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Crip spatialities and temporalities I : discreet crips in a discrete world

Par Enka Blanchard. Le 27 March 2020

1. Non-Euclidean spaces, discreteness, and optimisations.

Over the past decade, increased attention has been given to inconsistencies between our ways of representing space in a territorial, topographical fashion, and our ways of inhabiting spaces as members of rhizomes and complex networks of relationships. This analysis was especially developed by the Chôros laboratory (now the Chôros rhizome) with reflections on how the world often exhibits non-Euclidean features (Lévy 2012, Lévy and Lussault 2013, Poncet 2017). For example, Euclidean distances — and mathematical objects built from these distances such as areas — give a very biased and limited understanding of how humans evolve in the spaces surrounding them, where the temporal distance between places is more critical than the Euclidean topographic distance (Lévy 2009).

This article seeks to extend the original analyses with an ethnographic focus, by looking at a population for whom the non-Euclidean properties of space are amplified. We will base this work on ethnographic observations, formalised and systematised using mathematical intuition and familiarity with Chôros' work. This article is not addressed to mathematicians, and tries to avoid jargon[1], but we still need to define a few basic mathematical properties. We will look at many kinds of objects, from discrete sets of points to Euclidean spaces, not only as themselves but as support for cost functions (such as the time or money it takes to go through that space). For example, a space will be considered Euclidean (a subset of metric spaces), if the time it takes to go from A to B is roughly proportional to the distance between them. A space will be non-Euclidean when it features discontinuities, such as boundaries (in the non-geopolitical sense). For example, a border between countries with no visa agreement can create such a boundary (a topological boundary, using the terminology of Lévy, Maitre, and Romany 2016), in which case crossing the border changes the cost arbitrarily. The ground itself forms another boundary, limiting our exploration to a mostly 2-dimensional space. Abrupt changes in the time or money it takes to go somewhere will be counted as discontinuities.

When we discretise some objects, such as the figures featuring temporal expenses — where the

times are binned in sets of 5 minutes — a discontinuity will be going directly from one bin (that costs 5 minutes) to another that is not adjacent to it (that costs 15 minutes), without having a transition zone where it costs 10 minutes. Discreteness itself will play a role as we will consider objects that are independent and finite — such as places instead of spaces — and properties that are either true or false (instead of being on a continuous scale of truth). This will mostly feature in reflections on costs, for example on the issue of optimising one's path. In such contexts, discrete problems are known to be harder to solve than their continuous equivalent[2]. Of course, all our spaces feature some forms of discontinuities, but the main argument is that, while most people unconsciously experience space as being mostly continuous, impairments make discontinuities appear in all contexts[3], at all scales, and for a wide range of parameters, which will come into play as an additional cost factor.

Before getting into the substance of this article, some methodological and terminological decisions have to be explained, and some terms defined. First, we follow Robert McRuer in using the word[4] "crip", in the process of *cripping* existing concepts by analysing how they can be framed by the specific experiences of the disabled communities, following ethnographic practices (McRuer, 2006).

Those very practices indicate that the concerned communities' experiences and voices should be at the centre of the argument, which is at odds with the standard practice of citing published research. However, disabled researchers, only a small proportion of whom works on those subjects, make up a tiny minority of all researchers[5], and very little research in disability theory is done by non-disabled researchers. We must then turn to activists to get contemporary accounts and analyses of the communities' experiences, mostly as reflections spread on Twitter or Tumblr.

Terminologically speaking, "crip" will be used to denote an arbitrary disabled person. "Wheelie" will also be used to talk specifically about wheelchair users — whether they use manual or electric wheelchairs — as it is a commonly used word in the community. The term "biped", also commonly used in this context, will be used to contrast the wheelie's experience with the ones of someone who generally walks around. Although the article's arguments try to include many forms of disability[6], they will tend to focus on wheelies, and more specifically ones who use electric wheelchairs, due to the author's greater familiarity with the subject (being a wheelie themself).

2. Discrete bodies in anomalous spaces.

2.1 Restricted viewpoints.

The first spatial peculiarity of wheelies can be that, more than bipeds, they are restricted to a two-dimensional space when it comes not just to movement, but also to perception (Mairs, 1996, Toombs, 1995). In this context, we are not concerned with the issues of steps and stairs, but focused instead on where the head — and hence the eyes — can be. Both standing up and bending down can be arduous tasks for a wheelie, or even impossible when one is either paralysed or strapped to one's chair. This restricts the height (and the angles) from which one can view the world. The restriction might seem innocuous but it can have surprising effects when experienced constantly. For example, upon getting up — or getting to a vantage point — it suddenly becomes possible to compare other people's heights, which is difficult from a low position. Thankfully, this has little to no consequence — although height does seem to affect decision making when it comes

to both professional and romantic partnership, and it might be worth investigating whether the effects are still seen if the decision-maker is in a wheelchair (Agerström 2014).

On the more practical side we find objects we are meant to interact with, from menus etched into high tables to voting machines, which can be set on a plane that is at the eye or chin level, or require non-movable magnifying glasses, making the reading process difficult (Runyan 2007). The converse problem also exists, and writings on the floor (or on a low surface) that require squatting are no friendlier to wheelies than if they were on the ceiling.

This tendency to make most interactive objects fit to standing people can also sometimes be reversed. A recent striking example was the “Being Human” permanent exhibit at the Wellcome Collection (Marshall, 2019, Voon, 2019), the first major exhibit to be designed with disabled people in mind. This followed a smaller exhibit called “Can you see us Vancouver” that was organised 2 years earlier (Correia 2017). The latter was a small painting exhibit where the artworks were displayed 10 to 14 inches (25-36 cm) below their usual height, making the optimal viewing height that of someone sitting. The goal probably included leaving a weird impression on bipeds forced to squat to enjoy the artworks, helping them realise that the default point of view they generally enjoy is not universal. In a way, beyond making the news for the novelty of catering first to the disabled community, this can be seen as a replication of the — sadly often misguided (Nario-Redmond, Gospodinov, and Cobb 2017) — trainings where bipeds use wheelchairs for a day to understand the inherent difficulties.

2.2 Algorithmic motions.

The second aspect of spatial discreteness goes just beyond the body as a static object, concerning how it moves. Only a fraction of crips experiences this fully, but it features in one way or another in many lives. Our main example here is that of someone who, after being immobilised for an extended duration (or even since birth), learns to perform new movements, typically walking[7]. Without the relevant muscle memory, this requires a large set of actions. Unlike the pianist who repeats the same movements at a lower tempo to achieve the desired fluidity before accelerating, our crip cannot slow down. Efficient running — and walking, to a large extent — relies on being perpetually slightly unbalanced. However, this is unreachable for our newly-walking crip as they do not have the required reflexes to restore their balance when needed. Hence, they are stuck using decomposed movements, where, in the goal of always being balanced, conscious efforts are made to control their limbs. Each limb then moves in a prescribed motion according to a conscious algorithm, which might, one day, become internalised enough to allow for unconscious movement. The decomposition of the general movement and frequent stops to restore balance prevents using one’s inertia, and makes each step that much slower and costlier energy-wise. This is the first case where we can see the costs mentioned in section 1, where the continuous movement that is not performed consciously by the biped has a very high efficiency, whereas an impairment that discretises the movement also drastically reduces its efficiency. It is but one example, and algorithmic decomposition of everyday actions can occur in a variety of situations. This notably includes speech construction, whether it concerns treating stuttering symptoms by hiding noticeable discrete events at a high cognitive cost (Dayalu and Kalinowski 2002), or the algorithmic speech construction made famous by Stephen Hawking.

2.3 Anomalous personal spaces.

Most of the arguments in this article deal with the restriction of explorable or visible spaces in the

context of disability. However, the inverse effect can also be seen in some specific contexts, where the crip's space is not restricted but transformed instead. The prime example is that of personal space, which is felt differently by crips of all sorts, due not just to their disability but to how others interact with it. Three main elements affect the crip's differing experience of personal space, which we will look at successively.

The first element lies in an altered perception of the self, manifested in many ways. For example, lack of sensory information in parts of the body — e.g., following a spinal cord injury — can create a different sense of one's body. The other way around, crips often extend their notion of self to the mobility aids and prostheses they use. For example, many wheelies extend their senses, from touch to proprioception, to their wheelchairs, being able to "feel" when someone touches it — through the vibration this generates — albeit with reduced precision. The case is even clearer with people using limb prosthetics, especially as newer models integrate feedback mechanisms. This extension of the body and the sense of self through technological means come with a caveat. The legal protections afforded to organic bodies do not generally extend to the prostheses and mobility aids used. Most legal frameworks are still unclear on the issue, and treat damage to the prosthesis — an often individualised object which is felt as part of the self and is seldom replaceable as is — as property damage and not bodily harm (MacDonald Glenn 2012).

The second element comes from a different notion of personal space, often built around the different notion of the embodied self. The notion of personal space can differ greatly once the ability to move through space is impaired. In Europe, standing a meter ahead of someone's wheelchair or mobility scooter while indoors might not seem aggressive, as it is quite far from the accepted bounds of personal space (Sorokowska *et al.*, 2017). However, this can restrict greatly the wheelie's ability to manoeuvre, effectively trapping them. Standing behind a wheelie similarly limits their opportunity to manoeuvre, to a much greater extent than it would for a biped. Visually impaired people, who may lack the ability to accurately perceive the space surrounding them — which is dangerous in case of sudden movements — also have their own differing experiences of personal space (Eaton, Snook-Hill, and Fuchs, 1997).

Finally, the last element comes from the experience of repeated intrusions into this personal space, which are generally felt more keenly. Considering this extension of personal space, it can be surprising to learn that non-crips generally perceive it to be smaller, and give disabled interlocutors less personal space when interacting with them (Kilbury, Bordieri, and Wong, 1996). This extends much further, with the very autonomy of the crip often being denied, from intrusions into their personal space to prolonged unwanted contact, such as someone grabbing a crip's wheelchair's handles and forcefully pushing them despite their protestations (Mason-Bish and Kavanagh, 2019).

2.4 Autonomy as a prerequisite for exploration.

This notion of autonomy is at the centre of most of the arguments in the rest of this article, as it has been at the centre of most fights around disability rights. As it stands, the perceived right to body autonomy and spatial autonomy of crips is in a dismal state. What distinguishes this from other fights around social interactions (such as the issues around street harassment) is the near consensus among the general population (excluding disability rights activists) that restrictions on crips' physical[8] autonomy are natural or deserved (Mason-Bish and Kavanagh, 2019).

For example, it is generally accepted not just as a decent action but even as a moral imperative to go help someone apparently struggling on a wheelchair. This can be seen in relatively low-

importance situations, such as when one tries to open a door. It can be very hard to avoid getting help from a biped when entering a public building in a wheelchair. Although well-meaning, this interaction often infringes upon the personal space, as in the frequent case where the biped holds the door open while standing in the doorway, as in Figure 1. Repeated requests to let one handle it without help are generally unheeded, until the wheelie is forced to admit that the other is bothering them by being in the way, at which point a frequent reaction is anger at the well-meaning action being so badly received.



A doodle illustrating the frequent ways of unhelpfully opening a door for a wheelie. Image courtesy of Beth Wilson (www.doodlebeth.com).

This annoyance at being denied the opportunity to help is indicated in some public reactions to Sarah Waters. This activist decided to install spikes on her wheelchair handles to prevent unwanted grabbing (Brazell, 2019), an idea welcomed and copied by others in the wheelie community. However, many bipeds commented defensively, thinking the addition too aggressive, especially when it was just deterring well-meaning people. Multiple online movements have emerged to publicise this kind of issue, notably among the visually impaired community with the #JustAskDontGrab hashtag (Kavanagh, 2018).

Even sitting around with a book, listening to music with headphones, or having a phone call outside is a nontrivial act for crips, as people often interpret an unmoving crip as a struggling one, and believe it necessary to interrupt them to see if they need help. Non-autonomy is then generally accepted as the default fate of most crips[9].

Although the previous examples are somewhat benign, the consequences can be damaging. First, non-expert help is often detrimental, and can be outright dangerous, as when pushing a wheelchair while the person sitting in it has their fingers in the wheel, or grabbing/lifting someone by a random appendage which can be extra sensitive. Even supposedly trained personnel can have wrong instructions (typically, airline employees tasked with assistance to people with disabilities are told to grab the person if they fall, and are not told to ask how to interact and what to avoid when meeting the people in their care[10]).

Second, and most importantly when it comes to the exploration of space, this creates multiple additional costs for the crip in public. It means that, as they are always at risk of having their autonomy revoked and are always interruptible, there is a constant mental load and stress linked with being prepared for such interactions. It also means that the crip must be prepared to keep their calm despite the annoyance, lest their reaction affects their interlocutor’s view of all crips. Third, it also goes against what Shay Erlich calls the “right to struggle” (Erlich, 2019). Any remotely risky

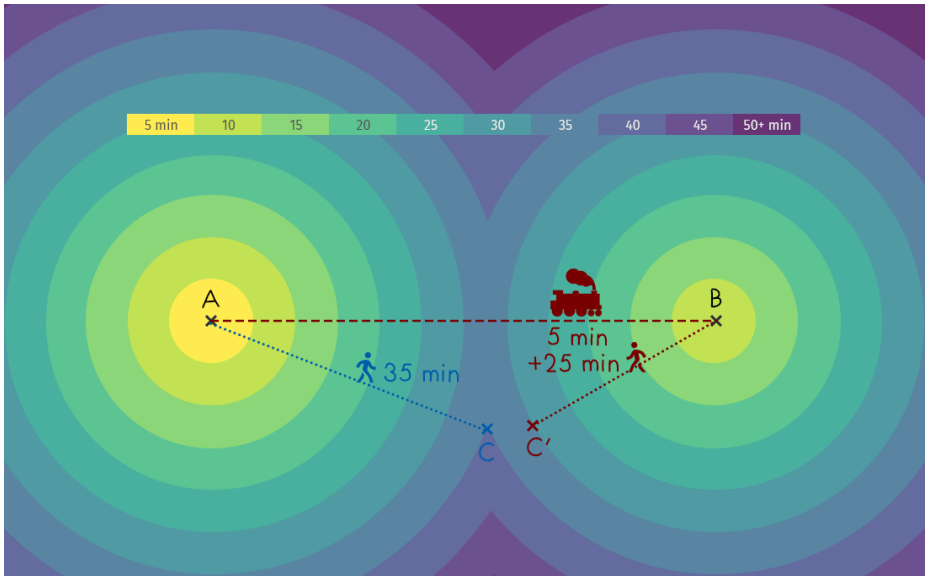
activity can lead to outward perceptions of struggling (wheelie dancers who are able to lift themselves from a fallen position being the original example). This leads to high chances of intervention, which makes even normal activities critically dangerous: instead of a practised fall, the crip risks having someone grab their wheelchair and push it, breaking the crip's fingers and leaving them incapable of autonomous movement for multiple months. This in turn can lead to learned helplessness (Friedland and McColl, 1992), and makes any spatial exploration even costlier as a crip, due not just to the impairment, but to the social attitudes towards it, mirroring the arguments made in the social model of disability.

3 Multiple levels of discrete spaces.

3.1 Reachability and discontinuity.

We have seen that, because of social issues regarding perceived autonomy, exploring one's surroundings — or existing in them — is costlier for crips. This will matter later, but we first have to tackle which regions of space are even explorable. Naturally, not every place is reachable on Earth, even discounting questions of disability. There are in fact multiple kinds of boundaries that make space discontinuous, although still mostly locally Euclidean. We can typically sort those boundaries in three groups: topographical (such as cliffs or rivers), geopolitico-legal (in the forms of borders with passport controls, or military zones), and architectural (such as a wall separating two buildings, which can require leaving the premises and getting back inside to move just one metre away — through a wall)[11].

We can then observe two properties. First, for nearly any given point within a populated space, most bipeds in the same country/region can get close (within a few dozen metres, often less) of that point. Second, those places are, up to a certain precision, locally Euclidean. In this context, it means that looking at almost any pair of points (A,B), going from A to B takes time and effort similar to going from A to C, when C itself is close to B. In other words, we have something that roughly follows the triangular inequality: going from A to C is not costlier than going from A to B, then to C. This all stems from the fact that discontinuities are relatively rare, and mostly happen in the form of shortcuts (making the distance between two places smaller when a train line connects them). The discontinuities in these cases affect not the cost of the path, but its trajectory. For example, if a train goes from A to B, the fastest way to a point C halfway between A and B is to go there on foot from A. But if we change the destination to C', a point slightly to B's side, the fastest path becomes just a bit faster, but goes through a completely different trajectory by taking the train to B and going from there on foot, as is shown on Figure 2.



Schema illustrating the time costs depending on the path taken from A to points C and C’ between A and B. The costs are continuous, but the path taken changes radically depending on the destination.

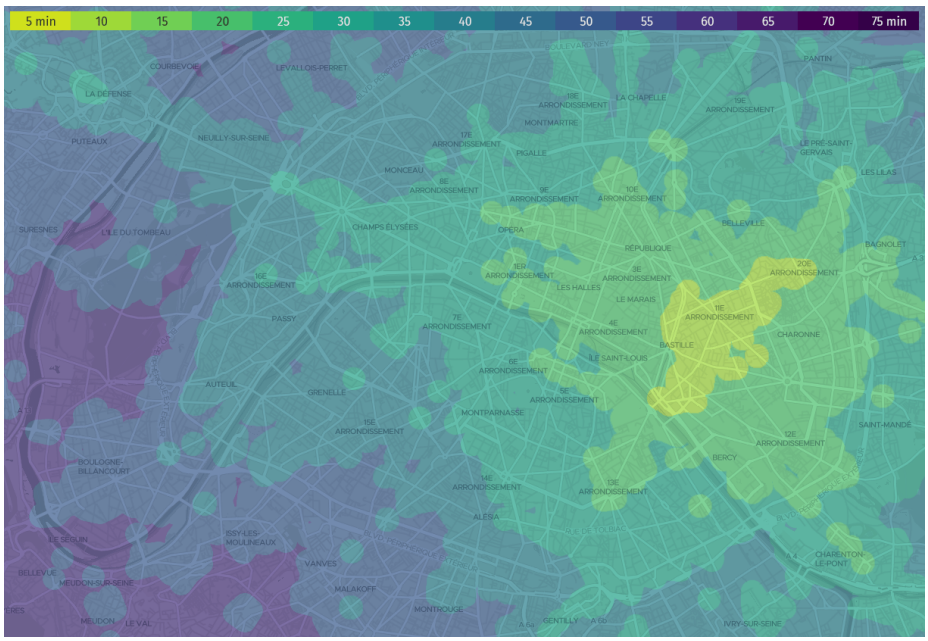
The question is then: what happens when a crip explores the same spaces? First, there is a very simple discontinuity that appears for people who depend on electric wheelchairs. Wheelchair batteries are limited[12], take up to half a day to recharge, and require chargers which are often both large and heavy (which makes taking the charger and recharging en route a move of last resort). This means that the cost to go to any point in the battery’s range is similar to that of a biped, but any point outside of this perimeter is simply not reachable (or with half a day’s delay for just a few kilometres). There is then a strong discontinuity when compared to a biped — or someone in a manual wheelchair — for whom the cost of each extra step only increases with fatigue, in a continuous fashion. We now refine this statement to incorporate more subtle effects. First, taking the radius as the battery’s range is not realistic, as the wheelie probably needs to come back home eventually, so we need to divide it by two to allow for the return trip in most cases. Second, there is a certain variability as to the battery’s range, as it depends on the average speed, the temperature and many other factors, and battery indicators are still highly inaccurate (an error of 50% not being rare when the battery is more than half-depleted). Because of this, we have to add an additional cost: that of worrying about whether one will be able to get back home. We then get two different boundaries: within a first circle — whose boundary is at a distance of about a third of the battery’s maximum range — space behaves mostly in a Euclidean fashion (regarding battery issues at least). A soft boundary around this circle covers the distances up to half the maximum range, where the cost to move increases quickly due to stress. There, a strict boundary separates the explorable zone from the rest of space, which is simply unreachable.

We have our first discontinuity, which happens at a medium scale (in the range of 5 to 20 kilometres). Let’s now turn to more local effects. First, we can note that the level of precision at which a crip can approach a point in space is lower: many buildings — in Europe especially — do not have large enough — or functioning — elevators. Despite regulations implemented over the last three decades, many businesses are still struggling to provide accessible ways inside (Aiden and McCarthy, 2014), creating a boundary at the entrance. Those are all local discontinuities, but the impact can be felt dearly in certain examples: exploring Saint Petersburg, one can get onto the sidewalk along the Neva river, and not find any way to go down for more than 1 500 metres (at

which point one gives up and accepts going back the way they came, with a 3 kilometre detour). This is an extreme case but detours of more than a kilometre to go down from a sidewalk are frequent from Washington DC to Luxembourg, and shorter ones are a daily occurrence, caused by anything from a forgotten trash bin or scooter on the sidewalk to street works (Lelyveld, 2019). This of course compounds to make the previous range inaccuracies worse.

The main problem, however, happens at the largest scale, as it concerns national and international travel. Theoretically, almost any place a biped can visit can also be visited by a wheelie. The issue is conserving one's autonomy and freedom of movement once there. For example, a wheelie can sometimes get into a car (without the wheelchair), and drive (or most probably be driven) to any nearby town. Once there, however, the capacity to explore the surrounding space becomes non-existent. This corresponds to a temporal variation on the previous inequality. Going from A to B, and then to C, can be arbitrarily costlier than going from A to C, even when B and C are very close[13] (as one sacrifices their mobility device to get to B). This gives rise to some peculiar properties. For example, there are no easy options when going as a wheelie from Paris to a place like Beaune (a town of more than 20 000 people, reachable in train or car in less than 3 hours and 25 euros). As the train station lacks elevators, the only way to get there with one's wheelchair (and freedom) is to get a special taxi. Counting the time to organise this, going to Beaune costs more (both financially and temporally) than going to Berlin.

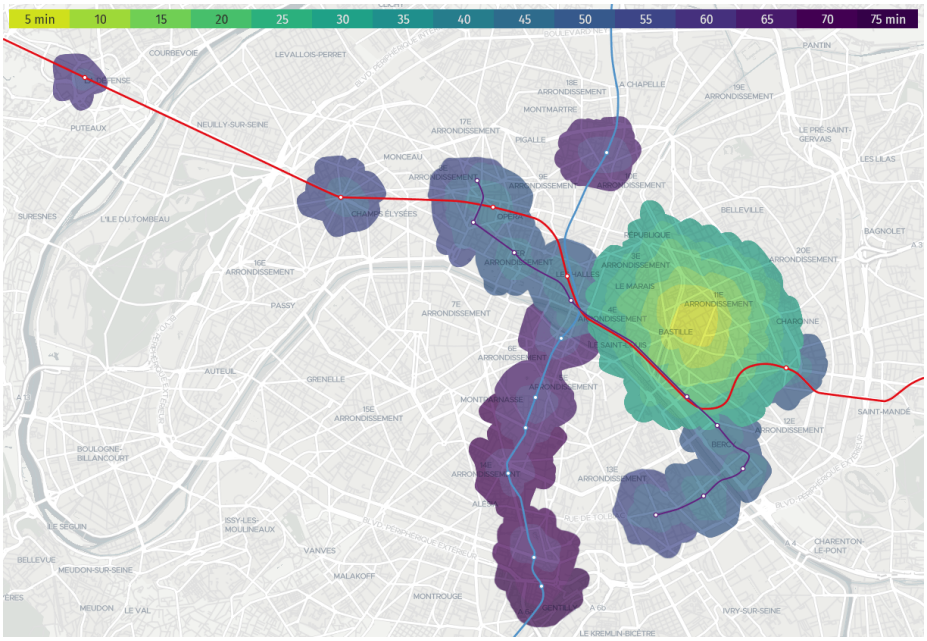
This brings us to a first distorted vision of space. We can take a biped at any point in inhabited space, and compute the time/money it takes them to reach the rest of the country/world (if ignoring visa issues for a moment). This function will be nearly everywhere continuous, although not monotonous (because of the shortcuts). Figure 3 shows an isochrone map for a biped in Paris allowed to used public transport from a starting point in the center of the XIth arrondissement. We can see some shortcuts, represented by the fact that the isochrone regions are not contiguous (la Défense, at the North-West, can be reached in 20 minutes, faster than the avenue going from it to Paris proper). Despite those shortcuts, the map itself is continuous: there are no abrupt transitions where the travel time goes from 30 to 50 minutes.



Isochrone map showing how long it would take for a biped to reach different areas of Paris using public transit from a starting point close to the

centre of the XIth arrondissement. This map (and the next) were compiled by hand using initial data collected through Targomo, with the help of L. Gabasova.

We can now look at Figure 4, which also features an isochrone map but for a wheelie with a few restrictions, all corresponding to practical realities. The wheelie starts from the same point, but they have a limited range of half an hour of battery to get to their destination while going at the same average speed as a biped, which is reasonable if they then have to use their wheelchair all day, and have enough battery for the way back (Cooper *et al.*, 2002). The second constraint is that taxis cannot be used as they are not reliable (delays of up to 2 hours to obtain an accessible cab — when one can be found using specialised services — are frequent, even when booked in advance). Third, only the public transit that is considered accessible by the French administration can be used, which eliminates most of the metro. Finally, buses are discarded for this map as they also suffer from many issues (frequently malfunctioning equipment, people refusing to make room to let one in, drivers refusing to use the equipment to help the crip onboard, sometimes because of municipal orders). To be fair, there exists one useful accessible public transit that is not shown, which is the tramway[14] going around the periphery[15], but getting to a station within range (the southernmost one) already takes two transfers and around 60 minutes. On such a map, we can see two new features: boundaries, especially boundaries within reachable spaces, such as the area at the edge of the Vth and XIIIth arrondissement, which is not reachable while satisfying the established constraints. This is despite being mostly surrounded by reachable spaces. The second feature is a solid discontinuity at the edge of areas where the wheelie has a choice between using their wheelchair or public transit. The most striking example on this map is the Île de la Cité, where the very edge is reachable using a wheelchair in 30 minutes. Because of the range constraints, reaching the rest of the island requires the wheelie to start rolling 20 minutes in an orthogonal direction, take a first train, transfer to a second train and then finish with the wheelchair, doubling their travel time to get just a hundred metres further. This corresponds to the sudden colour shift between green and purple close to the center of the map.



Isochrone map showing how long it would take for a wheelie to reach different areas of Paris from the same starting point, with a few constraints:

wheelchair range limited to 30 minutes, using only the wheelchair and accessible rail systems.

In Figure 3, 82% of the map shown can be explored in less than 40 minutes, a number that drops to 6% in Figure 4, where even spending an additional 30 minutes only lets the wheelie explore 16% of the map[16].

We have focused on wheelies with electric wheelchairs here, but the discontinuities are also encountered by other crip populations. For example, wheelies with manual wheelchairs do not have a set limit on autonomy due to the use of batteries. However, they are more often faced with one-way streets, where the slope is too high to climb. And, supposing that there are slopes requiring a high effort close to the wheelie's destination, they have to conserve their energy to be able to finish their trip, leading us back to the difficulties mentioned above.

The same kind of effect happens even more visibly at larger scales, but is harder to compute. If we take the representation of the world as an archipelago of metropoles — or as a set of archipoles (Poncet, 2017) — our new constraints induce a particular refinement of the archipelago. This refinement is non-linear, however, and the size of the city is poorly correlated with the costs linked to reaching it (for example, San Juan, Puerto Rico, can be much more reachable than San Francisco, California).

3.2 The freedom to alter your trajectory.

The previous arguments and the figures assume that one is taking the shortest path between their origin and their destination, or at least trying to find one despite the potential detours. This is often true, and many bipeds always take the same route from home to work, or to visit their habitual haunts. But, and this is crucial, there is often a choice, when walking, to cross at this intersection or the next, or to stop for groceries or a drink on the way home. Without going into topological details, there is a reason for this, linked to the Euclidean character of the ambient space. Put broadly, if we take two different paths that do not use non-Euclidean shortcuts — or that use the same set of shortcuts — we can take a path similar to the first, but modify it a bit to make it closer to the second path, and do this iteratively. Thus, it is generally easy to make alterations to the way one goes somewhere without incurring any major cost (besides the extra distance if one chooses to take a detour).

Let's now consider a crip going down the street. If they are familiar with their environment, they generally know which crossings have curb cuts, where the construction sites with annoying scaffolding are located, as well as the pubs with a crowd outside barring their way. The familiarity and high number of obstacles have a combined effect of pushing the crip to follow their usual path (Kitchin, 1998). They might try an alternative path, but there are generally few available ones. Moreover, they run the risk of encountering unknown obstacles, without the ability to simply cross the street, which means having to backtrack, often going all the way back to their usual path. Once we add the effects of increased costs mentioned earlier, from the stress[17] of being in a public place to worrying about emptying one's battery when taking non-optimal routes, we have a strong incentive to stick to what is known. This, by the way, does not only concern wheelies: people with visuo-spatial impairments, for example, can be familiar enough with their path to reconstruct and navigate its 3D environment, but can get disoriented when in unfamiliar places, which can slow them down dramatically (Antonakos, Giordani, and Ahston-Miller, 2004).

Here, we can take inspiration from the capabilities framework, an analysis of the relationships between people with impairments and society. This framework examines how the habits of society impact the crip's life experience, as well as how it impacts the freedom to achieve their goals in their own idiosyncratic value system (Burchardt, 2004). As said before, bipeds might rarely use this freedom to move around and explore their immediate environment, but the very freedom to explore means that they do not generally have to think about it. On the other hand, the inability to deviate from this path can be felt regularly by the crip, especially when moving as part of a group of people who do not share the same constraints. An even more critical case concerns wheelies who require an assistant to push their manual wheelchairs — because they suddenly become tired or unable to self-propel, or because they cannot afford the electric wheelchair they require. In such a case, the wheelie cannot even locally control where they are going, but they are — in a way — still responsible for whatever happens[18]. We have here a cost emerging from the denial of freedom, agency, and the necessity to consciously consider those issues, even as most people do not exercise the freedom they have.

3.3 Point-to-point travels.

As we have established, crips have increased costs when exploring all kinds of spaces, starting with the simple fact that some acts — such as manual propulsion on a wheelchair — can be exhausting. Other factors include stress from limited range and the omnipresent risk of facing harassment and denial of one's agency. This pushes the crip to only go from well defined — and well-known — spaces to other similar spaces. We can extend our earlier argument here. With the premise, illustrated in Figure 4, that crips can reach only a very limited set of spaces by using public transit, we can wonder what options are left. There are a few, the first being foregoing one's limited freedom and not bringing one's mobility aids to travel using a generic car. This makes the trip from A to B much more affordable, at the cost of having no option to explore around B, and having to go back to A to regain one's autonomy. As the crip is seldom the one driving, the ability to choose one's path on the way there is also mostly absent[19]. The second is to use specialised services — such as the municipal Paris Accompagnement Mobilité service in Paris — which generally only take regular clients who operate in quite a set fashion, taking the crip always along the same route at the same hours. When they allow occasional transport services, they generally have to be booked multiple weeks in advance — when provided and guaranteed by the government — or have an unreasonably high financial cost[20] — when trying to get a guaranteed service from a private supplier. This requirement to book in advance is in fact extremely common, with many public transit systems requiring advance notice going from 1to 48 hours. Using Tim Ingold's terminology (Ingold, 2007), whereas bipeds sometimes behave like *wayfarers*, enjoying the movement in space for its own sake, the crip is the ultimate *transported traveller*: "seeing in [time's] passage not an organic potential for growth but the mechanical limitations of his equipment"[21].

It then seems that, due to the costs of exploring and the constraints they are facing, crips often move directly from point to point both at the scale of the immediate neighbourhood and at the scale of regional or national travels (longer distance travels tend to be from point to point for bipeds too, as they often require trains or planes[22]). Going back to section two, we can also apply this observation to the immediate scale of the house or office. In such an environment, habits are frequent, from finding the optimal way of moving from one's chair to the bathroom (with an algorithmic set of motions), to the general tendency to only stay in a few specific places within

one's home where comfort — a potentially scarce sensation — has been optimised as much as possible.

We have seen how crips' experiences of space can differ, from idiosyncratic perceptions of the self and of personal space to restrictions on where to go, how to get there, and the related costs (Seguna, 2015). This leads to a discretisation of the experienced space, where people are either here or there, with a finite number of potential states, at multiple scales. Surprisingly, we can extend this naturally to the experience of time, as we will see in the last section.

4. Discrete temporalities and the spoon theory.

So far, we have explored how restrictions on mobility and autonomy can affect some of the prerequisites to explore space as an independent agent. It is beyond this article's purview to provide a detailed study of how this discretisation affects not only crips' spatialities, but also their temporalities. That said, it seems necessary to quickly introduce three main ways in which temporalities are also affected.

4.1 Autonomy and time discretisation.

As stated in section 2, lack of autonomy plays a big part in a crip's living experience. Sarah Waters did not only reclaim her autonomy when adding spikes to her wheelchair, she also started enforcing her right to have her own time, without being bothered by well-meaning but uninformed bystanders. Autonomy can mean having the power to choose where to go, but also to choose the temporality of one's travels. The previously mentioned public transit systems generally have strict rules when it comes to time. Travelling as a crip not only takes more time, it also limits the choices available (Pyer and Tucker, 2017). For example, many train services (including the French one) only have one wheelchair parking spot (out of 500 passengers, hence quite less than the proportion of wheelies). This means that there is much less choice in when to go, depending on whether other crips already booked, and makes travel as a group of crip nearly impossible (Lum, 2017). Beyond the arguments pondering economic interest and accessibility as a right, this can have major impacts on crip sociability. When considering that crips are often segregated in practice and tend to spend time surrounded by their peers, preventing group travel is almost equivalent to preventing travel altogether. Many trains are also not accessible, worsening the issue of limited choice. There is, thankfully, a lot of goodwill from the general population. This means that catastrophes can be handled (from a conference center changing their rooms to accommodate an unannounced wheelie to people carrying a chair up a flight of stairs). However, we could call this "accessibility as a favour", and it is pernicious. There are only so many times a crip can ask for special treatment (even when warranted and entirely caused by a local person or institution's incompetence), without drawing attention to themself, feeling like a burden, or even getting accused of being one. Thus, although a crip can decide to perform an act that relies on other people adapting the space, it is always a question of choosing when to ask for this socially and mentally costly special treatment. After getting their wheelchair carried up the stairs to a working space, the crip might decide to skip lunch in order not to have to ask twice more. Part of this is surely caused by self-censorship, but the high stakes make such behaviour rational.

Impulsivity is then not an option: any decision to move must be considered, every trip booked at the very least days in advance, with margins computed to make sure one is not left stranded. Combined with the previous considerations on the difficulty of exploring one's surroundings, it can

make many a wheelie's life follow a set routine. The routine includes a finite set of spaces — where the wheelie is often in the same position — and predefined routes between those spaces, which are generally taken at the same hours, with similar margins, thus splitting the day into discrete chunks. This then reduces the crip's potential for serendipity, even in urban settings (Lévy and Lussault, 2013).

4.2 Task discretisation and the spoon theory.

So far, a large chunk of the experiences mentioned focused on wheelies. Although the arguments and conclusions can sometimes apply to people with different kinds of disabilities, generalisations are risky. When it comes to time discretisation, the community of people with chronic illnesses has created a well-developed theory of temporalities. The spoon theory, introduced in 2003 by Christine Miserandino in an eponymous essay about her experience with lupus, is an attempt at such a theorisation (Miserandino, 2003). Many variations exist, but the general gist goes as follows: each action, even trivial, has a fixed cost, and the total budget for each day is limited. Miserandino then introduces the "spoon" as a basic unit of energy corresponding to what is needed to accomplish one such task. Although this can seem self-evident, the discretisation of many actions makes the model relevant. For example, taking a shower might not be seen as costly at all or even as an entirely conscious decision for someone without chronic illnesses. But, as each action becomes increasingly costly, it can be decomposed into multiple painful or tiring steps (such as getting dressed or undressed, on top of showering itself). An individual might realise that they only have the energy to perform one more action that day, when they still have to make an important phone call and eat dinner, having to sacrifice one or maybe manage both at the cost of extra pain and fatigue in the following days. Where most people would be able to absorb all the subtasks and ignore the related costs (considering the shower as a single action), the crip's (necessary) decomposition ensures that every subtask has a cost due to its conscientisation.

The need to budget for those extra costs creates an optimisation problem that is itself costly, by frequently leading to tough decisions. As Miserandino herself states: "I explained that the difference in being sick and being healthy is having to make choices or to consciously think about things when the rest of the world does not have to. The healthy have the luxury of a life without choices, a gift most people take for granted".

This theory has been extended in a variety of ways, often focusing on chronic illnesses and invisible disabilities, with some uses in mental health communities as well. An analysis of how the resulting models interact would require its own study, but one particular recent evolution deserves mention. The spell-slot theory — inspired by popular role-playing game Dungeons and Dragons — adds qualitative differences between the actions. Instead of a set of spoons, the crip gets a budget of a certain number of actions, in a set number of classes from easy to complex. Thus, brushing one's teeth might be an easy action, whereas cooking dinner would be a complex one. The interest of this model lies in the ability to use the complex action budget for easy actions but not reciprocally. The non-fungibility of the budgets then becomes another source of optimisation complexity.

5. Discrete spaces, times, selves?

Arbitrary regulations, increased costs due to material constraints, uncertainty, the stress of having one's consent potentially ignored at any point, and the complexity of ensuring one's safety while

juggling with those end up limiting many crips' experience of life to a set of discrete places and times, with little freedom to make impulsive decisions.

This also leads to an apparent paradox. In a way, the crip experiences space as more Euclidean: when faced with a step, a wheelie will experience a very Euclidean obstacle as they can only move on continuous surfaces. On the other hand, a biped will be able to introduce a discontinuity which allows them to ignore the step (their footprints are, after all, discrete places and not a continuous line). This extreme Euclideanness is then what creates all those local boundaries and discontinuities, creating, at a larger scale, an extremely reticular perception of space.

Over this article, we have mostly focused on physical and sensory impairments, but there are potential parallels with many other related minorities — whether they are considered disabled or not. For example, the discrete temporalities would be most interesting to study in the case of "multiple systems", people who identify multiple selves — often in the context of dissociative identity disorder (Ribáry *et al.*, 2017). In this context, strong perceived discontinuities in memory and consciousness itself put at risk both agency and autonomy.

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Note

[1] Section 3.2 could accurately be summarised by saying that the homotopy class of paths from A to B is a dense set for a biped, and at best a singleton for a crip. This is an efficient phrasing that gives no intuition on the subject. Most of this article's mathematical arguments could be made more rigorous by defining objects formally and adding erratas, but this would affect both comprehension and concision. That said, some mathematical habits will be followed, and "we" will be used to denote the reader and

author going through the argument together (Bloch, 2008).

[2] For example, finding the most valuable combination from a set of items with a limited total weight is trivial if we can take a fraction of an item, whereas having to take whole items worsens the optimal solution, and makes computing it exponentially harder. Closer to our considerations, finding the optimal path through *n* points is much easier in the Euclidean plane than in general spaces.

[3] Euclideanness as a concept is more often used in geography to notice its absence (Lévy et al., 2004). For example, mental maps are more often reticulated than Euclidean. If we consider a spectrum from Euclideanness to full discreteness,non-disabled people might be closer to the second, but crips would tend to be at the extreme end of the spectrum.

[4] The word itself is derived from “cripple”, one of the main slurs used against the disabled communities. The questions of which words to use is non-trivial as it indicates a position taken both politically and methodologically. For example, person-first language (person with disability, as opposed to disabled person) is rejected by many activists, especially within communities that often reject the disabled label (such as the Autistic and Deaf communities), but not only (Jernigan 1993). It also partially implies which framework is used, from the medical model that was dominant until a few decades ago (which focuses on fixing the individual person), to the social model and its successors (Oliver 2013). Those generally analyse disability as occurring from the relationship between society and its arbitrary rules on one part, and a person with an impairment on the other, as will be the case in this article.

[5] To give an example, the CNRS recently congratulated itself on doubling its proportion of disabled employees (not just researchers), even as it was still well below the proportion of disabled people in the general population (by a factor 2 to 4 according to INSEE, depending on definitions, see (Brown and Leigh, 2018) for the UK case). Moreover, the proportions might not reflect all disabilities equally: the booklet featuring this self-promotion showed an argument between two researchers debating recruiting a disabled candidate, a central argument in her favour being that she has a “light” disability and does not require a wheelchair (Bec and Constans, 2016).

[6] An important disclaimer is needed, as this article tries to exhibit multiple ways in which crips experience space differently. This does not mean that different impairments lead to similar experiences, or that revendications between movements (or within movements) are necessarily unified or aligned. Improving accessibility for one does not always make it better for all.

[7] One question which could affect this warped perception, but that we explicitly do not treat here is, who exactly counts as crip. This is not trivial, as someone who fractures their tibia and is fine within 2 months should probably not count, but what about the person who uses a wheelchair for years while going through painful physiotherapy?

[8] Here we only look at physical autonomy, but even greater restrictions come from increased costs linked to living with disability in most countries, also known as the #CripTax (Wong, 2017).

[9] During a session on disability at a recent usability conference (HCII, 2019), multiple scholars with disabilities argued about the situations in which an offer to help is welcome. Some made consensus: not asking whether to help but helping directly, or offering to help when the person is not struggling, both being strongly rejected. Offers to help someone struggling coming from another crip were generally considered fine (as they come with the expectation that a rejection would be respected, and that the other crip would ask how to help without rushing). Asking if a struggling crip needed help was the main contentious point, with multiple people opining that, in the current context of denied autonomy, not offering help was probably wiser (as the struggling person can generally call for help if needed).

[10] This behaviour once led to the author being pushed and falling from a plane (Blanchard 2020A).

More generally, places that handle travelling crips often try to limit their autonomy as much as possible, with airports often using wheelchair model that do not allow self-propulsion, or with breaks that cannot be disabled from within the chair.

[11] The second category corresponds roughly to Lévy's *topological* boundaries, but the typology does not translate directly as the third category operates at a different scale.

[12] Due mostly to costs and regulations (such as ones concerning the types of batteries allowed on planes), wheelchairs do not generally have lithium batteries. The alternatives (generally lead-acid) are both heavy and bulky, and can make up half of the total wheelchair weight — which also prevents any easy manipulation to change them when depleted.

[13] This is a second violation of the triangular inequality, which also implies that, if B and C are close, then the distances from A to B and from A to C are also similar.

[14] In terms of autonomy and accessibility, the tram is actually the best system, as crips do not — legally or practically — have to ask for assistance to board or unboard.

[15] This has led Patrick Poncet to ask whether the housing patterns of crips closely follow those accessible transit lines. This should probably be limited when compared to the impact of the prices of accessible housing in Paris.

[16] Paradoxically, this would mean that the wheelie behaves in a way most similar to the biped in their immediate surrounding, without using public transit. This is just a first order approximation, as it strongly depends on the local urban features, especially the side-walk design.

[17] This stress is mixed with anxiety, both caused by a multitude of factors, from the fear of unwanted contact (as mentioned before) to the knowledge that there is a high chance that something will go wrong on their route, due to the low tolerance for errors, without being able to plan for every eventuality (Pyer and Tucker, 2017 ; Mason-Bich and Kavanagh, 2019).

[18] This is especially true when the wheelie is at the hands of someone they do not know and trust, with a critical example being airport handlers, who seldom have enough specialised training to deal with those issues. Going through a crowd on a wheelchair pushed by the bad kind of handler is often a harrowing experience as they do not respect safety distances between the chair and the people in front of it. This has multiple potential explanations: they might not realise how far the feet extend beyond the chair, they also often seem to think it is the crowd's duty to give them priority, not considering that any collision, even at low speeds, tends to hurt the crip more than anyone else, and they do not feel the obligation to avoid the stereotype of appearing like one is a danger to everyone else through lack of control.

[19] The crip could here ask the driver to take a different path, but this request might appear as an unwarranted whim, and reduce the goodwill that might be needed later in the trip. Self-censorship in that regard is a potential problem.

[20] Here, unreasonably high financial cost means that the cost to get a guaranteed service is often two to three times the cost of getting a cab to do the same trip, even in places where charging extra for disabled passengers is illegal (Blanchard 2020A).

[21] Although crip questions do not appear in Tim Ingold's book, it points naturally to crip interpretations with the following paragraph: "For passengers, strapped to their seats, travel is no longer an experience of movement in which action and perception are intimately coupled, but has become one of enforced immobility and sensory deprivation".

[22] Plane travel might seem easier due to the fact that it involves more normalised spaces, reducing the potential for unforeseen issues. Two factors make this untrue. First, air travel often involves surrendering one's mobility aids, which is fraught with dangers, with up to 6% of wheelchairs damaged per trip, depending on the airline (Fraser, 2019). Second, subcontracting linked with lack of training add many new potential issues as both attendants and airport security personnel are often ignorant of how to proceed (Morris, 2018 ; Blanchard, 2020B).

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