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DESIGNING CITIES FOR HUMANS

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ABSTRACT

In recent years, cognitive scientists have increasingly recognized the importance of conceptualizing cognition as a process that goes on not in an abstract mental realm, but in the physical encounter between a lived body and a structured physical environment. We here propose that this radical embodied view of cognition is uniquely well equipped to serve as a theoretical framework in urban design. Specifically, we offer an overview of the perceptual psychology of James J. Gibson. We then apply his theory to the analysis of a series of road intersections. According to Gibson's concept of affordances, actors perceive the world in terms of relations that arise between specific structures in the environment and complementary physical capacities in the actor's body. A key insight for urban design is that there are asymmetries between actors in terms of the threats and opportunities that arise as a consequence of their ongoing movement: a person driving a car affords a threat of injury to a pedestrian or a cyclist's body in a way that does not hold in the opposite direction. We show that successful urban road intersections can be evaluated in terms of the difficulty people face in carrying out specific tasks, such as crossing the road. Accessible spaces should minimize the number of asymmetrical encounters with more-threatening road users. This is best achieved by arranging the environment so as to constrain the opportunities for threatening interactions to arise. Finally, we argue that the affordance concept, properly construed, offers a mechanism for connecting space syntax's global analysis of spaces with the first-person lived perspective of an individual moving around in that space.

KEYWORDS

Spatial cognition, embodied cognition, ecological psychology, affordances, tasks

1. INTRODUCTION

Space syntax begins with a theory of relational configuration in built systems (Hillier and Hanson, 1984; Hillier, 1996). The foundational insight is that cities and multi-room buildings can be understood as consisting of a complex of connected spaces: one space is connected to another space, and this connected pair of spaces is in turn connected to further spaces forming a larger complex.

What constitutes a connection between two given spaces? A hidden assumption of the space syntax approach is that the positing of connections between spaces assumes a specific type of actor moving through the configuration, namely a human actor. For example, consider an apartment in a high-rise housing block. In the space syntax jargon, such an apartment is said to be segregated from the street, in the sense that moving between street and apartment involves passing through a number of intervening connected spaces: one has to enter the building lobby, wait for the elevator, and walk down a common corridor past other housing units before finally arriving at the threshold of the apartment. Notice, though, that this sequence is only necessary if you happen to be a human actor. A bird can move directly from the street to the balcony of the apartment. An analysis of space in terms of segregation, or its inverse integration, would look quite different if the space were considered relative to a flying animal rather than a human.

If space syntax analysis assumes a human actor moving through a configuration, a corollary of this assumption is that time is already an implied part of the analysis. A human cannot move instantaneously from one space to another, but must locomote through the space in some way. In space syntax, this movement between spaces is conceived in terms of the depth of one space from another, where depth denotes the number of intervening spaces one has to pass through to get from some starting space to some target space. This is represented not in terms of metric time, but as a graph structure consisting of the distinct spaces one has to move through and their interconnections. The movement from starting space to target space is conceived, in other words, as a structured sequence of events.

Once it is granted that space syntax analysis assumes a human actor, it is well to consider what characteristics of the human body might be relevant in making sense of what the analysis is telling us. Among the more obvious factors, humans are bipedal (typically), non-flying, non-aquatic, have forward-facing vision, 360° hearing, are comfortable in an environment where the ambient temperature ranges on the order of 20–30°C. It is necessary to take these characteristics into account when trying to understand how the actor negotiates its environment. A central claim of embodied approaches in cognitive science is that the environment of an animal has meaning to that animal by virtue of the fit between the animal's body and structures that exist outside its body and that support or constrain activity (Chemero, 2009; Clark, 1997; Baggs and Chemero, 2018).

The embodied account reconceives what cognition is. It rejects the view that movement is the behavioural output of an internal computational process (e.g., Schank and Abelson, 1977). Instead, movement is understood in terms of the perceptual coupling between a living actor and a structured environment. That is, movement is part of an ongoing process in which the actor continually adjusts its orientation towards a space that already has its own structure. The most developed account of perceptually controlled movement, in this embodied tradition, is that of the psychologist James J. Gibson (1958, 1966, 1979). In this paper, we briefly outline some of the main currents of Gibson's thought. We then quickly turn to exploring how Gibson's thought can both inform and enrich space syntax's analysis of human movement in cities.

2. THE ECOLOGICAL APPROACH: THE ENVIRONMENT AS INVARIANT STRUCTURE

The concept with which Gibson is most often associated today is probably the concept of affordances, or opportunities for action—a term that Gibson invented (Gibson, 1966, 1979). Gibson did not develop this concept until relatively late in his career. In introducing the term, he was attempting to resolve some long-standing tensions in the study of perception, notably the tension between recognizing that animals have first-person experience and that the world has a pre-existing and in some sense objective structure (see Baggs and Chemero, 2018). But before introducing the affordance concept, Gibson had already developed a complete ecological understanding of perception. His theory was based on a rejection of classical optics, which starts with a description of the retinal image, in favour of an ecological optics, which starts by describing the structure of the environment towards which an animal can orient its activities (Gibson, 1961; Mace, 1977).

In order to perceive the structure of its environment, an animal has to move. This insight is the foundation of ecological optics. When an animal moves, its visual field undergoes a dynamic transformation, specifically a centrifugal expansion. The central point of this optical expansion specifies the animal's current direction of heading (Gibson, 1958). This optic flow pattern constitutes information to the animal about its orientation relative to its environment. A pilot attempting to land a plane, for instance, can control the landing by attending to the optic flow pattern (Gibson, 1950). If the current heading is to the right of the runway, this will be specified by an optical smearing of the runway in the left half of the pilot's visual field. If the heading is good, this will be specified by the runway's remaining centred in the visual field. The optic flow pattern itself is a key component in the control of the descent.

The centre of optic expansion is an instance of a more general concept—the concept of invariant structure, or structure that remains constant under transformation. It is this invariant structure that Gibson conceives as the basis of perception. A typical environment is cluttered with structured surfaces that expand and recede and occlude one another as the animal moves around. The patterns of change and non-change constitute information to the animal about the structure of its surroundings. To say that perception involves invariant structure is not to say that the environment itself is static or unchanging. A moving train viewed from a point of observation some distance from the train tracks still exhibits invariant structure. In terms of geometry, the train projects a visual solid angle to the point of observation and this solid angle transforms in a continuous way. At the same time, the surface pattern of the train remains unchanged: the train still appears to have the same number of doors and windows and wheels, and the same train company livery. This appears to be the case because it is the case. Invariance is what allows the train to be distinguished from the landscape it is traversing. If the visual form of the train was entirely variant, it would be imperceptible as a train, and would instead be perceived as an indistinct moving fog.

For present purposes, what is important is that, on the Gibsonian account, an actor controls its movement through the environment by attending to, in theory, a single perceptual variable, i.e. the invariant implicated in control of whatever task the actor is currently performing. In visually controlled locomotion, the centre of optic expansion might be the key variable, as discussed above (Gibson, 1958; Lee, 1976; Warren, 1998). In general, the ecological approach attempts to analyse ongoing tasks in terms of an actor minimizing, maximizing, or otherwise optimizing some perceptual variable (Warren, 2006). This has immediate implications for urban design: if controlling movement involves continuously attending to a single variable in the visual field and adjusting relative to it, then this places constraints on the extent to which the actor will be able to attend to the rest of her environment. We might posit, therefore, that ideally the configuration of the urban grid should not give rise to situations in which an actor is required to attend to multiple perceptual variables at the same time.

3. A STRUCTURED ENVIRONMENT STRUCTURES ATTENTION

Gibson's account of visual perception is unique in that it starts not with a description of the eye or of the visual cortex of the brain, but with a careful account of the structure that exists in the environment. The first half of his final book consists of a description of what the environment is, and how it is that this environment contains information for perception (Gibson, 1979). A limitation of the account is that the structure that Gibson describes is mostly the structure of the natural environment as it might be perceived by a single moving animal. Gibson is not generally concerned with explaining movement in built environments, or movement in environments that contain other people. This narrow focus on the natural environment is understandable given that Gibson is formulating an entirely new theory of perception from the ground up: such a theory must first establish the basic facts of what is perceived. On Gibson's account, the world of perception is made up of surfaces and their layout, and of events such as the occlusion of one object behind another, or the coming into or going out of existence of a surface.

Our concern in the current paper is to apply Gibson's account to an analysis of human movement in cities. Doing so will require an engagement with two aspects of real environments that Gibson pays relatively little attention to. First, real environments are structured not only by surfaces and events, they are also populated with other actors. Second, real built environments exhibit spatial configuration, in the syntactic sense of distinct spaces connected together systematically into a larger complex.

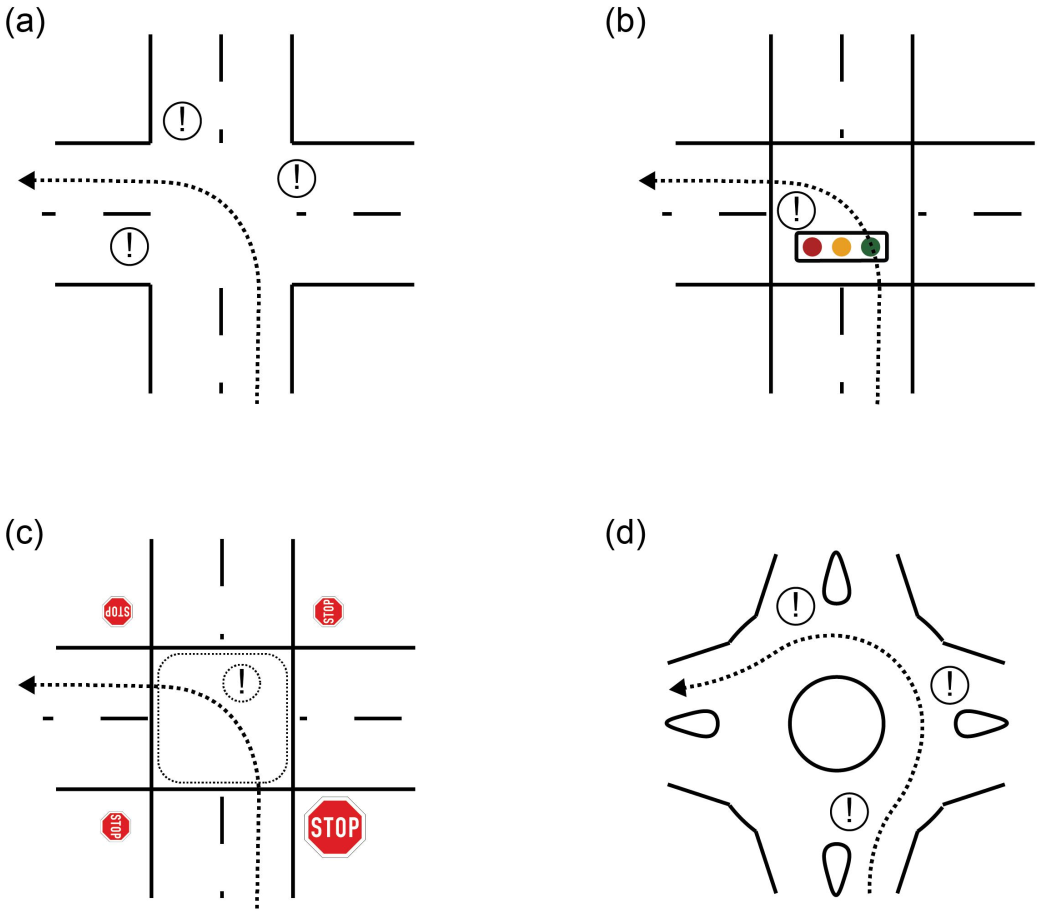

Fig. 1 A problem and three solutions: how to manage conflict at an intersection. The basic problem, (a), is that a driver has to attend simultaneously to potential threats from all three of the other arms of the intersection. The traffic signal solution, (b), solves this by redirecting the driver's attention to the signal instead. The stop sign solution, (c), demands that drivers treat the convex space of the intersection as a space for negotiated turn-taking. The roundabout, (d), breaks the task down such that potential conflicts are encountered one at a time.

A simple example that illustrates both of these features—i.e., a populated structure that exhibits spatial configuration—is a traffic intersection. Consider a regular four-way intersection where two roads cross perpendicular to one another. This configuration presents a basic problem of interpersonal coordination. There is one central space that must somehow be traversed by everyone going through the intersection. If multiple actors are attempting to cross the same space at the same time, then this calls for some reliable means of coordinating things so that collisions can be avoided. In practice there are three standard solutions to this problem: light-controlled entrances to the intersection that force actors to take turns; stop signs on the entrances that force drivers to yield to one another; and roundabouts (see Fig. 1).[1]

The basic coordination problem can best be appreciated by considering what the intersection looks like from the perspective of a person (a driver) approaching it. First, let's assume an intersection with no lights, stop signs, or roundabout, as in Fig. 1(a). And let's assume, as the ecological approach does, that an actor controls her movement by attending to a single variable continuously. The problem, in the case of the four-way intersection, is that for the driver entering the central space, there are three

[1] This does not exhaust the set of possible solutions to the problem. One of us recalls living in Cochabamba, Bolivia in the 1960s, before traffic lights had reached that part of the world. The rule there at the time was that whoever hooted first had right of way at the intersection. Louder horns were a benefit.

demands on her attention simultaneously: one for each arm of the intersection, from each of which another driver may potentially emerge. These demands are denoted by the exclamation points in the figure. Now, our driver could simply choose to attend to one of these attentional demands, and she could drive through the intersection at a constant speed, ignoring the other two entrances. This would clearly be reckless and, if every driver behaved like this, it would be unsustainable.

The traffic light solution solves the attention problem by replacing the thing that the driver has to attend to, as shown in Fig. 1(b). Instead of monitoring movement from the three other entrances to the intersection, the driver now has to attend to a single demand: is the light green? Notice that this does not solve the problem entirely. Many intersections allow drivers to turn across the oncoming traffic, requiring someone to yield, and so presenting an auxiliary attentional demand in addition to the light. Also, a red light does not *physically* prevent a driver from entering the intersection, so there always remains at least the potential that a car may emerge from any entrance even when the driver has a green a light.

The stop sign is an interesting solution in terms of how it alters demands on the driver's attention. Here we are considering the kind of low-volume four-way stop intersections common in residential neighbourhoods in the United States. At this kind of intersection, every driver is required to stop before entering the central space, as in Fig. 1(c). What this does is it forces the driver's attention not onto the place where she is headed, but into the convex space constituted by the intersection itself. The intersection interrupts the task of controlling forward movement. Once the driver reaches the stop line, she enters a new task, an interpersonal coordination task. She must first monitor for the presence of competitors for the space, she then edges into the space to confirm the other drivers' intention to yield, and finally she executes the manoeuvre and exits the intersection. Only once this is achieved can the driver return her attention to the task of driving forwards.

Finally, the roundabout. A roundabout is a different kind of solution to the coordination problem. It works not by simply changing the attentional demands experienced by the user of the space (as in the case of the lights or the stop signs). It also changes the configuration of the space itself. A basic four-way intersection, as in Fig. 1(a–c), has a central space that can be crossed from any entrance in any direction to any exit point. The roundabout replaces this space with a central loop within which every driver travels in a single direction (either clockwise or counterclockwise, depending on the country).

Roundabouts are known to be safer than the other two types of intersection (i.e. those controlled by traffic signals or stop signs). Studies that look at the effects on safety when four-way intersections are replaced by roundabouts consistently find that fewer collisions and injuries occur after the roundabout has been installed, while fatalities are reduced by anywhere between 50 and 90%, depending on the nature of the intersection that has been replaced (Persaud et al., 2001; Elvik, 2003; Daniels et al., 2010). The reasons for this are not mysterious. The safety outcomes are a direct result of the altered configuration. The presence of a roundabout makes it impossible for a driver to traverse the intersection at speed. Moreover, because all traffic is moving in the same direction, head-on and T-bone collisions are not possible. Roundabouts do not afford collisions of these types. This constitutes a major safety advantage for roundabouts, because it is these collisions that result in the most serious injuries and fatalities (Rodegerdts et al., 2010).

Another distinguishing property of the spatial configuration of the roundabout is the way that it structures the driver's attention. Recall that the original problem posed by the intersection was that of multiple simultaneous demands on the actor's attention. The light- and yield-controlled intersections solve the problem by forcing the driver into a different task: attending to the light, or attending to the intersection itself as a common space for taking turns. The roundabout, in contrast, subdivides the attention task into a sequence of individual go/no-go decisions. On approaching the roundabout, the driver must first check in the direction from which the traffic is circling to see whether it is safe to enter the roundabout itself. Next, the driver either takes the first exit, or continues around the roundabout, encountering the first potential conflict point where another driver may be attempting to enter. This is repeated as many times as necessary until the driver reaches her desired exit. Note how in Fig. 1(d) the attentional demands, denoted by the exclamation points, are sequenced in space along the driver's route, denoted by the dashed arrow.

The upshot is that the driver can take any exit she wishes (including turning around and going back the same way the entered), and the task always has a consistent structure. The structure can be summarized thus: ENTER–N(MONITOR)–EXIT, where the central term denotes an arbitrary number of intervening exits that the driver chooses not to take. The way that the roundabout solves the basic attention problem, then, is that it breaks the movement control task down into a sequence of smaller, more manageable tasks. The roundabout structures attention in time as well as space.

The above is an analysis of the task structure of three different types of intersection. It is a simplified analysis. For one thing, we have only been imagining one type of actor using the space, namely a driver in a car. In reality, intersections should be usable by different kinds of actor, and designers should give priority to the most vulnerable road users—pedestrians and cyclists (Daniels et al., 2010). The analysis above is intended to illustrate some of the principles of a task-oriented approach to design in cities. The designer must take into account that urban spaces are populated, and that they exhibit spatial configuration. The difficulties that the actor will encounter are shaped by the configuration of the space. In the next section, we turn to the use of a common space by different types of actor.

4. AFFORDANCES AND THE HIERARCHY OF MENACE IN PUBLIC SPACE

To describe the surroundings of an actor in terms of affordances is to describe those surroundings in terms of both opportunities and threats. As Gibson defined the term, 'The affordances of the environment are what it offers the animal, what it provides or furnishes, *either for good or ill*' (emphasis added, Gibson, 1979, 127). In academic writing on cities, pedestrians and cyclists are sometimes referred to as 'vulnerable road users'. This label is accurate because it denotes the fact that, from the perspective of a cyclist or a pedestrian, the environment is populated by threatening objects, namely motorized vehicles. Indeed, there exists an inherent set of inequalities between road users, which we refer to as the hierarchy of menace. A driver in a truck is in control of an object that, when in motion, is a menace to a driver in a small car. The car in turn constitutes a menacing object to a cyclist, and so on. The same does not hold in the opposite direction. A pedestrian does not pose an immediate threat to a driver of a car. And for the driver of the truck, none of the other vehicles on the road usually pose an immediate threat of personal injury, except, perhaps, for other trucks.

In cities, large motorized vehicles are the problem, and we do not wish to suggest that smooth, uninterrupted driving should be the thing that traffic designers are aiming for. We must, then, go beyond the driver-centric analysis offered above. Roundabouts are an efficient and safe piece of road infrastructure design, assuming everyone on the road is driving a car of similar size and physical robustness. This assumption is not appropriate for real roads within cities.

In recent years, several major cities have been trying to make their street grids more user-friendly for cyclists and pedestrians. Officials within New York City's transport administration, for instance, have sought to encourage human-powered modes of locomotion by such measures as restricting provision for automobiles and installing cycle lanes (Sadik-Khan and Solomonow, 2016). Implementing new infrastructure for cyclists and pedestrians in a city is a challenge, in design terms. It involves superimposing a grid of lanes intended for use by a vulnerable group on top of a pre-existing grid used by cars, whose drivers are following an established set of attractors and movement patterns (Penn et al., 1998). Inevitably, these grids will have to intersect at various points. The challenge is to arrange the points of intersection in such a way as to bestow agency and control to those lower down the hierarchy of menace. We here briefly consider two problematic scenarios.

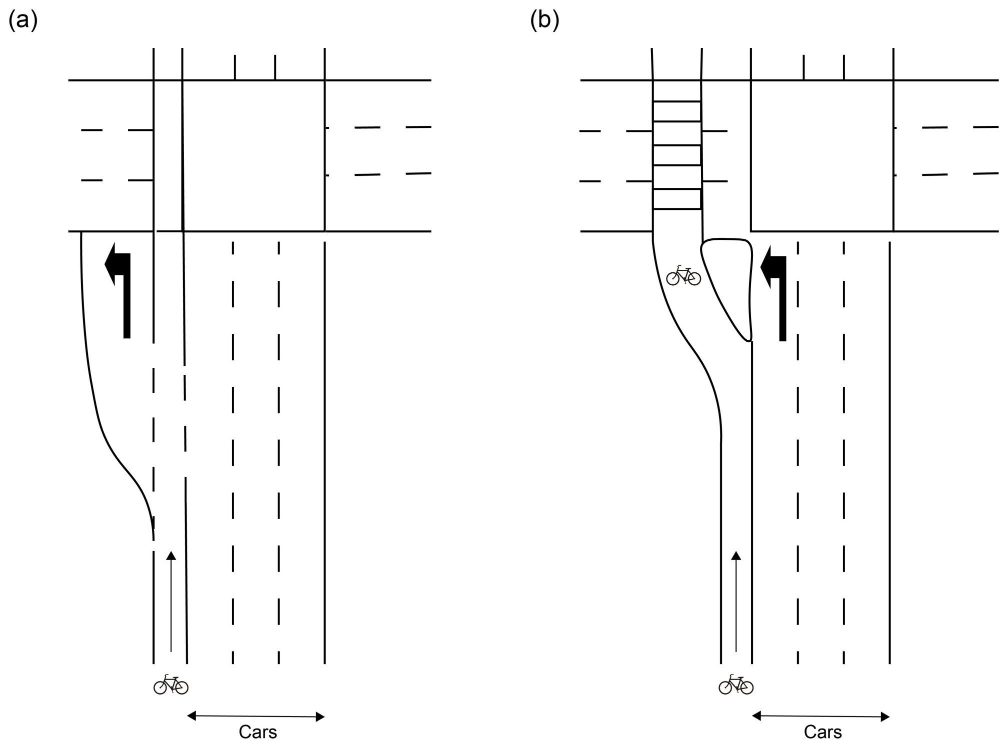

Fig. 2 Two cycle lane configurations. In (a), cars turning left have to cut across the cycle lane to get to the turn lane; this is dangerous for the cyclist. This cutting-across problem is solved in (b), in which cars turn left before encountering the cycle lane.

4.1 CYCLE LANES

Consider the scenario depicted in which a cycle lane is installed along the extreme left of a three-lane, one-way street, as in Fig. 2(a). This works fine until the cycle lane is interrupted by a vehicle turn lane, designed to allow car drivers to turn left. To get to this lane, drivers must cut across the cycle lane. Imagine cycling in the cycle lane here and it is immediately clear that the experience would be an uncomfortable one. There are two relevant factors here. First, motor traffic tends to travel faster than the cyclist, and second, the cyclist's visual attention is restricted by the fact of forward-facing human vision. The reason for the feeling of discomfort is that, if you are the cyclist, there is a risk of being crashed into by a vehicle approaching from behind your right shoulder. If you are already engaged in the attention-absorbing task of propelling yourself forwards along the cycle lane, then you cannot simultaneously attend to things behind you; the threatening object is outside the current horizon of your visual attention.

Contrast the first scenario with a slightly redesigned left turn setup, shown in Fig. 2(b). In this second case, the vehicle turns left before crossing the cycle lane. In this scenario, the cyclist meets the vehicle on the perpendicular. This means that the relevant potentially threatening movement of the car is visible to the cyclist, and there is no longer a possibility of the car's colliding unseen with the cyclist. What's more, at the point where the cycle lane crosses in front of the car, the car has already slowed down to take the turn.

The second design achieves the objective of overlaying a cycle lane on a vehicle-carrying grid while bestowing agency to the cyclist. The second design does not require more space, assuming it is implemented through the removal of a dedicated left-turn lane for vehicles. What this illustrates is that, in designing overlapping grids for different modes of locomotion, designers need to pay particular attention to the needs of users lower in the hierarchy of menace, and their designs should recognize the constraint imposed by forward-facing human vision.

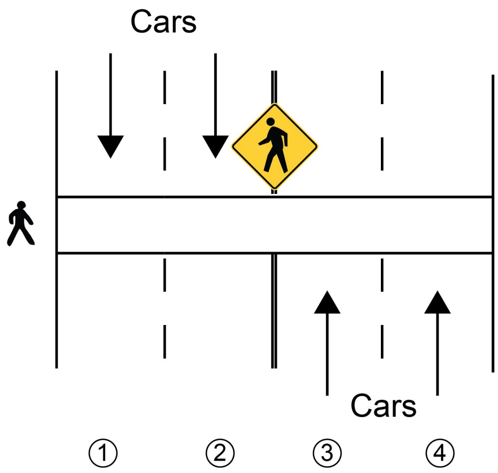

Fig. 3 A crosswalk across four lanes of traffic. Such crosswalks are common in the United States. This design causes confusion because responsibility for coordinating movement is diffused across multiple actors who are spread out in space.

4.2 PEDESTRIAN CROSSWALKS

Now consider the pedestrian crosswalk depicted in Fig. 3, which is a simplified version of a crosswalk design currently used in Cincinnati, Ohio. The crosswalk traverses four lanes of motor traffic, two in each direction. Assume that this crosswalk is positioned mid-block, and that it is not controlled by traffic signals, but is marked by high-visibility signs indicating a pedestrian crosswalk. According to Ohio's Motor Vehicle Laws, drivers are required to yield the right of way to a pedestrian attempting to cross at such a crossing.

Yielding, in this context, means that the driver is supposed to give the right of way to a pedestrian already in the roadway. In practice, we have observed that drivers routinely fail to yield to pedestrians attempting to cross at these locations, and pedestrians typically wait until the road is clear in both directions before crossing. Despite the requirement to yield being codified in state law, the crosswalk design is ineffective as a means of getting the pedestrian across the road. To understand why, it is necessary to appreciate that this is once again an instance of a task that is structured in a spatiotemporal sequence and that involves interpersonal coordination.

First, consider the task from the pedestrian's point of view. The task of crossing a four-lane road has a straightforward syntax, arising from the configuration of the road: the pedestrian plans to traverse the lanes 1, 2, 3, 4; for lanes 1 and 2, she must attend to potential threats arriving from the left; for lanes 3 and 4, to potential threats from the right. Physically crossing the road, however, takes time. And if there is no central pedestrian refuge to break up the task, then the entire action sequence must be planned in advance, from the starting position at curb. Whether it is possible to plan the sequence at all depends on how fast the pedestrian is able to walk. The more lanes she has to traverse the greater the difficulty of planning the movement.

In theory, of course, it is not actually necessary for the pedestrian to plan the entire crossing in advance, because the drivers are supposed to yield the right of way. But now consider the scenario from the point of view of a driver approaching in lane 1. The driver here may see the pedestrian waiting at the curb. The driver could slow down as a signal to encourage the pedestrian to enter the crosswalk. But the pedestrian is unlikely to take up this invitation without first checking what is going on in lanes 2, 3, and 4. The driver in lane 1 has no direct influence on what is going on in these other lanes. Furthermore, the driver in lane 1 may have another car following in the same lane. That second car's driver may not be expecting the first to slow down. Slowing down to the degree necessary to yield to the pedestrian is in fact a dangerous option. It leads to global confusion, and there is no guarantee that it will lead to the pedestrian taking up an opportunity to cross.

What this demonstrates is that explicit rules are not always sufficient for the smooth functioning of multi-modal traffic infrastructure. If roads are to be usable by different types of actor, both drivers and pedestrians, then it would seem necessary that some formal structure exist enabling the interaction to be negotiated safely. The four-lane crossing fails because there is a mismatch of time scales. The pedestrian's movement has to be planned in a sequence, i.e. it is diachronic, but it relies on synchronic interpersonal coordination between a number of actors (between the drivers in each of the four lanes, and between all of those drivers and the pedestrian) who may not immediately perceive the situation in the same way as one another. This ambiguity can be removed by decomposing the overall task into a structured sequence of subtasks in space, for example by arranging traffic lanes so that the pedestrian only has to cross one lane at a time. (Notice that this breaking down of the task follows a similar principle as operates in the roundabout.) Alternatively, the city may choose to replace the yield signs with a formal light-controlled crosswalk, requiring all lanes of traffic to stop for as long as it takes for the pedestrian to complete the crossing.

5. RECONCILING SPACE SYNTAX AND ECOLOGICAL PSYCHOLOGY

We conclude with some observations on the prospect of a fruitful theoretical reconciliation between the syntactic approach to spatial configuration and the radical embodied or ecological approach to human perception and action.

In *The Social Logic of Space*, Hillier and Hanson (1984) set out to understand 'the relation between space and social life' (ix). They do so by offering an analysis of space and society at the architectural scale, that is, at the scale of buildings and their rooms, street segments and their connections, and so on. Gibson's (1979) ecological approach, meanwhile, is pitched at the ecological scale, that is, at the scale of interaction between an individual animal and its surroundings (Baggs and Chemero, 2018). Reconciling the two research programmes would seem to require a reckoning with the relation between these two scales of analysis.

In the introduction we suggested that the divide between these two scales may not be as unbridgeable as it might first appear. The space syntax method of analysis already assumes a human actor moving between spaces. This assumption of a human actor is not often stated explicitly. The three case studies discussed above sketch further how the two scales can be taken into account at the same time. The key is to recognize that human movement in cities has to be planned in both time and space. Further, movement has to be planned in an environment populated with other actors who are themselves actively regulating their own movements. The roundabout example demonstrates that movement tasks have a structure in time as well as space, and the structure of these tasks is constrained by the capacity of the human attentional system. The roundabout is a robust solution to the problem of negotiating potential movement conflicts at an intersection between two busy roads. It works because the spatial configuration of the roundabout subdivides the task into a manageable sequence of subtasks, while eliminating the most dangerous potential conflicts. The bike lane example shows how the capacity of the human actor to plan upcoming movement is constrained by human anatomy, in this case, by the fact of forward facing vision. Designers should pay particular attention to such constraints when installing new bike lanes within existing street grids. Finally, the four-lane crosswalk example shows that interpersonal coordination in the urban context ceases to work when responsibility for coordinating the task becomes too diffuse and ambiguous, that is, when it requires coordination between too many actors in too little time. Changing the spatial configuration was again proposed as a solution to this diffusion of responsibility.

For space syntax theory, the most important message here is this: in a populated environment, spatial configuration is not static, but is dynamic because the configuration itself is partly constituted by the movement of actors within the space. Consider the four-lane crosswalk again. The configuration of the road itself does not change over time, but its affordances do change from moment to moment. From the perspective of the pedestrian, the road looks very different when it is empty of vehicle traffic compared to when it is populated with heavy traffic in all four lanes.

In order to develop a complete understanding of the design of usable urban spaces, it will be necessary to operate across both scales of analysis, the architectural and the ecological. One obvious direction for future enquiry is to ask how best to arrange street networks as a whole in order to make them usable by individual human actors using human-powered locomotion. This is a problem only hinted at with the bike lane example above. Our suggestion is that the cities that most effectively enable human-powered movement are those designed with a careful appreciation of both global spatial configuration and first-person task configuration. Unifying explanation across both scales would potentially offer a powerful way of thinking about designing accessible spaces in cities.

ACKNOWLEDGEMENTS

This work was supported by funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 706432.

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