to choose an adequate proxy variable for subjective SOP. We can then compare the ability of the emotively weighted variable with the ability of simple distance measures as a predictor of behavior.

5. Integrating subjective and objective aspects

In this section we introduce a way of thinking about place that integrates both subjective and objective aspects of place by using a geographically sensitive measure of individual behavior in space as a proxy for sense of place. Let us hypothetically reject NH2, asserting that there are individual, personal, and emotive aspects

[8] Formally, Hypothesis 2 states that Concern C_i of Agent A_i located at H_i about the Object $O_j = f$[Distance of Agent A_i from the Object O_j] $\neq 0$. Further, Hypothesis 2 asserts that $C_i > 0$ for Object O_1 as compared to similar Object O_2, if and only if Distance of Agent A_i from the Object O_1 is less than the distance to the Object O_2, and so on for j Objects. This will imply that f is strictly a monotonic decay function.

[9] Formally, Hypothesis 3 states Concern C_i of Agent A_i located at H_i about the Object $O_j = w_1{}^*f$[Distance of Agent A_i from the Object O_j] + $w_2{}^*g$[Experiences, Feelings, Attachments of A_i to O_j], where $\sum w_k = 1$, for $k = 1,2, \ldots, \infty$.

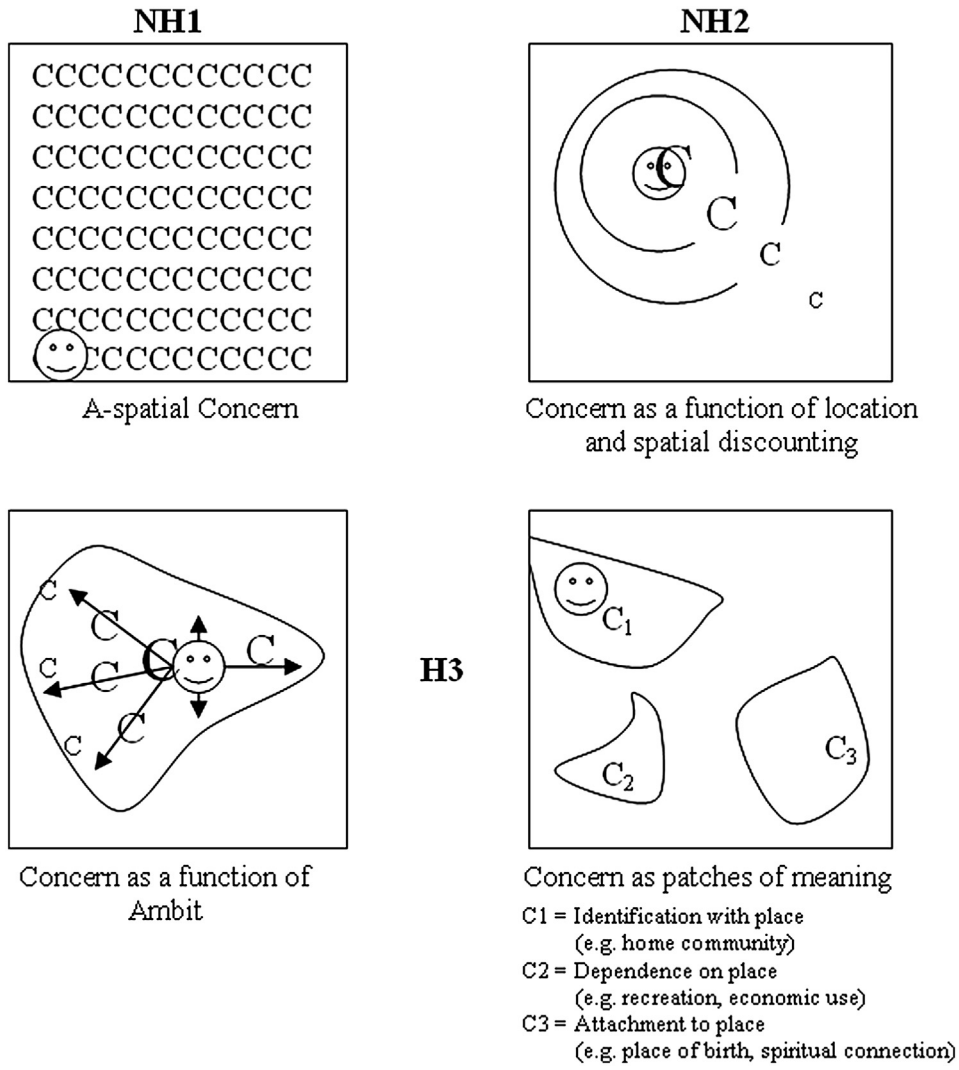

Fig. 1. Potential landscapes of concern, or C-Spaces.

that shape an individual's SOP. Accepting the reductionist model as explaining variation in individual levels of concern solely as a function of distance from the individual's home would minimize the special relationships so central to subjective approaches to place. We consider complicating that model by assuming that for most people the decay of concern is not a simple function of the distance from hazard or amenity to one's home. Special relationships, activities, knowledge, and interactions that defy spatial proximity, according to this view, are essential to SOP; and we therefore seek measures that might track the personal attachments to place.

Speaking, again intuitively, we can ask what factors contribute to sense of place values that would generate expansions or contractions of a "C-space" laid out in a landscape of concern as concentric circles of declining *C* across a two-dimensional (Euclidean) projection of geographic space away from the individual's home place. Individuals who have, or behave as if they have, the concentric circle model (NH2) have no sense of place beyond a sense of distance of a hazard or an attractor from their home or the homes of their loved ones. To explain their behavior one needs no distinction between place and location. Rejecting NH2, on the other hand, implies that, because of particular individual interactions and spatially sensitive relationships, we should expect that an individual's *C* will not decline isotropically in concentric circles. Rather, it will resemble an irregularly shaped "blob"—a 3D polygon—with contours of various degrees of care. Expansions and contractions of C-space may be represented in a third dimension as increasing/decreasing degrees of concern around the attractors/hazards. So deviations from concentricity in different directions from an individual's home could provide a measure of the intensity of individuals' *C* that cannot be explained by increasing distance from home alone. Deviations from the predictions of the reductionist, null hypothesis model that results in concentric circles thus reveal the subjective aspects of an individual's sense of place.[10] Individual and emotive sense of place are thus captured, at the finer-grained scale of individual behavior, as deviations from the predictions of NH2.

Fig. 1 provides simple representations of these alternative conceptualizations of spatial concern. The a-spatial NH1 is illustrated

[10] Formally, we will describe this deviation from concentric circle model as a distortion theory for sense of place. Distortion theory asserts that $\Delta C_i > 0$, if $w_1{}^*f(.) < w_2{}^*g(.)$. Distortion theory thus implies that as agent A_i spends more *free* time in places not predicted by the concentric (exponential decay) theory, the time dependent weights shift from objective to subjective side of the sense of place continuum.

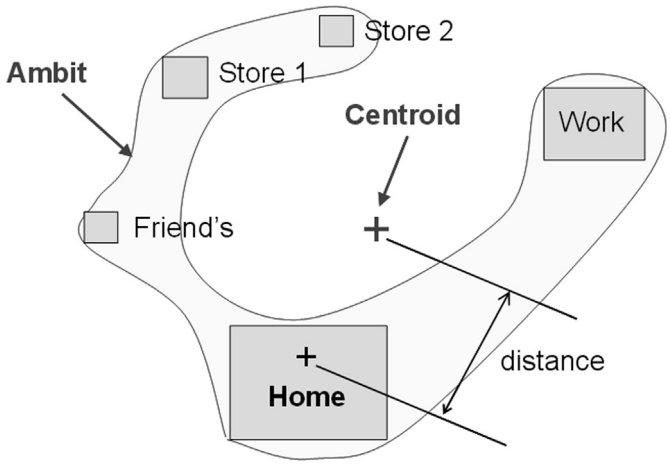

Fig. 2. Illustration of ambit scope and centroid.

as uniform *C* across a landscape, while the distance-based NH2 reveals concentric circles of declining *C*. Two alternative illustrations reveal possibilities for a subjective H3: C-space defined by one's ambit of movement over time; and *C* as represented by discontinuous patches of activity in a landscape. As an example of the latter, if someone jets to his or her country home for weekends, that person might develop a bicameral SOP. The texture of this ambit-based representation might help to explore differences between the often-fragmented SOP held by residents of modern, industrialized countries and the more continuous SOP of less technologically developed cultures, even when migratory.

Assuming that the null hypothesis NH2 will prove false, we proceed to explore integrative measures that could serve as proxies for *C* to capture the more subjective aspects of SOP. This conceptualization of ambit is intended to provoke alternative theories that relate movement of individuals through space to SOP.

5.1. Ambit

A simple way to represent movement through space around a person's home place is to identify a person's ambit as the limits of movement from the home of the individual/organism/group outward in all directions over a period of time. Integrating across *longer durations* can provide a periphery outlining the "regular ambit" of the individual as it is expressed in trips to destinations in various directions or nodes in 3-D space–time activity prisms.[11] The ambit provides, then, a behavioral measure of the extent of movements, which can be understood as a proxy variable for many individualized choices taken for many particular decisions of individuals as they move through the space around their home place.

5.2. Centroid

The centroid measure summarizes ambit—both with respect to the direction or the duration of trips away from home – in condensed form. Fig. 2 illustrates how both the ambit and centroid could be depicted on a map of time spent in various locations, where the size of the box is proportional to the time spent there. The centroid is determined from this spatial layout, analogous to the center of a weighted mobile. The distance from the centroid to one's home could then serve as a proxy for SOP, such that the smaller the distance, the greater the SOP.

The centroid of activities could either be derived from weighted time spent in different locations (*time-weighted centroid*), or from weighted number of trips taken to different locations (*trip-weighted centroid*). The ways in which obligatory long-duration trips are treated (e.g., to work) would be minimized in the latter, but both measures warrant exploration regarding sense of place. These centroids are formalized as follows:

5.2.1. Time-weighted centroid

The centroid of an individual's movements through space represents the weighted average of the time spent in various locations over a period of time, with long durations in a place being represented in the placement of the centroid.

The time-weighted centroid, or centroid of duration, variable provides a proxy measure for SOP on the basis of empirically tracked movements of people over time. Formally, if time-spent proportional weights (w_1, w_2, … ,w_T) are attached to each location (P_k) of an agent's ambit for *k* locations, where the *k*th location is agent A_i's home, then the centroid (Ψ) in a two-dimensional space for a given time period *T* can be estimated as:

$$\psi_{(x,y)} = w_t P_k + w_{t-1} P_{k-1} +, \ldots + w_1 P_1; \; for \sum w_t = T \tag{1}$$

Let us then consider X_i for the *i*th agent as the Euclidean distance between agent A_i's home (P_k) and centroid, as:

$$X_i = \left| P_k - \psi_{(x,y)} \right| \tag{2}$$

Then SOP for agent A_i could be represented as an inverse function of X_i, i.e. the greater SOP is signified by lesser *X*, or

$$\mathrm{SOP}(A_i) \propto \frac{1}{X_i} \tag{3}$$

Equation (3) operationalizes SOP as a local phenomenon, so, by definition, if X_i is global (larger in scale), then it connotes lesser SOP. This functional assumption is based on the premise that SOP is stronger for local community activists or "agents of change."

5.2.2. Trip-weighted centroid

The centroid of an individual's movements through space can be represented as reflecting the intensity of an individual's relation to a location, measured as the cumulative number of trips to that location. The formalism for the trip-weighted centroid follows Equations (1)–(3), except that the weights in Equation (1) represent the distribution of trips τ, and not time spent, across all the locations P_k. So, $\sum w_t = \tau$.

5.3. Super-ambit

The super-ambit concept combines the scope of the ambit with the psychometric intensity of concern assessed through activities over time. If one has data adequate to calculate an individual's centroid over a period of time, that data—whether a record of duration or trips—would allow the creation of an ambit (represented as the periphery of the individual's movements over a period of time) with "weights" representing either duration of time spent in a location within the periphery—or representing the psychometrically estimated concern for a specific location over the period. This super-ambit could be represented as a heat map with color gradients reflecting intensity of *C*, analogous to satellite

[11] The choice of temporal scale (e.g. 1, 10, 25, 50 or 75 years) for aggregation across *longer durations* may however result in different ambulatory patterns. This choice will also affect how demographic mobility, arising from individual/household level choices, is understood at larger spatio-temporal scales. Technological changes that occur during the *longer durations* will further complicate the analysis.

images of thunderstorms in an area as shown on weather channels. Such representation would be helpful for finer-grained analysis of an individual's or group's SOP, but its multiple dimensions (intensity *and* scope of concern in a landscape) could obscure its power as an explanatory variable.

6. Assessing ambit from a survey of Californians

To test these hypotheses and operationalize the ambit-based constructs for sense of place, a survey instrument (see Appendix) was designed to elicit an individual's ambit over a temporal scale of one year. The survey was implemented in the spring of 2008 to collect ambit data from 74 residents of Silicon Valley in California. The small study size minimized the cost of survey collection while demonstrating a prototypical application of the ambit-based sense of place theory. Although the survey instrument is limited by human memory, survey data also represent the subjective/phenomenological bias of respondents, assuming that respondents tend to remember and report about those places for which they have higher concern. To analyze the extent of subjective and memory biases, time measurements were included in the survey protocol for measuring the reporting error.

A sample of 74 respondents in California's Bay area (Silicon Valley) completed the survey. The data from each survey protocol were coded using spreadsheet software and then imported into spatial analysis software to calculate Euclidian distances for annualized trips of an agent. Google Earth Pro was used to calculate the Euclidean distances from a respondent's home to all the trip destinations for each of the 74 respondents.

Table 1 presents descriptive statistics for the key variables in the study that were measured for each respondent. In terms of temporal completeness of reporting, on average, respondents reported about 7556 (±1193) hours. Since 2008 was a leap year, there were a total of 8784 reportable hours. Reporting bias thus varied from 51.74% under-reporting to 18.48% over-reporting. On average, the sampled respondents under-reported by 13.97% (±13.59%). The time-weighted centroid of respondents averaged 96.66 (±243.97) miles, much larger than the trip-weighted centroid, which averaged only 15.63 (±15.68) miles around the respondent homes.

Table 2 presents descriptive statistics for the key variables in the study that were measured at the level of each trip destination reported by the respondents. Each respondent averaged about 31 (±57) trip destinations per year. At least 399.67 (±1116.05) hours per year are reported to be spent by each respondent outside their homes, traversing on average one-way Euclidean distance of 110.65 (±626.87) miles per year towards their trip destinations.

6.1. Testing linear and non-linear spatial discount rate hypotheses

Using the approach by which Hannon (1994:166) calculated a spatial discount rate for squirrels, we calculated a spatial discount rate for the sampled respondents by plotting % time spent versus distance from home, as shown in Fig. 3. Of all the functional forms tested for fitness (i.e. linear, exponential, power, logistic etc.), the logarithmic function explains the most variation (R^2 at 44.3%). This is very similar to the exponential decay function. We estimate that for every ten miles of distance away from their home, respondents spend Exp (−2.98) = 5.07% less amount of time. The decaying spatial discount rate of 5.07% estimated for the sampled respondents enables us to reject both NH1 and NH2. We reject NH1 because respondents spend exponentially less time away from their home. We also reject NH2 because we observe significant deviations in the observed values of the time spent from the predicted logarithmic decay function. The R^2 at 44.3% does not explain the total variation in the sample. In fact, a non-linear cubic logarithmic spatial discount rate function is an even better fit (R^2 at 76.3%) than the linear logarithmic decay function, as shown in the estimated equations in Fig. 3. Nevertheless, even a non-linear cubic logarithmic function does not explain total variation in the ambulatory behavior of sampled respondents.

On the basis of these empirical ambit data, we examined deviations to the logarithmic decay function as suggestive of a subjective SOP. By analyzing mean error in estimating logarithmic and cubic logarithmic decay functions, we found that the predicted error rate increased as the distance from the home of a respondent increased, implying that respondents spent more time in distant places than predicted by the logarithmic decay function. The error rate propagation away from home was somewhat rectified in estimating the cubic logarithmic decay function (as it had a better fit), but then this implied that sampled respondents exhibited highly non-linear spatial behavior. Analyzing this non-linear empirical pattern in terms of NH2, we found that sampled respondents appeared to be more concerned about distant places (because they spent more time there) than predicted by their logarithmic or cubic logarithmic spatial discount rates.

As indicated in the Appendix, survey questions were asked about trips taken by purpose, to differentiate travel to work or school (question 3), to visit relatives (question 4) and friends (question 5), to shop (question 6), or for recreational purposes (question 7). We found that sampled respondents spent the most time at home, followed by school, work, and shopping trips, followed by visits to family and friends, followed by recreational trips. In contrast, as anticipated by subjectivist SOP theory, sampled respondents traversed the farthest distances away from home for attachment-related social visits and the shortest distances away from home for necessary trips to school, work, and shopping that signify place dependence.

Table 1
Descriptive statistics for 74 survey respondents.

	N	Minimum	Maximum	Mean	Standard deviation
Hours reported	74	4239.00	10,407.00	7556.07	1193.80
Time Weighted centroid radius (Miles from home)	74	.36	1330.88	96.66	243.97
Trip weighted centroid radius (Miles from home)	74	3.43	81.93	15.63	15.68
Reporting bias (%)	74	−51.74	18.48	−13.97	13.59

6.2. Exploring the relationship between SOP and community activism

As part of the survey, respondents were asked how active they were in their community (see question 9 in the Appendix). The relationship between ambit-based SOP and self-reported community activism is represented in the form of an error bar, in Fig. 4. Here, self-reported activism is divided into just two categories: “low” represents 0–4 and “high” represents 5–10 on the activism scale. The error bars in Fig. 4 show the 95% confidence interval. Those who were high on the activism scale tended to have a low time-weighted centroid, with a mean of approximately 20 (±10) miles, while those who were low on the activism scale tended to have significantly high time-weighted centroids, with a mean of approximately 120 (±70) miles.

In addition to their self-reported activism, survey respondents were asked about how many voluntary community meetings they attended over the course of the prior year. Fig. 5 illustrates the

Table 2
Descriptive statistics for trip destinations reported by 74 survey respondents.

	N	Minimum	Maximum	Mean	Standard deviation
Time spent (h)	1399	.00	7750.00	399.67	1116.05
Timeweight	1399	.00	.88	.045	.12
Distance from home (Miles)	1395	.00	7842.00	110.65	626.87
Time distance = Distance*Timeweight	1384	0	1325	5.17	57.60
Trips per year	1360	.00	490.00	31.01	57.35
Tripsweight	1361	.00	4.29	.05	.15
Trip distance = Distance*Tripweight	1358	.00	118.78	.90	4.29
Travel distance = Distance*2*Trips	1382	.00	49,560.00	815.23	2511.82
% Time spent	1399	.01	88.22	4.55	12.72

responses for the number of meetings attended relative to the time-weighted centroid for each respondent. Sense of place measured through the time-weighted centroid provides an indication of likely participation in voluntary community meetings. Specifically, when the time-weighted centroid exceeded 75 miles, the likelihood of a respondent attending 5 or more voluntary meetings in a year dropped below 10%.

The data analysis of the results from this survey highlights the operational utility of ambit-based centroid measures for thinking about sense of place. These empirical findings are thus illustrative and not necessarily generalizable, a task that remains for future empirical research.

6.3. Survey limitations

The empirical methodology deployed in this study has several limitations. First, the survey methodology is limited in that respondents do not remember all of their trips undertaken in the last one year, which typically results in the underestimation of their time-weighted and trip-weighted centroids. Data collected with global positioning systems (GPS) would improve the accuracy of ambit estimation in future studies and could be coupled with psychometric surveys. Cell phone data could also be useful. Finally, time use surveys and travel diary databases could also be analyzed to test the proposed theoretical hypotheses.

A second limitation is that Euclidean distances were measured to estimate trip- and time-weighted centroids, resulting in underestimation of these variables as compared to distances accounting for the road network. Future studies should compare both Euclidean and network distances. In addition, the geocoding of various trip destination addresses was limited because some respondents either provided incomplete addresses or wrong addresses that were not matched by Google Earth Pro. This study had an 85% successful geocoding rate. GPS-based studies do not require a geocoding step and thus would not have geocoding address matching issues. The collection and analysis of GPS-based data is relatively costly, however, in addition to posing important privacy concerns.

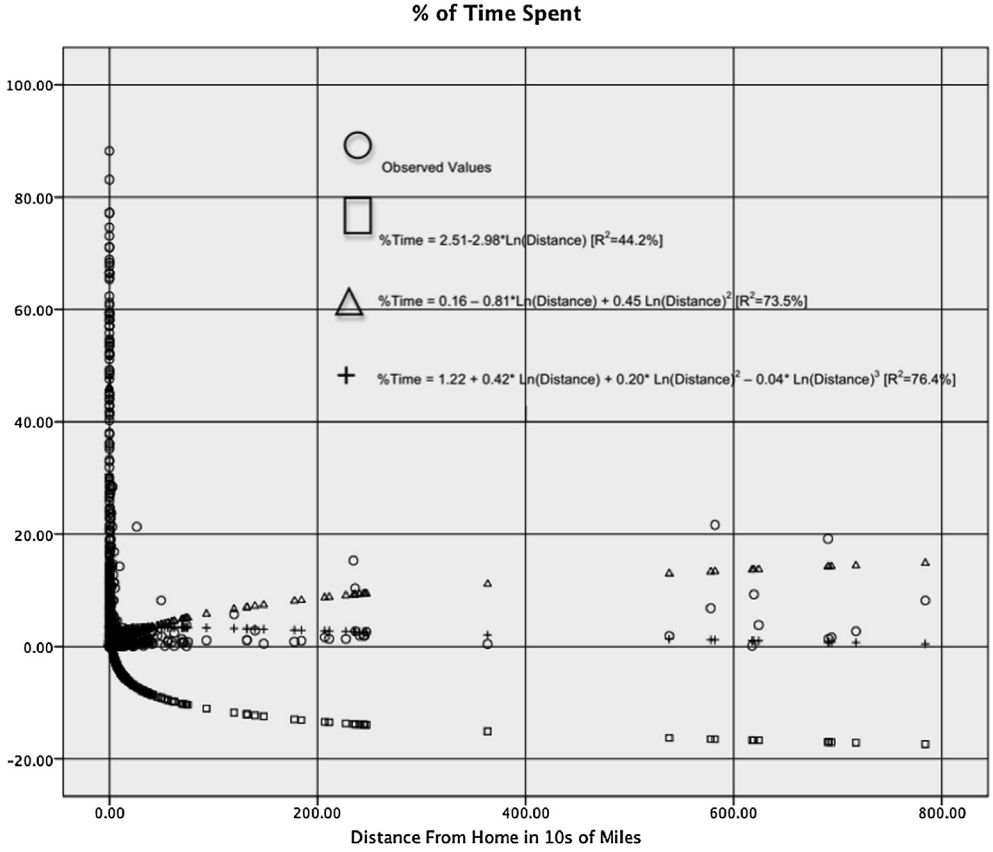

Fig. 3. Spatial discount rate estimators for % time spent versus log of distance from homes.

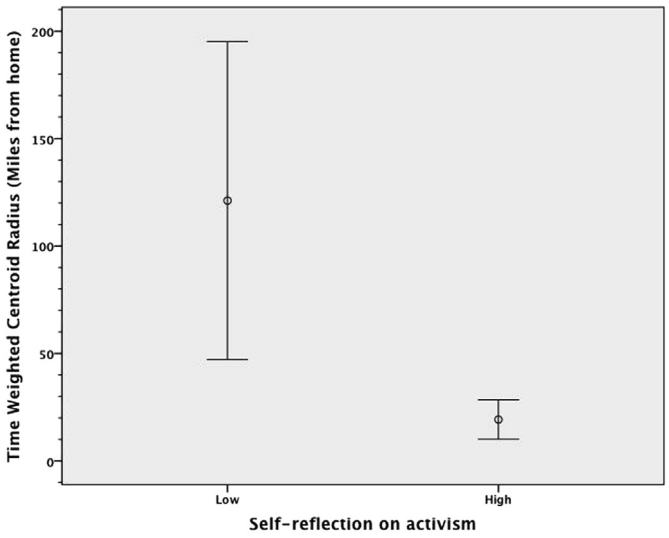

Fig. 4. Time-weighted centroid for low and high community activism.

Third, we did not directly measure the psychological status of respondents, i.e. the phenomenological strength of their feelings towards various places. Future studies could measure both ambit and phenomenological strength of people's feelings towards places. Fourth, we did not explicitly measure the concern of people around environmental amenities and dis-amenities. In future research, ambit-based measures could be combined with phenomenological and psychometric approaches, on the one hand, and econometric and hedonic approaches, on the other hand, to compare ambit based measures with environmental concern.

Finally, based on responses from 74 volunteers, the sample of this study is small and not random, Future studies should be designed to elicit appropriately chosen random samples for the study area. The survey analysis conducted in this paper is limited to a scale of one year, but empirical extensions of this work will examine patterns over longer time scales (10 years, 25 years, and so on).

7. Developing ambit-based sop theory

Ambit-based conceptualizations for sense of place open the door to measuring behavior that is expressive of many daily decisions shaping (and shaped by) motion through space, on the premise that some of that mobility will express commitments and attachments associated with place. We have articulated and explored ambit-based measures such as the time-weighted and trip-weighted centroids so as to facilitate interdisciplinary research on sense of place that involves diverse empirical and analytical methods. In future research, empirical ambit measurements could be derived from volunteers who wear or carry GPS devices over extended periods of time, creating a detailed data source such as that which informed the rich visualizations of space–time behavior developed by Kwan (2000, 2004). Alternatively, a person's ambit could be drawn based on an interview in which respondents are shown a map with major routes away from their place and asked how far they have gone in that direction in the last year, where they have spent their time relative to the time spent in their homes, and about their intensity of concern and attachment for various places visited or would like to visit. Over longer time-scales, decadal to centurial, super-ambit based measures could be adjusted to account for mobility dynamics of people's homes and explain long-term human settlement patterns closer to attractors and farther from hazards, with an underlying social ecological complexity driven by changes in the state space of the attractors (e.g., water quality deterioration in the lakes due to nutrification) and hazards (e.g., climate change induced increases in extreme weather events). More nuanced ambit-based analyses could be developed for people who have two or more "homes," or people migrating from place to place, or even "traveling salesmen." Furthermore, a longitudinal study measuring ambit-based SOP must also be sensitive to changing homes, i.e. time-weighted and trip-weighted centroids will need to be measured with multiple "homes" or reference points.

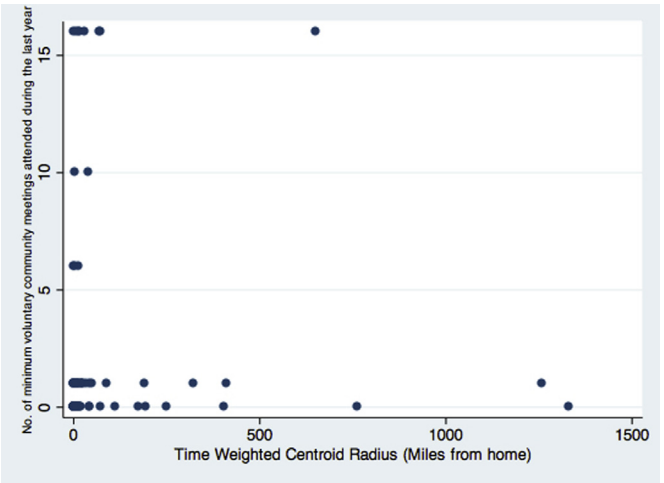

Fig. 5. Participation in voluntary community meetings.

Anchored in the behavioral focal level of a hierarchical SOP, the super-ambit is suggestive of diverse possible empirical applications for the study of place-based attitudes and behaviors. If ambit representations are accompanied by information about the purpose of trips and attachment to the places, ambit data may be parsed so as to reflect attitudes and purposes that explain the behaviors in question. In surveys such as the one we conducted, categorization of trip purpose helps to distinguish the mandatory trips from optional ones. While many of the visits one takes (e.g., to a dental office moved to an inconvenient location or to some location dictated by work) may not reveal any attitudinal attraction or antipathy for a location, many other trips people make are discretionary. The meaningless trips broadly cancel each other out as random noise with respect to personal experience of SOP, while discretionary trips (e.g., where one goes on holidays or to visit the graves of family members, weekend getaways at the family cabin) stand out as reasonable indicators of spatial concern. Thus, if ambits are circumscribed by all trips, then perhaps many non-voluntary trips will cause so much "noise" in data that movements mean little about attitudes and preferences. Interview or survey data could be used not only to determine migratory behavior, but also to elicit self-reported reasons for particular trips and degrees of attachment to various places inhabited over time, and thereby begin to reveal spatial preferences from the noise of our mobile society.

A detailed analysis of information beyond actual geographic movements (such as trip purpose and psychometric degree of attachment) allows particular ambit measures to reflect value-loaded choices that express an evolving SOP, adding a dynamic behavioral component to the SOP model. Distinguishing psychometric sources of attachment could enable emphasis on different aspects of SOP that have been identified in the literature, such as: *dependence* – a place is meaningful because a person depends on it for some behavior or activity (Clark & Stein, 2003; Eisenhauer,

Krannich, & Blahna, 2000; Hidalgo & Hernandez, 2001; Williams, Patterson, Roggenbuck, & Watson, 1992); *identification* – a place is meaningful because it is a part of who a person "is" (Clark & Stein, 2003; Prohansky et al., 1983) or where a person is "rooted" (Gustafson, 2001a; 2002); and *attachment* – a place is meaningful because a person has an emotional connection to it (Altman & Low, 1992; Hidalgo & Hernandez, 2001; Williams & Vaske, 2003).

The proposed ambit-based SOP theory is very relevant to the existing research and theories of place attachment, as deftly synthesized by Lewicka (2011). After a thorough review and synthesis of the existing literature, Lewicka (2011: 226) laments the lack of theory development and under-emphasis on the place and process components of the tripartite person-place-process model of place attachment: "The vast literature on place attachment includes very few studies driven by a specific theory or meant to test specific hypotheses." Our proposed ambit based SOP theory could potentially contribute towards integrative theory development that bridges subjective and objective dimensions of place attachment and SOP. Specific elicitation processes for space–time activity patterns could contribute to understanding the underlying processes that generate the observed curvilinear relationship between place attachment and place scale, where home and city generate greater attachment than neighborhoods (Hidalgo & Hernandez, 2001). Lewicka (2010:42) investigated this curvilinear relationship between place attachment and place scale for four cities (Warsaw, Wroclaw, Lodz, and Lviv) and found that when it is measured by declared behavior, place attachment seems to stand in a different relation to the place scale than attachment measured by the declared feelings towards the place. Our proposed ambit based SOP theory could expand upon this line of inquiry by systematically measuring the patterns of space–time activity "routines," as proposed by Seamon (1980), and assessing deviations from the "routines". We may expect that the deviations from these established routines may look different depending upon whether the measured component of place attachment is behavioral or affective. Future research could thus compare the behavioral and affective approaches to SOP measurement for the same set of respondents in longitudinal/panel studies. Further, the role of mediating factors such as cultural (Chang, 2001; Gifford et al., 2009) and social, physical and demographic (as explained in Lewicka, 2010) in explaining SOP and place attachment could be empirically investigated through the ambit-based SOP theoretical framework developed in this paper.

The conceptual framework developed in this paper complements other efforts to operationalize sense of place. Brown and Raymond (2007) do so by treating their unit of analysis as a parcel of land (e.g. a conservation park, a forest land) and assessing SOP about that parcel of land as experienced by locals, tourists, and other stakeholders. They establish that local residents who have spent more time in a national park may tend to have stronger SOP about that park than visitors. In contrast, our approach treats an individual person as a unit of analysis and uses hierarchical theory to articulate the ambit as a proxy for SOP. This enables us to approach SOP theory from the perspective of individual behavior (i.e., time spent in different places), allowing for a full range of possible subjective and objective models to emerge from the "inside out." This conceptualization of the ambit at the observable level of a hierarchical SOP theory relates to and builds upon scholarship examining the behavioral components of place (Genereux, Ward, & Russell, 1983), the nuanced meanings of place (Gustafson, 2001b), and gendered differentiations in spatial practices (Coluccia & Louse, 2004).

In addition to the empirical possibilities, useful extensions of this research include the development of agent-based models to serve as virtual laboratories in which to experiment with theories about sense of place that utilize the ambit as developed in this paper. Agent-based models capturing dynamics at multiple temporal scales can help to develop theory about sense of place by simulating individual attachments as well as aggregated societal measures that emerge from the individuals. These models can help to transcend scalar difficulties by enabling aggregate characteristics and social norms to emerge from the "bottom up," while accessing SOP from the "inside out" of well-defined individual perspectives.

Agent-based models may help to develop SOP theory by exploring the hypotheses developed above (and illustrated in Fig. 1), treating the SOP constructs as independent variables embedded in agents of homogeneous or heterogeneous societies. Combined with mechanisms for agent interaction via communication, such models could simulate the emergence of SOP values at the societal scale. We may expect that homogenous societies embodying the objective NH2 measure of distance decay would focus on local environmental actions. In contrast, societies embodying a more subjective H3 measure as the distortion of ambit relative to concentric circles may reveal wider, globalized environmental policies. This example suggests how sense of place may be operationalized as an independent variable affecting political outcomes. Likewise, a model expressly designed to explore spatial dynamic behavior can be leveraged to simulate the formation of SOP as a dependent variable. Here, the proxy ambit and centroid measures would be computed dynamically in a model as mobile agents go about their activities. Richer psychological notions can also be examined by embedding mental models into the agents.

Once this general idea of the constitution of place consciousness is developed into an operational ambit-based measure, it is possible to test alternative theories about sense of place as both a dependent and independent variable. Agent-based models are advantageous for this purpose because they enable sense of place to be simulated as endogenous to the system. The interconnections between sense of place and regional development policies, environmental politics, and migration patterns may then be explored via simulated feedback mechanisms. The ambit-based measures defined in this paper provide a potential filter for aligning simulated SOP with empirical patterns as part of an iterative modeling process informed by observation (Grimm & Railsback, 2005; Grimm et al., 2005). The linkage of agent-based models with rich geographic data has been demonstrated in a variety of examples (Batty, 2005; Gimblett, 2001). Using agent-based models to explore sense of place would help address Henrickson and McKelvey's (2002) call for increased use of agent-based models to develop social theory congruent with new understandings of complexity science as highly contextual.

8. Conclusion

This paper addresses the need for sense of place to include both subjective and objective aspects of human relationships to place. Using hierarchy theory to locate the behavioral concept of ambit at the focal level of a tri-level model stratifying mechanism, behavior, and regulation, we explore the rich middle ground between a purely positivist understanding of SOP as distance only, and the difficult-to-measure phenomenological understanding of SOP as embodying subjective and personalized choices and experiences. If, as intuition warrants and as many have suggested, SOP must be understood as representing at least in part peoples' subjective relationship to space, and if it is to be measured based on data, then, we have argued, it will be necessary to look at data that are not aggregated at the population level. We will need to look at what individuals do in particular places and at how they move between them.

By conceptualizing the ambit as a behavioral approach toward sense of place that reflects the spatial extent of human activity over

time, we have introduced an independent measure that serves as a behavioral core for theories about sense of place that have to do with how people live. In so doing, we offer advocates of both subjective and objective paradigms a behavioral anchor for their theories. With the ambit as an example, we argue that there is an alternative option to being either strictly objective or strictly phenomenological, but rather a meeting place in behavioral analysis for these paradigms.

While the ambit is only a proxy for a concept of SOP that is integrative of both objective and subjective components, it has the advantage of being based on descriptive reports of observable phenomena. The ambit also allows for parsing of individual data in ways that correspond to theoretical concerns that have been previously difficult to test. We draw upon an empirical analysis of ambit data from a survey of 74 Californians to illustrate how hypotheses regarding sense of place can be tested with time- and trip-weighted centroids associated with individual ambits. Survey results regarding community activism as influenced by the time-weighted centroid of respondents' ambit indicate that more work in this direction is warranted. We discuss how theories about sense of place could be further developed empirically using GPS data, interviews, and longitudinal surveys to characterize the human ambit. Further, we point to the potential for embedding ambit in agent-based models to endogenize SOP and represent multi-scalar dynamics in ways that adhere to hierarchy theory.

This work has important implications for regional development and environmental policy analysis. Sense of place shapes the way people think about and relate to structures of governance and to civil society (see Cantrill & Senecah, 2001; Cheng et al., 2003; Kaltenborn, 1998; Norton & Hannon, 1998; Yung et al., 2003). Furthermore, our most pressing and daunting environmental problems tend to cross the boundaries of established political jurisdictions (see Blomquist & Ingram, 2003; Hajer, 2003; Ostrom, 2005). As we work to develop new formal and informal institutions for dealing with problems that both exist in places and cross the boundaries of established spaces, it will be increasingly important to know something about people's contours of meaningful place attachments as experienced on the ground.

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Appendix A. Supplementary data

Supplementary data related to this article can be found at http://dx.doi.org/10.1016/j.jenvp.2014.08.001.

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