Analysing the effects of spatial configuration on human movement and social interaction in Canadian Arctic communities

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Abstract
In the archaeological record, the rise of sedentary communities is often a gradual process involving increasing settlement nucleation, and the indigenous development of more complex levels of community organization. In contrast, the creation of permanent nucleated settlements in the Canadian Arctic by the Federal Government in the 1950s and 1960s introduced Inuit families to settled community life almost overnight. The layout and design of these new arctic towns were based upon Euro-Canadian concepts of community structure, administrative control, and social cooperation. Roads, utility hookups, and building codes replaced cultural values, familial ties, and the requirements of traditional activities in determining the placement of roads and homes within settlements. Axial analysis is used to examine the effect that the spatial configuration of Canadian arctic communities has had on patterns of movement and social interaction among Inuit inhabitants. Analysis of field observations conducted over a two-month period in the hamlet of Arviat, Nunavut Territory indicate that integration is a much better predictor of vehicular than pedestrian traffic, and that each is characterized by a different pattern of movement. I argue that this unique pattern of pedestrian movement is generated by cultural values in Inuit society which stress the need for regular face-to-face contact among members of extended families. These results may have important implications for northern community planning.

Keywords
Inuit, Canadian Arctic, human movement, Space syntax, Northern community planning

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Introduction

In 1950, V. Gordon Childe published an article in *The Town Planning Review* entitled "The Urban Revolution" in which he defined the traits associated with the origins of urbanism in the archaeological record. Among the attributes he outlined was the presence of conspicuous order in the spatial configuration of towns and cities. The formalization of building and activity locations within settlements was viewed as evidence for the existence of architects and planners who possessed the power to make decisions regarding the location of new buildings and facilities. Out of these decisions emerged the urban grid – a mechanism for generating and sustaining patterns of human movement and encounter which defined a shared way of life. In the archaeological record, the emergence of urbanism represents the culmination of

indigenous cultural processes that extended over many thousands of years. This stands in vivid contrast to the Canadian Arctic where, during the post-war period, settled community life emerged as an "event" rather than as a process. While the term "urbanism" is often used to define aspects of life in large cities, the transition from small nomadic camps to settled towns and hamlets during the 1950s and 1960s introduced Inuit to communities of a larger and more permanent social scale. This transition was encouraged by Canadian Government officials who felt that Inuit families could be better provisioned with health care, education, and public services if they were centrally located rather than scattered across the north in small, highly mobile groups. The layout and design of these new arctic communities was based upon Euro-Canadian concepts of community structure, administrative control, and social cooperation. Roads, utility hookups and building codes replaced cultural values, familial ties, and the spatial requirements of traditional activities in determining the location of buildings within settlements.

Recent research in the field of space syntax analysis indicates that the spatial configuration of European and North American cities generates encounter fields among inhabitants that create opportunities for social interaction, exchange, and community life (Peponis et al., 1997; Hillier et al., 1993; Hillier, 1996). Consequently, the spatial configuration of any town or city can be seen as a projection of the social relations of its inhabitants. The term "virtual community" has been used by Hillier (1996) to describe the pervasive social effects generated by urban layouts. Configurational descriptions and observational studies of Western cities and towns have revealed that the length, connectedness, and position occupied by each route of movement within the urban grid will influence the density of human movement that occurs along it (Hillier, 1996). Out of this concept has emerged the understanding that integration is a powerful predictor of how "busy" or how "quiet" a path or street is likely to be. Integration is measured by examining the differences in "trip" lengths required to move from each individual route to all other routes within the urban grid. The more centrally located the route, the shorter the trip lengths to other destinations within the grid, and the greater its level of integration. By examining how integration is distributed throughout the urban grid, one therefore gains a sense of how towns and cities function in generating encounters between individuals that define what Hillier (1996) has called "the virtual community".

To date, most configurational analysis has focused on Western cities and towns in Europe and North America, where spatial configuration is more or less congruous with the economic practices and cultural values shared by their inhabitants (see Peponis et al., 1997; Hillier et al., 1993; Hillier, 1996). In these locations, practitioners of space syntax analysis have documented strong correlations between

human movement and spatial integration. But what if the occupants of Western cities were suddenly replaced by people with a radically different way of life and set of cultural values? This hypothetical situation describes the reality of many communities in the Canadian Arctic and raises a number of intriguing questions. First, to what degree is natural movement a culturally variable phenomenon? Second, if spatial configuration is an important means of defining and sustaining urban life through movement, then how well would the movements of one cultural group link to the spatial configuration of a community designed by another?

In order to explore these questions, axial analysis of two Canadian Arctic communities was undertaken. Observational data on various categories of vehicular and pedestrian movement densities were then collected in one of the two communities to test against the axial model. Results so far indicate that integration is a much better predictor of vehicular than pedestrian traffic, and that each is characterized by a distinctive pattern of movement. I argue that the unique pattern of pedestrian movement I observed is generated by cultural values in Inuit society which stress the need for regular face-to-face contact among members of bilaterally extended families. This is necessary to sustain networks of mutual assistance which allow for the sharing of food and hunting equipment and the organization of labor. These results suggest that human movement is indeed a culturally variable phenomenon, and that this has important implications for northern community planning.

Spatial configuration, movement and co-presence

Configurational modeling of urban networks has become a major focus of space syntax studies. Such models are constructed by breaking up the urban layout of a city or town into the fewest and longest lines of sight and access that pass through all possible routes of movement. The resulting axial map can then be analyzed using a number of statistical measures that describe the configurational properties of the network. A measure of how accessible each axial line segment is to neighboring lines can be obtained by simply counting the number of connections per segment (Hillier et al., 1993: 35). In addition to measuring the connectivity of a line segment, the relationship of each axial line to the whole urban system provides an important global measure called *integration*. The most integrated lines in a network are those with the shortest average "trip" lengths to all other destinations within the grid. In contrast, the most segregated lines are those in which trip lengths vary to a much greater degree. In other words, integration measures the mean depth of every axial line in the grid relative to all other lines (Hillier et al., 1993: 35).

The discovery of significant correlations between the integration value of an axial line and the amount of pedestrian and vehicular traffic that flows along it suggests that the spatial configuration of an urban network exerts a strong effect on human movement (Hillier et al., 1993; Penn et al., 1998; Hillier, 1996; Peponis et al., 1997). What is especially interesting about this relationship is that it contradicts the idea that movement density is determined primarily by patterns of land use. Early examinations of pedestrian and vehicular movement tended to apply a "point to point" approach in which the presence/absence of "attractors" such as retail shops and other service providers along a route of movement determined how "busy" or "quiet" it would be. However, Hillier et al (1993) demonstrate that the normally linear relationship between integration and movement density is transformed into a logarithmic one in the presence of these types of attractors. This led Hillier et al (1993) to conclude that attractors tend to serve as multipliers on a basic pattern of movement, and that movement densities are therefore more an outcome of the position occupied by a route of movement in the urban grid.

By examining how integration is distributed throughout the urban grid at local and global levels, one can develop a sense of how towns and cities with different spatial configurations generate what Hillier (1996) has called "encounter fields" in which patterns of movement create possibilities for meeting and avoiding others. If culture is continually reproduced through such encounters, then it seems reasonable to assume that human movement must also be culturally variable. As a result, the spatial configuration of cities and towns should reflect the spatial logic of their intended inhabitants. When urban grids become "deformed" through poor planning or unchecked growth, the natural pattern of human movement is changed, encounter fields are altered, and urban problems can result (Hillier, 1996).

The Spatial Characteristics of Canadian Arctic Communities and Traditional Camps

Northern communities in Canada provide us with an entirely unique example of a deformed grid because of the challenges posed by construction in arctic environments. The spatial layout of these communities is determined primarily by servicing and administrative requirements. The urban grid is configured to balance two tendencies: the need to make the pattern as small as possible to reduce the costs of development and servicing, and the need to separate buildings by at least 12 meters in order to control the spread of fire (Strub, 1996: 92). In most arctic communities, drinking water is trucked from reservoirs to dwellings and public buildings, where it is stored in tanks (Bruce, 1969: 8; Gerein, 1980: 91). Likewise, sewage and household refuse are collected from residences and trucked to dump sites located on the outer edges of the community (Bruce, 1969: 8; Gerein, 1980: 91). Consequently, the compactness

of the urban grid is an important consideration in reducing transportation costs (Gerein, 1980: 92). Snow drifting and drainage problems are also paramount concerns in northern community development (Gerein, 1980: 92; Strub, 1996: 92). Significant accumulations of snow can block off areas of the settlement, making access difficult for water, sewage and fire trucks. Street patterns are therefore elongated and paralleled with the prevailing wind direction to keep streets free of snow (Gerein, 1980: 93). Buildings are oriented in a similar fashion to reduce wind resistance and minimize the accumulation of snow in lee side areas (Strub, 1996: 94-96). However, the regular placement of street systems and buildings frequently has a tendency to interrupt the existing drainage pattern of the land (Strub, 1996: 92). This can limit the direction and extent to which settlements can expand. For example, the southward expansion of the hamlet of Arviat, Nunavut, was limited by the combination of an eastern drainage area and drainage via a stream to the south (Makale, 1977: 51). Easy access to administrative and consumer services is another important determinant of settlement organization in contemporary arctic communities (Strub, 1996: 92). This requires the central location of facilities such as the community health center, band office, RCMP headquarters, schools, and the CO-OP within the settlement.

In addition to the fact that the urban grids of Arctic communities are deformed by the functional requirements of life in a northern environment, they also embody Western cultural values which differ considerably from those of hunting and gathering societies such as the Inuit. An analysis of spatial behavior among 100 hunter-gatherer societies by Todd Whitelaw (1991) reveals the existence of certain cross-cultural regularities in how social processes are reflected in spatial organization. First, Whitelaw (1991: 149) discovered that as population density increases, occupation density decreases resulting in greater spacing between residences. In large communities there are greater numbers of people who are less familiar with one another. This increases the rate of encounters with strangers, resulting in stressful situations. In order to counteract this, dwellings are spaced further apart to create a spatial buffer zone (Whitelaw, 1991: 158). Changing the orientation of a dwelling so that it opens away from the dwellings of others also serves to insulate the occupant from unwanted social interaction. Second, Whitelaw (1991: 158) determined that increases in the social scale of the community leads to greater structural organization and patterning in community layout. Larger communities are usually associated with a clumped pattern in which groups of dwellings placed in close proximity to one another represent social and/or corporate groups. In these situations, clustered or circular patterns of dwellings represent greater levels of integration and cohesion within the residential group. A classic example of this is the !Kung dry season camp in which the circular layout of the camp and the metric distance between huts correlate with the relatedness of camp members. Finally, Whitelaw (1991:

151) ascertained that settlement density relates to duration of occupation, with high density settlements being occupied for shorter periods of time than low density settlements. In this case, the shuffling of residential units between camps alleviates the tensions that develop in densely occupied settlements as the rate of encounters with strangers increases.

In summary, it is apparent that Canadian Arctic communities and the traditional settlements of hunter-gatherers such as the Inuit are spatially organized according to different social and functional principles. It is therefore logical to assume that each type of settlement would generate different patterns of natural movement. How well then do patterns of Inuit movement match the spatial configuration of a Canadian Arctic community? The Inuit community of Arviat provides us with an opportunity to examine this question.

Figure 1: Aerial photo of the Inuit community of Arviat, Nunavut

The Community of Arviat and the Caribou Inuit of Western Hudson Bay

Formerly known as Eskimo Point, Arviat is located on the western coast of Hudson Bay and is currently home to approximately 2000 people (Figure 1). Inuit families form the majority of the population and are broadly categorized as “Caribou Inuit”; a label assigned by ethnographers to all Inuit groups living on or near the west coast of Hudson Bay. During the 1950s and 1960s, Caribou Inuit groups were encouraged to permanently settle at Eskimo Point (Arviat) and other communities in the region so that they could be better provisioned with housing, healthcare and education by the Canadian Government. This initiative was partially triggered by episodic famines which frequently plagued the area due to oscillations in the availability of caribou. Damas (1988) has remarked that that the creation of similar settlements across the Canadian arctic brought about the end of the contact-traditional horizon; a period when Inuit lived more or less autonomously from mainstream Euro-Canadian society.

The establishment of a nickel mine at nearby Rankin Inlet in 1958 resulted in hunters leaving Arviat to obtain work. These years were also difficult for the town's residents as regular epidemics of colds, influenza, dysentery and polio occurred. On September 1st, 1977, Arviat assumed the legal status of Hamlet, which enabled it to propose and administer its own budget, and enact and enforce its own bylaws. Further progress was made towards self-determination on April 1, 1999, following the creation of Nunavut Territory.

Methodology

Axial maps of Arviat (Figure 2) and Rankin Inlet[1] (Figure 3), a second arctic community located 500km to the north, were constructed from recent plans of the settlements provided by the Nunavut Territorial Government . The resulting maps were processed and analyzed using Axman software. Fieldwork was then undertaken in Arviat during the months of July and August 2002 to collect observational data on rates of pedestrian and vehicular movement along various road segments. Observations were taken at 45 gate positions covering a wide range of heavily used, moderately used, and poorly used areas. Each route was observed between five and seven times across five standard time periods: 8-10AM, 10-12AM, 12-2PM, 2-4PM, and 4-6PM. Observations were made for 8 minute intervals and were conducted over a variety of different weather days; from light snow and rain to sun, and in temperatures ranging from 5^0C to 20^0C. While work by Hiller et al (1993: 42) has revealed that weather and temperature seem to have little effect on movement, it must be acknowledged that the observations reported here will likely differ considerably from those in winter, where daily temperatures in Arviat can drop as low as -40^0C.

Figure 2: Axial map of the Inuit community of Arviat, Nunavut

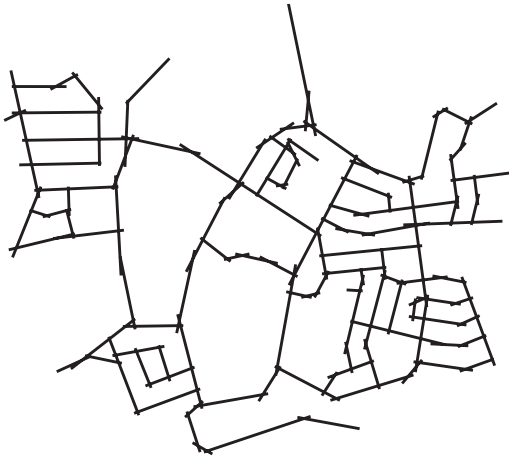

Figure 3: Axial map of the Inuit community of Rankin Inlet, Nunavut

Vehicular and pedestrian traffic was broken down into different subcategories for observation. Inuit communities are somewhat unique in the types of vehicles that are commonly employed. The most popular vehicle during the summer is the all-terrain cycle (ATC). ATC's are used for traveling to and from hunting camps, and for driving around town. Trucks used by the Hamlet office to transport water and sewage to and from houses are also frequently observed throughout the community. Cars and light trucks are driven, but are few in number because they are expensive to ship to the community.Within the category of pedestrian movement, distinctions were made between men, women, and children, with the latter estimated as being of 16 years of age or less.

Results of the Configurational Analysis

Measurements of connectivity and integration were then taken from the axial maps constructed for Arviat and Rankin Inlet. Integration was measured at both the local (rad = 3) and global (rad = n) scales for both communities. High correlations between these measures provide an indication of how intelligible the urban grid is to the occupants of the community. An intelligible system is one in which axial lines are both well connected and well integrated, and in which there is a smooth interface between local and global scales of movement (Hillier 1996:129). In systems that are highly intelligible, the configuration of the entire community can be predicted from knowledge of the configuration at the local level. Recent space syntax studies have demonstrated that intelligibility is a property that is linked to way-finding; a term that refers to the route-choice decisions made by people that allow them to move easily throughout a building or community without becoming disoriented or lost (Conroy-Dalton, 2001). Figures 4 and 5 show the unprocessed and processed axial maps for Arviat and Rankin Inlet. The processed maps are presented here in grey scale so that dark lines indicate highly integrated routes and light grey lines indicate routes with low integration values.

Figure 4: Processed axial map of Arviat, Nunavut

Figure 5: Processed axial map of Rankin Inlet, Nunavut

Visual inspection of each axial map reveals that integration is distributed differently within each community. This may relate to the more elongated and regular grid layout of Arviat as compared with the more radial and irregular grid layout of Rankin Inlet. An examination of the processed axial map for Arviat identifies an integration "core" comprised of several long and highly integrated lines that link the eastern and western sections of the community. In contrast, the integration core of Rankin Inlet is sparse, containing few highly integrated lines that are shorter, and that do not reach into the peripheral areas of the community. Statistical results indicate that while connectivity is weakly correlated with integration (rad = n) in both communities, R^2 values were lower for Rankin Inlet (Table 1). Examination of the correlations for integration (rad = 3) and integration (rad = n) reveal a much higher R^2 value for Arviat than Rankin Inlet (Table 1). The strength of the correlation between local and global integration indicates that the spatial configuration of Arviat is far more intelligible than that of Rankin Inlet.

Table 1. Intelligibility values for Arviat and Rankin Inlet

Community	Intelligibility
Arviat	R^2 = 0.7323
Rankin Inlet	R^2 = 0.2566

The Relationship between Integration and Observed Human Movement

The "edge effect" is a phenomenon in axial analysis that occurs when the routes that lie along the periphery of the axial map become segregated purely as a function of the size of the boundary selected for analysis (Hillier, 1997; Penn et al., 1998: 61). Previous research has demonstrated that the larger the boundary, the more integrated peripheral lines become. One way of overcoming this problem is to use a smaller radius of integration. As a means of minimizing the edge effect, a measure of integration at radius = 3 was selected for analyzing the relationship between integration and the density of pedestrian and vehicular movement in Arviat.

The 8 minute observation counts at each gate position were converted into counts per hour and then averaged out over the two-month period of the study. Figures 6a-f present the scattergrams which graph movement per hour against integration (rad = 3) for each category of pedestrian and vehicular movement. Correlation coefficients are presented in Table 2.

Table 2. Correlations between Integration and Movement Rates

Category	Correlation	Category	Correlation
All Vehicles	r = 0.7420	All Pedestrians	r = 0.4622
ATC	r = 0.7716	Adults	r = 0.5698
Car/Truck	r = 0.5868	Children	r = 0.2642

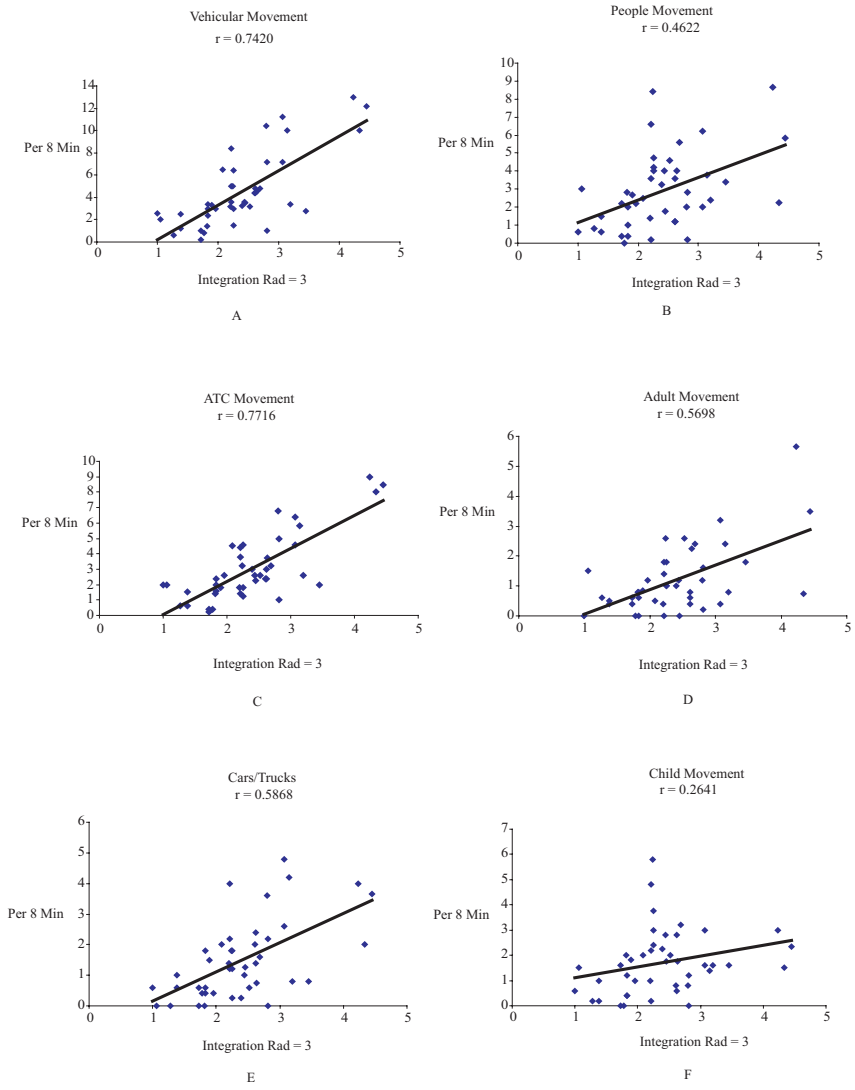

Figure 6a-f: The relationship between pedestrian and vehicular movement and integration (rad = 3) for Arviat

Results indicate that integration correlates with vehicular movement to a much greater degree than pedestrian movement. Within the category of vehicular movement, ATC's produced the highest correlations, followed by cars and trucks. Among pedestrians, the highest correlations were observed among adults and the lowest among children[2]. What is immediately striking about these results are the relatively low correlations observed between integration and pedestrian movement.

As mentioned previously, a number of studies, mostly of European and North American cities, have revealed much stronger correlations between integration and pedestrian movement (Peponis et al 1989; Hillier et al 1993). Why is this not also the case for Arviat? The answer to this question is likely related to both the functional factors that "deform" the grid layouts of Arctic communities and to the unique life-ways and cultural values that continue to characterize Inuit society.

Discussion: Deformed Grids versus Traditional Camps

As discussed previously, the importance of servicing and administrative requirements as primary determinants of settlement organization result in forms of spatial configuration that differ considerably from those of traditional Inuit camps in which spatial configuration was determined primarily by social factors. The spatial configurations of Arviat and Rankin Inlet are characterized by compact grids of regularly spaced dwellings placed in peripheral areas of the community, and the centralization of administrative and servicing facilities in the "downtown" core. However, the regular spacing of dwellings, deemed necessary for reducing the risks of fire and snow drifting, also eliminates the possibility of increasing the distance between residences which was used traditionally as a means of alleviating social tensions in Inuit society. Furthermore, while familial relations and access to the land play much more of a central role in Inuit life than Government administrative and servicing facilities, it is the latter that are spatially centralized within the integration core of Arviat. The placement of dwellings in peripheral areas of the settlement, coupled with housing allocation practices that often place unrelated families in adjacent dwellings, also altered the regularity with which members of kinship groups encountered one another. This stands in contrast to traditional Inuit communities where members of kin groups lived in close proximity to one another, substantially increasing the probability of encountering members of the kinship group (Whitelaw, 1991: 158). Finally, the layout of roads and paths according to prevailing wind direction, and the optimal routing of essential services, create an urban grid that is almost completely devoid of any social logic. In extreme cases like Rankin Inlet, this significantly reduces the intelligibility of the urban layout, making it difficult to predict who or what one will encounter while moving through the settlement. As a result, encounters with strangers are more random and less controllable. In other studies which have examined the transitions made by hunter-gatherers to life in large, non traditional communities, the inability to regulate and control interactions with others was found to contribute higher levels of conflict and stressful behavior, and to the breakdown of traditional values and social systems (Whitelaw, 1991: 181).

Discussion: Cultural Values, Traditional Activities and Human Movement

While many changes have affected Inuit life in the post-war era, the majority of families in Arviat continue to engage in traditional activities to varying degrees. These activities supplement family incomes and serve as an important source of cultural identity. Outpost camps are maintained by many families and are used to acquire and prepare traditional foods such as caribou, arctic char, black bears, polar bears, and a variety of shorebirds. On average, informants stressed that over 50% of the foods they consume are derived from the land. Many aspects of traditional Inuit

social organization are also in evidence. These include social networks of mutual assistance, the importance of bilateral extended families as the primary economic and social units of production, as well as many aspects of kinship and marriage. The maintenance of these central features of Inuit social organization demand face-to-face contact that is frequent, regular and predictable. This is especially the case for networks of mutual assistance which play an essential role in the organization of subsistence activities such as hunting and fishing. Because of high unemployment in the community, many family members actively pool hunting equipment and labor as a means of increasing their access to traditional foods. Social visits between family members are also frequent. One does not knock on doors in an Inuit community, one simply walks into house after house and is offered tea, traditional food, and conversation. This pattern of intensive socializing is evident in the movements of an Inuit woman who, at my request, kept track of her travels by foot over a three-day period. Figure 7 reveals that three-quarters of her time was spent moving through the community visiting with family and friends, while only one-quarter was spent accessing government services and retail shops. This is almost opposite to the type of behavior we would expect to see in a typical Euro-Canadian suburb, where people are more likely to spend three-quarters of their time accessing retail outlets and services, and only one-quarter of their time visiting with other family members and friends within the community. Consequently, the fact that Inuit emphasize regular face-to-face contact among family members and friends to a greater degree than they access government services and retail outlets likely explains why pedestrian movement correlates poorly with integration in Arviat. Family members distributed throughout the community serve as powerful “attractors” that generate pedestrian movement in such a way that it circumvents the influence normally exerted by the spatial configuration. As a result, if we were to turn Arviat “inside out” by centrally locating residences and peripherally locating other types of services, then these correlations would likely be far stronger. Thus, it would seem that the traditional cultural values of Inuit society have produced a uniquely Inuit pattern of movement which has been superimposed on a Euro-Canadian form of spatial configuration.

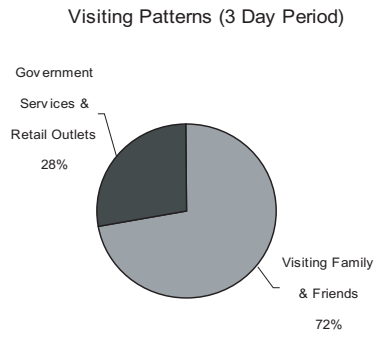

Figure 7: The pedestrian movements of an Inuit person recorded over a three-day period

Why, then, are the correlations between vehicular movement and integration so much higher? The answer to this question is likely that vehicular movement significantly reduces opportunities for face-to-face contact. Vehicles such as ATC's are noisy and often driven at excessive speeds, thereby limiting the possibility of social encounters with others while in transit. In addition, they tend to be used primarily for traveling to destinations like government offices, retail outlets, and hunting and fishing locations. The fact that many of these destinations lie along highly integrated roads, and that these roads provide the most direct route to and from hunting and fishing locations explain why vehicular movement correlates so well with integration.

Conclusions and Directions for Future Research

In conclusion, the results of this study demonstrate that the link between spatial configuration and human movement breaks down when urban grids becomes deformed by hyper-functional variables, and when inhabitants require encounter fields that differ from those generated by the layout of the community. In this regard, Canadian arctic communities are somewhat unique because of the planning requirements determined by the extreme nature of the environment, and because of the cultural makeup of the people that inhabit them. The fact that Inuit appear to move about Arviat in accordance with their own cultural values re-affirms the relationship between culture and spatial configuration, and suggests that this fact should be recognized as an essential element of urban planning. This is especially the case when urban planners from one culture design communities for members of another. In the case of the Canadian north, a balance needs to be struck between administrative and servicing requirements and the cultural values and lifestyles of Inuit. Future research will focus on expanding this study to other Inuit communities in the Canadian Arctic.

Notes:

[1] Rankin Inlet was included in this study for the purpose of comparing the spatial configuration of Arviat with that of another arctic community.

[2] Hillier (1996) refers to children as "space explorers" and has commented on the fact that they frequently seek out spaces located away from adults. The low correlation observed for children likely reflects a similar type of behavior, and may have interesting implications for the socialization of Inuit children.

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