The Social Connection in Mental Representations of Space: Explicit and Implicit Evidence

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Abstract. If spatial cognition hopes to understand memory of and reasoning about real-world environments, then all aspects of the environment, both spatial and non-spatial need to be considered. Non-spatial information can be either integral to or merely associated with the spatial information. This paper reviews two lines of research conducted in our lab that explore interactions between spatial information and non-spatial information associated with it (namely social information). Based on results of numerous studies, we propose that full accounts of spatial cognition about real-world environments should consider non-spatial influences, noting that some phenomena, while seemingly spatial in nature, may have substantive non-spatial influences.

Keywords: spatial categorization, non-spatial categorization, implicit processing, social cognition.

1 Introduction

In the world around us, spatial and non-spatial information is inextricably linked. This point can be illustrated by imagining a tour of a university campus you are considering attending. On your tour, you may note the location of an interesting building, but its spatial location is probably not the only information that you remember. Along with location, you may remember relatively fixed features about the building such as its color (yellow), building material (brick), shape (L-shaped) and/or architectural style (Classical Revival). More fluid features of the building may also be noted, such as its function (Philosophy Department) or decorations (neon pink flyers for an upcoming lecture). Finally, you may recall information situationally associated with, but not directly related to, the building, such as the race and/or gender of students seen walking out of the building as you passed it. Although we experience and remember both spatial and non-spatial information, little research has examined their interaction in memory and problem solving.

The overarching goal of the present paper is to build a case suggesting that spatial cognition cannot be divorced from other, non-spatial associations. To meet this goal, we first outline cognitive parallels between processing spatial and social information. Next, we discuss methodological adaptations that cross between spatial and social cognition, potentially enhancing the toolbox of both sub-disciplines. With an understanding of the methodologies, we review a number of studies conducted in our lab that explore the interaction of spatial and non-spatial information. This work focuses on a particular class of non-spatial information, specifically social information that is not integral to, but instead associated with, spatial locations. Finally, based on the results of these studies, we argue that a full account of spatial cognition must consider non-spatial associations. Further, these associations may provide viable explanations for seemingly spatial phenomena.

2 Parallels in Cognitive Processing of Spatial and Social Information

The complexity and multi-faceted nature of both spatial and social information make them cognitively interesting. Research suggests that people categorize both types of information in an attempt to make them cognitively manageable,. At the same time, however, categorization can lead to biases and distortions in memory and the way the information is used.

Some of the complexity of spatial information comes from its hierarchical nature [1-3]. Spatial features, such as those found on your hypothetical campus tour, conform to geometric definitions of point, line, and plane. The campus itself is a plane, the roads and walking paths running through it are lines, and the buildings are points. Thus, the conceptualization of locations by their geometrical assignment helps define the environment's hierarchical nature. Spatial categorization takes advantage of this hierarchy. People use line-based features to sub-divide the overall space into sub-areas. Research has made apparent that people use line-based spatial features such as mountain ranges, roads [4], and artificial boundaries [5] and perhaps plane-based locations [6] to group and organize point-based locations [7, 8]. However, organizing spatial information is further complicated by its nested, hierarchical structure. The same information can be geometrically classified at different levels, depending on the specific scale, level of analysis, or zoom [9]. For example, the campus would be considered a point when thinking about the larger city in which it is located, but as a plane when trying to find a particular building on that campus. Research suggests, however that regardless of scale and of availability of boundaries, these grouping processes are prevalent in the way people structure their cognitive maps. People tend to spontaneously organize and categorize spatial information [8].

The categorization process itself leads to spatial distortions. In Stevens and Coupe's [6] now classic study, they illustrated how boundaries (e.g., state borders) promote categorical reasoning. Specifically, judgments about the relative location of two cities in different states relied on knowledge of the relative locations of the states. More generally, people perceive locations sharing membership in a superordinate as more similar to one another and more distinct from locations not sharing this membership, [5, 8, 10, 11]. This perception of within-category similarity induces spatial distortions in memory. Locations within a category are remembered as closer together than equally distant locations residing in different categories [e.g., 12, 13].

People similarly group social targets (people), as can be seen in the in-group bias [14, 15] and stereotyping [e.g., 16, 17, 18] literatures. The in-group bias suggests preferential treatment for individuals sharing some aspect of social identity [e.g., women, Asians; 14, 15]. Social information can be categorized based on different, relevant cues, including appearance (e.g. skin color) and/or behavior (e.g. aggression). As with spatial information, social categorization also leads to category-based errors. Such errors include failure to differentiate individuals within a social category, notably an out-group category [e.g., 16, 19] and differential similarity judgments within versus across social groups [e.g., 20, 21, 22]. People more often confuse individuals in the same racial category than they do individuals from different categories.

Social and spatial information have frequently been linked in our real-world experiences. It is not uncommon for individuals of different racial or ethnic groups to reside in the same neighborhood. Taking Boston, Massachusetts as an example, one expects to find a greater preponderance of Asian individuals in the China Town area of Boston and more Italian-Americans living in the North End. Indeed, the neighborhood names frequently become associated with the dominant racial or ethnic group living there.

Another cognitive connection between spatial and social information is evident in how physical space is harnessed to mentally represent abstract concepts. Two such connections can be seen in spatial representations of affective valence [23] and time [24]. For instance, several studies have found similarities between thinking about space and thinking about time and in the language used within these two domains [25]. Like time, social information is generally abstract. Ties between social variables and physical space have cultural and ideological ties. Cultures around the world manipulate space at both smaller and larger scales, from house layouts to city planning, to convey social and ideological relationships [e.g., 26, 27, 28]. For instance, residential patterns in ancient Mayan cities were arranged in relation to cardinal directions and topography, conveying a cultural map that represents social status. Elite and royal buildings were located northward—culturally associated with the sun's zenith and the celestial realm—and at higher elevations so as to be closer to their ancestors [26, 29]. Our society today places locations of political power at higher elevations. For example, Capitol Hill in Washington, D.C. is modeled after the most important Roman temple, dedicated to Jupiter Optimus Maximus on Capitoline Hill, the highest hill in Rome [30].

Abstract indicators of social status (e.g., power, wealth, influence, intellect) are often related to physical space. We often link these intangible concepts with varying levels of height through the use of metaphors. Take phrases such as "she was climbing the ladder of success" or "Alice was taught to dress *above* her station" [31] or "he thought unskilled labor *beneath* him" [32]. Through these metaphors, social status becomes grounded in our perception of vertical space. "Up," is often used to represent the abstract concepts of power, wealth, and intellect, whereas "down" is comparatively inferior. The potentially additionally exists to transfer these spatial indicators of social status to other social variables (e.g., race or gender), in line with culturally developed stereotypes.

Whether the use of spatial information to represent abstract concepts is intentional or incidental is not known. They could be either or both. We do know that aspects of both spatial and social information appear to be, at least partially, processed implicitly. We explore further implicit associations between social and spatial information in studies described in this paper.

In sum, when considered both separately and in combination, spatial and social information appear to engage similar cognitive processes. Both types of information, because of their complexity, are organized and used categorically. Further, because of its more concrete nature, people recruit the representational power of spatial information for understanding more abstract social relations. For the most part, however, spatial and social information processing has been experimentally explored separately. The remainder of this paper describes the methodological, conceptual, and empirical progress our lab has made explicitly exploring the interaction of spatial and social information.

3 Cross-application of Methodology

Methodology often develops within a discipline to address fundamental questions of interest. Increasingly, however, interdisciplinary approaches to research questions have shown success, in part, because they bring to bear different methodological approaches. The same can be applied to sub-disciplines of a field. As discussed above, similarities exist in how people process spatial and social information. To capitalize on these similarities and maximize our explorations of how spatial and social information might interact, we have adapted some paradigms more traditionally used in social psychological research in our studies of spatial phenomena. These include the "Who-Said-What" task (a Category Confusion task) and the Implicit Associations Task (IAT). These paradigms, however, can be seen more generally as assessing associations to categories. This broader definition makes them directly applicable to spatial information.

3.1 Category Confusion Tasks

The "Who-Said-What" task is a speaker-statement matching task developed by S. E. Taylor et al. [22]. Participants watch a simulated conversation between individuals from different social categories, as defined by one social dimension (e.g., 3 Black and 3 White males). In other words, the conversation individuals differ on one social variable (e.g., race), but other social variables are held constant (e.g., gender). After watching the conversation, participants complete a surprise statement-matching task. In the task, they see a conversation statement and picture of one of the conversation individuals and decide whether the pictured individual said the statement. The general findings show that participants more likely wrongly attribute a statement to someone in the same racial category than to someone from different racial categories. This task can be generally conceived of a category confusion paradigm and, consequently, applicable to other domains, such as spatial information, where categorization appears to occur readily.

We call our adapted paradigm the "Who-Works-Where" task. Participants first learn a spatial environment and information associated with each location. To date, we have primarily used this task with learning via a map [13, 33] although future work will examine learning through virtual (VR) navigation. The associated information has included racial information about people associated with the locations. After learning, participants see a location name and a person name or picture and decide whether they associated the person to the location during learning. However, because the task generally assesses category use, it could also be adapted to examine categorical spatial associations.

3.2 Implicit Association Tasks

The IAT evaluates the relative effort required in making congruent versus incongruent associations by measuring speeded responses during a category discrimination task. Traditionally, this task has been used in experimental social and personality psychology to identify associations between, for example, gender target categories (male/female) and job-type attribute categories (engineer vs. teacher). If the target categories (male/female) are differentially associated with the attribute categories (engineer/teacher), the participant will categorize examples from all four categories faster and more accurately when the associated target and attribute concepts are congruent (e.g., male/engineer) versus incongruent (e.g., female/engineer). Thus, the IAT is thought to measure automatic and implicitly activated subconscious judgments, while minimizing the use of explicit strategies [34, 35]. Like the category confusion tasks, the IAT can be modified to other categorizeable information types. Unlike the category confusion tasks, the IAT measures already developed, rather than experimentally learned associations.

We adapted the IAT to measure the implicit association between either different aspects of spatial information (cardinal direction and topography) or between social categories (powerful/average individuals) and location-based features, such as topography (e.g., mountainous/level terrain) [36]. As with the classic uses of the IAT, participants progress from a single to multiple categorization task. They first see instances of one category (e.g., topography, represented by picture of mountains or flat plains) and button-press to indicate their categorization (mountainous or level). As the task progresses, the two categories of interest are intermixed in successive trials. Further, their associations to response buttons are either congruent with one another or incongruent. The implicit association is interpreted from the difference in response time and accuracy between congruent and incongruent category assignments.

3.3 Distance Estimation as a Similarity Assessment Task

The two tasks discussed thus far take traditional social cognition methods and apply them to a spatial context. A traditional spatial cognition task, that of distance estimation, can also be applied to explorations of spatial-social connections. Distance estimation tasks are methodologically simple. Participants simply estimate the distance between two locations. The task can be specified for a particular type of spatial distance, for example Euclidean (crow-fly) or route distance [37]. The task can be implemented by having participants give numeric responses on a particular scale (e.g., miles) or scaled responses based on a spatial reference (e.g., mark the distance on a line representing the farther distance between locations within an environment).

The application of distance estimation tasks to spatial-social connections comes from a more general interpretation of the task. Specifically, distance estimation can be viewed as a similarity assessment task. Just as spatial relations are used metaphorically to represent abstract ideas, distance can be conceptualized both in concrete and abstract ways. The fact that people talk about "bringing the ideological gap" or "coming closer to agreement" when discussing ideas shows this metaphorical use of distance. "Closer", in this sense, means more similar.

We have employed distance estimation in the more traditional spatial cognition approach, but include social variables in analyzing influences on these estimates. This approach has been effective in exploring the spatial-social information interaction.

4 Interaction of Spatial and Social Information

The import in understanding how spatial and social information interact lies in understanding spatial memory in the real world. Real-world environments generally include both spatial and social information. Walking around your own neighborhood you see the blue house on the corner and the Asian woman tending a garden in the yard or you see the old man sitting at the corner bus-stop. In our experiences, social and spatial information interact. This co-occurrence would suggest that they interact cognitively as well.

Some earlier studies hint that social and spatial information can interact, but not until recently did researchers more systematically investigate this interaction. The earlier studies examined how one's own racial membership and accompanying experiences influenced the cognitive map of his/her own neighborhood [38, 39]. On-going research in our lab is more systematically examining factors affecting spatial and social information interactions in memory [13, 33, 40]. Our approach is multi-pronged and employs traditional methodology from both spatial and social cognition. The application of the methodology, however, is not traditional and crosses between spatial and social cognition. Our overall approach can be said to combine explicit and implicit approaches. The more explicit approach involves participants learning from a novel map that provides information about, but no direct experience with, unfamiliar individuals with different social characteristics. Memory and distance estimation tasks then assess spatial and social information effects. The implicit approach involves the IAT. Results of multiple studies strongly suggest that explorations of spatial cognition in real-world settings are incomplete without considering how social information interacts.

4.1 Cross-over Spatial and Social Influences

Think again about touring a college campus. You most likely noted the locations of some buildings. Further, if you encountered people on this tour, you processed social factors associated with them, perhaps their race and/or gender [22, 41]. Did this information become cognitive integrated? We know that non-spatial characteristics of an environment are perceived and incorporated into one's cognitive map along with spatial features [42, 43]. When this information has categorical structure, people cluster locations based on their function [10, 44], their physical similarity [45] and the semantic category into which they fall [46]. But social information is one more step removed from the spatial information than is function or physical similarity. Function and similarity are integral to the locations themselves. Social information is merely associated with them. In previous and on-going research, we have explored the extent to which social information associated with locations is cognitively integrated.

These investigations have used a common methodological approach. Participants study a map of business locations in a small town. The map is divided into neighborhoods (spatial categories). During study they focus on one location at a time, learning both its location and other associated information, including some type of social information about each business proprietor (e.g., race, political affiliation). After studying, participants completed distance estimation and category confusion (Who-Works-Where) tasks. Different instantiations of this methodology focused on making either the spatial or the social category more salient. We predicted that category salience would play a role in the interaction between spatial and social information [47].

We manipulated salience in a number of ways, including presentation order, presentation format, the nature of the category, and the correlation of the two categories. Presentation order either grouped locations by neighborhood (spatial category) or by social category. The spatial presentation order first went through all locations in a neighborhood before moving on to the next neighborhood. The social presentation order first presented all locations associated with one social category before going on to the next. Presentation format differences depended on the category. To make the neighborhoods more salient, one study labeled the neighborhoods. To highlight the social categories more, the associated information either used labels (less salient) or pictures (more salient, particularly for race). Another way of manipulating the social category involved instantiating different social categories. Most studies used the salient social category of race, but we also examined the less-salient category of political affiliation. The relationship between the categories could be highlighted through their correlation, functionally leading to either socially segregated or socially integrated neighborhoods. Segregated neighborhoods had the majority (8 of 12) of locations associated with one social category. Integrated neighborhoods had an equal number of associations to each of the social categories.

This line of work has made clear the fact that spatial and social information interacts and that category salience changes this interaction. Maddox et al. [13] found consistent interactions between racial and spatial categories with distance estimates. Participants estimated that locations from different neighborhoods that shared an association to the same race as closer together than those that had different race associations. For this spatial task, the interaction did not appear for locations within a neighborhood, suggesting a stronger role of spatial category on the more spatial task. Looking across studies revealed the effects of category salience [48]. The correlation between categories appeared to highlight their relationship. Participants showed a sensitivity to this correlation, as suggested by a more pronounced effect of social category on distance estimates with segregated neighborhoods [13]. Further, whether the presentation order focused on the spatial or the social category had an effect, for both the distance estimation and category confusion tasks. Both tasks showed interactions between spatial category, social category, and presentation order in the direction predicted by the presentation order focus. Salience based on the category nature also had an effect; the less-salient political affiliation category did not interact with the spatial category, even though it has cultural associations to spatial areas (e.g., red and blue states during elections). Finally, we manipulated the salience of race by either relating racial information through labels (e.g., *African American, Asian*) or through pictures. Results showed the same, consistent interaction between social and spatial categories on distance estimates that additionally interacted with how the racial information was related. Pictures appeared to strengthen the effect of the racial category compared to labels alone.

Taken together, the results of this line of work show strongly that when social information about an environment is available, people incorporate it into their spatial representation. Further, the salience of and focus on the category alters the interaction in the direction of salience. In these studies, unlike those discussed next, participants explicitly studied the social information along with the spatial. The next discussed line of work examines more implicit social-spatial associations.

4.2 Implicit Spatial-Spatial Associations: An Interesting Phenomenon

Our recent investigations of implicit associations between social and spatial information came about in incremental and programmatic studies attempting to explain an interesting phenomenon we have been exploring, that of a southern bias in route selection [49]. The research progression is integral to our overall exploration of social and spatial information interactions and, therefore, is worthy of explanation. As an overview, the progression moved from identifying a particularly interesting spatial phenomenon to exploring spatial explanations to exploring possibly alternative and clearly related social explanations.

In the work that identified the southern bias, participants selected the "best" of two equidistant routes. The routes either go generally eastward or westward, connecting landmarks that lie north-south of one another, or generally northward or southward, connecting landmarks that lie east-west of one another. With east-west route dilemma trials, route choice reflects the equidistant nature of the options with selections for the eastward route approximately half of the time and selections for the westward route approximately half of the time. The north-south route dilemma trials show our interesting phenomenon. For these trials, route selections do not reflect the equivalent distance of the routes. Instead, participants show a consistent bias for south-going routes. This bias was evident in route selection within a fictitious small town and in estimates of route travel times for routes traversing the United States, thus showing generalization across scale. Current work in our lab is exploring whether this bias results from explicit strategy use or an implicit association.

People may show this southern bias in route selection because of an association between north and uphill. Some evidence of this association comes from a follow-up rating task with the same routes. Participants rated northern, compared to southern, routes as more scenic, a quality associated with higher elevation. East and west routes did not show a difference in scenery ratings. Participants also rated northern routes as requiring more calories to traverse than southern routes, a difference again not evident in east-west route comparisons.

More direct evidence of an association between north and uphill comes from recent work using the modified IAT [40]. In this case, the IAT compared implicit associations between high and low elevation (mountainous versus level terrain) and cardinal directions (north and south). For the IAT, the congruent pairing had north and mountains sharing one response button and south and level sharing the other. The incongruent mapping required south and mountains to share one response button and north and level to share the other. Participants completed blocks of both mappings (congruent and incongruent) in counterbalanced order. Thus for these categories, response latencies for image categorizations should reflect the strength of implicit target (north/south) and attribute (mountains/level terrain) associations [34, 35]. We ran two experiments differing only in their representations of cardinal directions, either maps with stars to the north or south or compass roses showing either "N" or "S" to designate direction. Results revealed significantly faster categorization response latencies during the congruent north/mountain pairings relative to incongruent south/mountain pairings ($p < .05$). Our findings provide the first direct evidence for an automatic association between north and higher elevations. This association can then be implicated in spatial heuristics that bias spatial decision making performance.

The source of this association is still unclear, however. Different possible sources make sense, including mapping conventions (e.g., north as up) and topography. We have examined the topography possibility. The participants in the original studies showing the south-route bias resided in the north-eastern United States where topography reinforces the idea that north is uphill. In this region of the U.S., people travel north to mountains to either ski or hike. An international, collaborative follow-up, however, suggest that a topographical association is not contributing to the southern bias. Current on-going cross-cultural and cross-topographical studies are exploring a topographical association explanation. Collaboration with other U.S. and European labs [50] suggest that local topography, e.g., mountains to the north, do not explain the phenomenon. Labs with mountains prominent in directions other than north also find a southern route preference.

4.2 Implicit Social-Spatial Associations: Explaining the Interesting Phenomenon

Our success in using the IAT to explore associations between different aspects of spatial information suggested to us that the IAT could also be used to explore associations between spatial and social information, such as those seen in our map-learning studies [13, 33, 48]

To investigate social-spatial associations, we again employed the IAT [51]. Our adaptations were similar to those exploring the association between topography and cardinal directions. In this case, we examined associations between social variables (e.g., social power, gender) and topography (mountainous vs. level terrain).

As discussed earlier, social power would seem to have a relatively clear association to higher elevations. To explore this association, we selected powerful people from Time Magazine's list of powerful people, which includes international leaders and executives. We matched the average people to the powerful in terms of gender, age, and ethnicity. Our participants most likely did not explicitly identify the powerful people, because they involved relatively unfamiliar individuals such as leaders of foreign nations or business leaders. As such, the operationalization of social power involved attire. As such, the stimuli consisted of images of both men and women matched for age and ethnicity dressed in either suits (powerful) or relatively casual clothing (average). Spatial topography operationalization involved images of mountains (high elevation) and level plains (low elevation) matched for climate and amount of visible sky. Our findings provide unique evidence for an implicit association between powerful individuals and high elevation, and, as a corollary, between average individuals and level elevation. Data supporting this assertion involved faster response times for congruent (high/powerful, low/average) response mappings relative to incongruent (high/ average, low/powerful) response mappings. The strength of this effect could be seen in the lack of either a main or interactive effect of block order (i.e., congruent versus incongruent first, p's $> .5$). These results support the notion that abstract conceptions of social status are grounded in physical space. They also suggest that our underlying social and ideological connotations regarding elevation might impact our perception of space in general, which carries important implications for predicting human behavior and theories of spatial and social cognition.

We also examined whether this association carries over to a stereotype-based, more indirect relationships. In many western cultures, men are perceived as having higher social status than women. Evidence of this can be seen in higher compensation [52] and promotion [53] rates for men, holding qualification and performance measures constant. Additionally, people may associate people's height with topographic elevation; men, on average, are taller than women. Using an IAT that pitted categorization by gender against categorization by topography, results did not show a strong implicit association. The relationship between gender and topographic elevation may be too indirect to be captured by the IAT. The association is mediated through social status. Mediated semantic relationships do show implicit effects, in the form of priming [54]. However, other cognitive processes needed for the IAT, including executive functions [55], may make it insensitive to mediated associations.

To sum up, our recent studies show that the IAT can be used to explore implicit associations between spatial and social information, particularly those with a more direct connection. More mediated relationships, such as the association that goes from gender to social status to topographic elevation, may either not have the strength or cognitive processes engaged during the IAT may not be sensitive to them. Important to the broader study of spatial memory and reasoning, the evidence of social-spatial associations strongly suggests they influence spatial cognition and should be considered when investigating real-world spatial behavior.

5 Conclusions: Why Spatial and Social Interactions Matter

Now imagine you have just finished your college campus tour. Perhaps on your tour, you passed the building housing the Asian Languages and Literatures Department. Further along the tour you noted the interesting architecture of the Asian Student Affinity House. Finally, as the tour neared its end, you saw a group of Asian students engaged in an animated conversation as they exited the Student Union. While there is nothing Asian integral to these locations, they now all have Asian associations. How do these associations come to bear when you later think about this campus, perhaps deciding whether you will attend this university or what the best route is from where you parked your car to the highway out of town?

We have outlined two different lines of current research in our lab exploring how social associations to locations affect spatial cognition. The two lines originally had quite different goals. One line explicitly set out to examine the interaction of social and spatial category effects. The second came out of a programmatic approach to explaining an interesting route-selection phenomenon. Clearly the two research lines also approach the question of social-spatial information interaction using different methodologies and assumptions (e.g., intentional versus incidental learning). Despite these differences, consideration of both lines together provides compelling support for the importance of considering non-spatial influences on spatial memory. People categorize both spatial and social information and when in the same overall context (e.g., learning a map) the two types of categories interact. They interact on tasks that focus specifically on spatial aspects of the map (distance estimation) and on associations about map locations. The interactions can be seen when information is intentionally studied and implicitly associated, thus having far-reaching implications for spatial problem solving and decision making.

The present paper also provides support for having methodology cross conceptual boundaries. We outline here the use of traditionally social cognition tasks that, in our research, revealed interesting spatial cognition findings. We also outline using traditionally spatial cognition tasks with which we have found interesting social-spatial information interactions. Crossing methodologies in this way and using multiple methodologies means variety in methodological assumptions and strength in convergent findings based on them.

Spatial behavior is complex. Research exploring spatial behavior supports the contention that it is complex. While we would not claim to have brought parsimony to explanations of spatial cognition, our findings make clear that social and spatial information interact. This fact should not be ignored in broad accounts of spatial behavior.

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